DRAFT
PRE-DESIGN INVESTIGATION WORK PLAN

ARKEMA PROJECT AREA

Prepared for
Legacy Site Services LLC
665 Stockton Drive
Suite 110
Exton, PA 19341

Prepared by

integral consulting inc.
319 SW Washington St.
Suite 1150
Portland, OR 97204

DOF DALTON OLMSTED FUGLEVAND
1001 SW Klickitat Way
Suite 200B
Seattle, WA 98134

June 18, 2020

CONTENTS

LIST OF FIGURES ..... **vii**

LIST OF TABLES ..... **x**

ACRONYMS AND ABBREVIATIONS ..... **xi**

1 INTRODUCTION **1-1**

1.1 RECORD OF DECISION BACKGROUND AND TERMINOLOGY 1-1
1.2 PORTLAND HARBOR AND ARKEMA PROJECT AREA DESCRIPTION AND HISTORY 1-2
1.2.1 Site Description 1-3
1.2.2 Historical Operations Summary 1-4
1.2.3 Upland Source Control Measures 1-4
1.2.4 Subaqueous Geology and Surface Sediment Grain Size 1-5
1.2.5 Hydrodynamic Conditions Overview 1-6
1.2.6 Groundwater Setting 1-7
1.2.7 Overview of Current Habitat Conditions 1-9
1.3 CONCEPTUAL SITE MODEL 1-9
1.3.1 Contaminant Sources 1-9
1.3.2 Transport Pathways, CSM, and Arkema Project Area Reaches 1-13
1.4 WORK PLAN ORGANIZATION 1-16

2 REVIEW OF EXISTING DATA **2-1**

2.1 BACKGROUND 2-1
2.2 USE OF RALS AND PTW FOR SCREENING AND REMEDIAL DECISION-MAKING 2-3
2.3 SURFACE SEDIMENT AND RIVERBANK SOIL 2-4
2.3.1 DDx 2-4
2.3.2 2,3,4,7,8-PeCDF 2-4
2.3.3 1,2,3,7,8-PeCDD 2-5
2.3.4 2,3,7,8-TCDD 2-5
2.3.5 Total PCBs 2-5
2.3.6 Total PAHs 2-6
2.3.7 Chlorobenzene 2-6
2.4 SUBSURFACE SEDIMENT 2-7
2.4.1 DDx 2-7
2.4.2 2,3,4,7,8-PeCDF 2-7

2.4.3 1,2,3,7,8-PeCDD 2-7
2.4.4 2,3,7,8-TCDD 2-8
2.4.5 Total PCBs 2-8
2.4.6 Total PAHs 2-8
2.4.7 Chlorobenzene 2-8
2.4.8 Maximum Depth of RAL Exceedances 2-9
2.5 NAPL 2-9
2.6 GROUNDWATER 2-10
2.6.1 Groundwater between Acid Plant Area and Top of Bank 2-10
2.6.2 Groundwater Flux to River 2-11
2.7 EXISTING DESIGN SUPPORT INFORMATION 2-12
2.7.1 Bathymetric and Topographic Survey 2-13
2.7.2 Geology 2-14
2.7.3 Geotechnical Investigations 2-15
2.7.4 Characterization for Hazardous Materials and Waste Disposition 2-16
2.7.5 Dock Structures at the Arkema Site 2-18
2.7.6 Surface Debris in the Arkema Project Area 2-19
2.7.7 Arkema Property Use and Constraints 2-19
2.8 HYDRODYNAMIC CONDITIONS 2-20
2.8.1 Pre-Existing Hydrodynamic Data Summary 2-21
2.8.2 PHSS Draft Feasibility Study Appendix Hc 2-21
2.9 CURRENT HABITAT CONDITIONS 2-25
2.10 DATA GAP ANALYSIS 2-26
2.10.1 Surface Sediment and Riverbank Soil 2-27
2.10.2 Subsurface Sediment and Riverbank Soil 2-29
2.10.3 Groundwater Discharge and Porewater 2-35
2.10.4 Sediment Deposition Rates 2-36
2.10.5 Geotechnical Evaluation 2-37
2.10.6 Dock Investigations and Structural Analysis 2-37
3 INVESTIGATION ELEMENTS AND RATIONALE 3-1
3.1 SEDIMENT AND SOIL CHEMISTRY SAMPLING 3-1
3.1.1 Sediment Chemistry 3-1
3.2 RIVERBANK SOIL 3-4
3.2.1 Problem Statement 3-4
3.2.2 Goals of the Study 3-5
3.2.3 Study Design 3-5

3.3 NAPL 3-5
3.3.1 Problem Statement 3-5
3.3.2 Goals of the Study 3-6
3.3.3 Study Design 3-6
3.4 SEDIMENT STABILITY 3-9
3.4.1 Problem Statement 3-9
3.4.2 Goals of the Study 3-10
3.4.3 Study Design 3-10
3.5 ADDITIONAL DESIGN SUPPORT DATA 3-11
3.5.1 Structural Analysis 3-11
3.5.2 Survey 3-12
3.5.3 Debris 3-13
3.6 GROUNDWATER DISCHARGE AND COC FLUX 3-14
3.6.1 Residual COCs in Groundwater 3-14
3.6.2 Hydraulic Gradient and Groundwater Flux 3-15
3.6.3 COC Flux to the River 3-17
3.7 HYDRODYNAMIC EVALUATIONS 3-18
3.7.1 Problem Statement 3-18
3.7.2 Goals of the Study 3-18
3.7.3 Study Design 3-19
3.8 GEOTECHNICAL EVALUATION 3-20
3.8.1 Problem Statement 3-20
3.8.2 Goals of the Study 3-21
3.8.3 Study Design 3-21
3.9 PHASED PRE-DESIGN INVESTIGATION APPROACH 3-22
4 FIELD METHODOLOGY 4-1
4.1 SURFACE SEDIMENT 4-1
4.2 SUBSURFACE SEDIMENT 4-1
4.2.1 Sonic Drilling 4-1
4.2.2 Mud-Rotary Drilling 4-2
4.2.3 Vibracore Sediment Sampling 4-2
4.3 RIVERBANK SOIL 4-3
4.3.1 Hand Auger Boreholes 4-3
4.3.2 Test Pit Explorations 4-3
4.4 GROUNDWATER DISCHARGE STUDY 4-3
4.4.1 Piezometer Installation 4-3

4.4.2 Groundwater Monitoring....4-4
4.4.3 Seepage Meters....4-4
4.5 SEDIMENT POREWATER....4-4
4.6 ADDITIONAL DESIGN SUPPORT DATA....4-4
4.6.1 Dock Structural Analysis....4-5
4.6.2 Survey....4-5
4.6.3 Debris....4-6
4.7 HYDRODYNAMIC EVALUATIONS....4-6
4.7.1 Site Visit and Observations....4-6
4.7.2 Reporting....4-7
5 PROJECT TEAM AND RESPONSIBILITIES....5-1
5.1 PROJECT COORDINATOR AND SUPERVISING CONTRACTOR....5-1
5.2 INVESTIGATION TEAM....5-1
5.2.1 DOF Team....5-1
5.2.2 Integral Team....5-1
6 SCHEDULE....6-1
7 REFERENCES....7-1

Appendix A. Field Sampling Plan
Appendix B. Quality Assurance Project Plan
Appendix C. Site Health and Safety Plan
Appendix D. Emergency Response Plan
Appendix E. Figures from Previous Reports
Appendix F. Geotechnical Data from the Arkema Project Area
Appendix G. Evaluation of PTW Threshold for HxCDF

LIST OF FIGURES

Figure 1-1. Site Location

Figure 1-2. Arkema Project Area, Arkema Site, and Adjacent Properties

Figure 1-3a. SMA Footprint from the ROD

Figure 1-3b. Locations of PTW Threshold Exceedances and Potential NAPL

Figure 1-3c. Technology Application Decision Tree from the Portland Harbor ROD

Figure 1-3d. Decision Guide for Characterizing and Implementing Remedial Action for ROD River Banks

Figure 1-4. Dredge and Fill and Historical Uses at the Arkema Site

Figure 1-5. Upland Source Control Measures for the Arkema Site

Figure 1-6. Sediment Thickness Map

Figure 1-7. Top of Basalt Elevation

Figure 1-8a. Data Excluded from Consideration Due to Detection Limits above RALs or PTW Thresholds

Figure 1-8b. Existing Surface Sediment and Riverbank Soil Sampling Stations

Figure 1-8c. Existing Subsurface Sediment and Riverbank Soil Sampling Stations

Figure 1-9. Conceptual Site Model Diagram—Dock 1 and 2 Reach

Figure 1-10a. Visual Surface Debris Survey, Outfall 004 Area

Figure 1-10b. Visual Surface Debris Survey, Between Docks 1 and 2

Figure 1-10c. Visual Surface Debris Survey, Between Dock 1 and Salt Dock

Figure 2-1a. DDx Surface Sediment and Riverbank Soil Data

Figure 2-1b. 2,3,4,7,8-PeCDF Surface Sediment and Riverbank Soil Data

Figure 2-1c. 1,2,3,7,8-PeCDD Surface Sediment and Riverbank Soil Data

Figure 2-1d. 2,3,7,8-TCDD Surface Sediment and Riverbank Soil Data

Figure 2-1e. Total PCBs Surface Sediment and Riverbank Soil Data

Figure 2-1f. Total PAHs Surface Sediment and Riverbank Soil Data

Figure 2-1g. Chlorobenzene Surface Sediment and Riverbank Soil Data

Figure 2-2a. DDx Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance

Figure 2-2b. 2,3,4,7,8-PeCDF Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance

Figure 2-2c. 1,2,3,7,8-PeCDD Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance

Figure 2-2d. 2,3,7,8-TCDD Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance

Figure 2-2e. Total PCBs Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance

Figure 2-2f. Total PAHs Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance

Figure 2-2g. Chlorobenzene Subsurface Sediment and Riverbank Soil Data with Maximum Depth of PTW Exceedance

Figure 2-3a. Maximum Depth of RAL Exceedances for all Focused COCs – Riverbank Area, Arkema Project Area, and Navigation Channel Area

Figure 2-3b. Maximum Depth of RAL Exceedances for all Focused COCs – Shallow Zone (Shoreward of -2 ft CRD), Less than 5 ft Sediment Depth

Figure 2-3c. Maximum Depth of RAL Exceedances for all Focused COCs – Shallow Zone (Shoreward of -2 ft CRD), Greater than 5 ft Sediment Depth

Figure 2-3d. Maximum Depth of PTW Exceedances for all Focused COCs and Additional Contaminants– Riverbank Area, Arkema Project Area, and Navigation Channel Area

Figure 2-4a. Arkema Project Area Bathymetry – 2018

Figure 2-4b. Arkema Project Area Bathymetric Change – 2004-2018

Figure 3-1. Summary of Proposed Remedial Design Investigation Subsurface Sediment and Riverbank Soil Chemistry Sampling Stations

Figure 3-2a. Detailed Proposed Remedial Design Investigation Sediment and Riverbank Soil Chemistry Sampling Stations Downstream of Dock 2

Figure 3-2b. Detailed Proposed Remedial Design Investigation Sediment and Riverbank Soil Chemistry Sampling Stations Upstream of Dock 2

Figure 3-2c. Subsurface Sediment Sample Analysis Decision Tree

Figure 3-2d. Riverbank Soil Sample Analysis Decision Tree

Figure 3-3a. Evaluation of Potential Subsurface NAPL

Figure 3-3b. Conceptual Sampling Vessel Layout and Core Processing Table

Figure 3-4. Proposed Groundwater Discharge Study

Figure 3-5. Proposed Porewater Sampling Locations

Figure 3-6. Proposed Sediment and Riverbank Soil Geotechnical Sample Locations

LIST OF TABLES

Table 3-1. Sediment Sampling Groups
Table 3-2. Subsurface Sediment Data Quality Objectives
Table 3-3 Riverbank Soil Data Quality Objectives
Table 3-4. NAPL Assessment Data Quality Objectives
Table 3-5. Sediment Stability Data Quality Objectives
Table 3-6. Groundwater Discharge Study Data Quality Objectives
Table 3-7. Geotechnical Data Quality Objectives

ACRONYMS AND ABBREVIATIONS

AOPC	area of potential concern
ASAOC	administrative settlement agreement and order on consent
ASTM	ASTM International
Bayer	Bayer CropScience
bgs	below ground surface
bml	below mudline
BNSF	Burlington Northern Santa Fe Railway Company
COC	contaminant of concern
CRD	Columbia River Datum
CSM	conceptual site model
CUL	cleanup level
DDD	dichloro-diphenyl-dichloroethane
DDE	dichloro-diphenyl-dichloroethene
DDT	dichloro-diphenyl-trichloroethane
DDx	total of 2,4'- and 4,4'-DDD, DDE, DDT
DEQ	Department of Environmental Quality
DOF	Dalton Olmsted & Fuglevand
DQO	data quality objective
EE/CA	engineering evaluation and cost analysis
EPA	U.S. Environmental Protection Agency
ESD	explanation of significant differences
FMD	future maintenance dredge
FSP	field sampling plan
GPS	global positioning system
GWET	groundwater extraction and treatment
HxCDF	1,2,3,4,6,7,8-hexachlorodibenzofuran
Integral	Integral Consulting Inc.
LSS	Legacy Site Services LLC, agent for Arkema Inc.

LWG	Lower Willamette Group
MPR	manufacturing process residue
NAPL	nonaqueous-phase liquid
NAVD 88	North American Vertical Datum of 1988
Nav-FMD	navigation channel and future maintenance dredging
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PDI	pre-design investigation
PeCDD	1,2,3,7,8-pentachlorodibenzo-*p*-dioxin
PeCDF	2,3,4,7,8-pentachlorodibenzofuran
PHSS	Portland Harbor Superfund Site
Pre-RD Group	Portland Harbor Pre-remedial Design Group
PTW	principal threat waste
QAPP	quality assurance project plan
RAAC	removal action area characterization
RAL	remedial action level
REV	reference envelope value
RI/FS	remedial investigation and feasibility study
RM	river mile
RM7W	River Mile 7 West
ROD	record of decision
SMA	sediment management area
SCM	source control measure
SDU	sediment decision unit
Siltronic	Wacker Siltronic Corporation
SOP	standard operating procedures
SPT	standard penetration test
SVOC	semivolatile organic compound
TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
TCDF	2,3,7,8-tetrachlorodibenzofuran

TCLP	toxicity characteristic leaching procedure
TZW	transition-zone water
USACE	U.S. Army Corps of Engineers
UV	ultraviolet
VOC	volatile organic compound

1 INTRODUCTION

This pre-design investigation (PDI) work plan has been prepared to support data collection within the Arkema Project Area of the River Mile 7 West (RM7W) Project Area, which is part of the Portland Harbor Superfund Site (PHSS) in Portland, Oregon (Figures 1-1 and 1-2). The Arkema Project Area includes all riverbanks from top of the bank to the river. The River Mile 7 West Project Area includes the Bayer Project Area (approximately river miles [RM] 6.5 to 6.9) in the downstream area and the Arkema Project Area (approximately RM 6.9 to 7.6) in the upstream area. The Willbridge Cove Project Area is immediately upstream of the RM 7 West Project area (approximately RM 7.6 to 8.1).

The following sections present background information, the Arkema Project Area description and history, and the report organization.

1.1 RECORD OF DECISION BACKGROUND AND TERMINOLOGY

This work plan uses the following key terms, which are presented by the U.S. Environmental Protection Agency (EPA) in the 2017 Portland Harbor Record of Decision (ROD; USEPA 2017) and the 2020 Remedial Design Guidelines and Considerations, including the "Guidance for River Bank Characterization and Evaluations at the Portland Harbor Superfund Site" (USEPA 2020):

- Cleanup Level (CUL): A CUL is the residual concentration of a hazardous substance determined to be protective of public health, safety and welfare, and the environment under specified exposure conditions.
- Remedial Action Levels (RALs): RALs are contaminant-specific sediment concentrations used to identify areas where active remediation will be performed, and thus are the basis of the sediment management area (SMA) boundaries or footprints.
- Principal Threat Waste (PTW): PTW is a source material considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environmental should exposure occur.
- Sediment Management Area: SMAs are areas delineated by RALs where containment or removal technologies will be considered to immediately reduce risks upon implementation.

Portland Harbor-specific CUL, RAL, and PTW threshold values were included in the 2017 ROD and are used in this work plan, with one exception. The CUL and RAL for polycyclic aromatic hydrocarbons (PAHs) in the 2017 ROD were superseded by the 2019 Explanation of Significant Differences (ESD) for the Portland Harbor ROD (USEPA 2019). The SMA footprints and PTW threshold exceedance locations in and adjacent to the Arkema Project Area are presented in

Figures 1-3a-b, respectively. The ROD's technology application decision tree provides guidance on assigning remedial technologies to address the SMAs and PTW threshold exceedances and is presented in Figure 1-3c. The decision tree for characterizing and implementing remedial actions for the ROD riverbanks from EPA's Remedial Design Guidelines and Considerations is presented in Figure 1-3d.

In EPA's development of remedial alternatives, SMAs were identified as areas where containment or removal technologies were considered to immediately reduce risks upon implementation (USEPA 2017). The SMAs represent areas with contaminant concentrations in surface sediment where natural recovery is not occurring or is not likely to be effective in reducing COCs within a reasonable time frame. In addition, the presence of PTW was used to delineate SMAs. The Arkema Project Area, the focus of this work plan, encompasses the SMAs located along the west side of the Willamette River approximately between RM 6.9 and 7.6.

The ROD states: "A capping model was utilized in the FS to identify PTW that cannot be reliably contained by a cap. Representative Site conditions and capping options were modeled to determine the maximum concentration of COCs in PTW material that would not exceed ambient water quality criteria (AWQC) in the sediment cap pore water after a period of 100 years."

1.2 PORTLAND HARBOR AND ARKEMA PROJECT AREA DESCRIPTION AND HISTORY

The Arkema Project Area is located near the center of the PHSS study area, which encompasses approximately 10 miles (RM 1.9 to 11.8) of the Willamette River in Portland, Oregon.

In 2000, the EPA added the PHSS to the National Priorities List pursuant to the Comprehensive Environmental Response, Compensation and Liability Act. Pursuant to an Administrative Settlement Agreement and Order on Consent (ASAOC) between EPA and, the Lower Willamette Group (LWG) (USEPA 2001), a remedial investigation and feasibility study (RI/FS) of the PHSS was completed, and in January 2017, EPA issued a ROD for the PHSS. EPA's selected remedy incorporates a combination of technologies, including capping, dredging/excavation, *in situ* and *ex situ* treatment, enhanced natural recovery, monitored natural recovery, and institutional controls to address Portland Harbor sediment contamination (USEPA 2017).

In 2019, the EPA issued an ESD to the ROD to correct technical issues associated with the risk from PAHs presented in the ROD (USEPA 2019). The ESD changed the total PAH RAL from 13,000 μg/kg to 30,000 μg/kg. In addition, EPA has issued several versions of the Portland Harbor Remedial Guidelines and Considerations, the most recent of which is from February 28, 2020 (USEPA 2020). The guidelines and considerations presented in this document that are important to this work plan include 1) the incorporation of the riverbank area to the top of bank

with the sediment remedy and 2) the need to collect two consecutive 1-ft sediment samples below RALs and PTW thresholds to define the bottom of the dredge prism. EPA's Portland Harbor remedial guidance document also includes "Guidance for River Bank Characterizations and Evaluations" in Appendix D. This appendix provides a decision guide for characterizing and implementing remedial actions for riverbanks, which was followed in this work plan.

On February 21, 2020, an ASAOC for remedial design at the river mile 7 west project area was executed. The ASAOC covers the Arkema and Bayer CropScience Project Areas, as noted above. This PDI work plan meets the requirements presented in the Arkema Statement of Work in Appendix A-1 of the ASAOC for the Arkema Project Area (Figure 1-2).

1.2.1 Site Description

The Arkema Project Area is located in the PHSS on the west side of the Willamette River approximately between RM 6.9 and 7.6 (Figure 1-2). The harbor area is heavily industrialized, and land use along this portion of the lower Willamette River includes marine terminals, manufacturing, rail access, and other commercial operations, as well as public facilities, parks, and open spaces.

The upland portion of the Arkema site encompasses approximately 54 acres of land. All historical site buildings have been demolished except for the office building. The Arkema site is bounded on the southwest and northwest by Front Avenue and on the southeast by Bird Inc./GS Roofing. Other sites of interest in the area include, but are not limited to, the Wacker Siltronic Corporation (Siltronic) facility downstream of the Arkema site, which occupies approximately 85 acres in Portland Harbor between approximately RM 6.4 and 6.9; the Willbridge Bulk Fuel Terminal upstream of the Arkema site between approximately RM 7.6 and 8.1, with three docks operated by Kinder Morgan, Chevron, and ConocoPhillips; and the Bayer CropScience (Bayer) facility located about 1,000 ft southwest of the Arkema site (Figure 1-2).

The PHSS ROD includes areas with contaminated riverbanks (USEPA 2017, Figure 9) and categorizes water areas as shallow, intermediate, or Nav-FMD (USEPA 2017, Figure 18). The PHSS ROD states: "River banks are defined as the area from the top of bank down to the river. River bank data were collected under DEQ-led investigations." Contaminants detected in riverbank material in the Arkema Project Area include, but are not limited to, dichloro-diphenyl-trichloroethane (DDT), dioxins/furans, polychlorinated biphenyls (PCBs), and metals (chromium and lead; USEPA 2017).

The PHSS ROD (USEPA 2017) defines Navigation Channel as the federally authorized navigation channel and Future Maintenance Dredge (FMD) areas as "those locations in the river that are periodically dredged to allow continued marine activity such as vessel activity, shipping, docking, etc." The PHSS ROD (USEPA 2017) defines the intermediate and shallow regions as follows: "The intermediate region is defined as outside the horizontal limits of the

navigation channel and FMD areas to the riverbed elevation of approximately -2 ft CRD. The shallow region is defined as shoreward of the riverbed elevation of approximately -2 ft CRD."

The Arkema Project Area includes all of these defined areas: riverbanks, shallow, intermediate and Nav-FMD. The FMD areas are associated with the three existing docks at the site. These docks are no longer in use and will be removed as part of the remediation work, eliminating the underdock and FMD areas in the Arkema Project Area.

1.2.2 Historical Operations Summary

Inorganic chemicals were manufactured at the Arkema site from 1941 until 2001, when the facility was closed and chemical manufacturing was discontinued (Figure 1-4). For most of the site's history, chemical manufacturing activities involved electrolytic decomposition of brine solutions to manufacture inorganic chemicals, including sodium chlorate, chlorine, sodium hydroxide, hydrogen, and hydrochloric acid. Other chemical manufacturing processes included the production of DDT from 1947 to 1954, and ammonium perchlorate from 1958 to 1962 (ERM 2005). The shoreline adjacent to the site was used as a staging area for logs by other parties from at least the early 1920s to the early 1980s.

The historical Acid Plant area is located on the upland portion of the site between Docks 1 and 2. The Acid Plant was used in the manufacturing of DDT, magnesium chloride hexahydrate, ammonium perchlorate, solid sodium hydroxide, a grass defoliant, sodium orthosilicate, and hydrochloric acid.

The historical Chlorate Plant area is located on the upland portion of the site between Dock 1 and the Salt Dock. The Chlorate Plant area was used primarily to manufacture sodium chlorate and potassium chlorate (Integral 2016).

River access to the Arkema site historically was provided from three docks—from upstream to downstream—the Salt Dock, Dock 1, and Dock 2. Dock 1 was originally constructed in the 1940s, Dock 2 was originally constructed in the late 1950s and early 1960s, and the Salt Dock was constructed in the 1960s.

These docks (the Salt Dock, Dock 1, and Dock 2) are no longer in use and will be removed as part of the remediation work.

1.2.3 Upland Source Control Measures

Source control measures (SCMs) have been implemented on the upland portion of the site for stormwater and groundwater. The SCMs were conducted under oversight of and approval by the Oregon Department of Environmental Quality (DEQ) and are considered an interim action that is being applied in advance of the site-wide feasibility study and selection of a final site

remedy that addresses contaminants of concern (COCs) in soil, groundwater, and stormwater in the upland portions of the site. Thus, all SCMs implemented to date are considered temporary in nature. The final upland site remedy is anticipated within approximately the next 5 years.

1.2.3.1 Stormwater SCMs

Stormwater SCMs consist of collecting site stormwater, conveying it to a stormwater detention basin via two rock-lined channels, equalizing the storm volume, providing primary solids removal through sedimentation in the basin, and providing second stage treatment through a sand filtration system. Treated stormwater is then discharged to the river through Outfall 004. Figure 1-5 shows the configuration of the stormwater treatment system. Other elements of the stormwater SCMs include temporary capping of selected areas of the site that contain COCs in exposed surficial soil and decommissioning of unused stormwater conveyance piping. Construction of the stormwater SCMs began in April 2012 and was substantially complete in February 2013. Treated stormwater began discharging from the site in December 2012, and monitoring at Outfall 004 commenced. Since December 2012, monthly monitoring has been conducted at Outfall 004, and results have shown greater than 95 percent reduction in DDT concentrations since the construction of the stormwater SCM.

1.2.3.2 Groundwater SCMs

The groundwater SCMs consist of a groundwater barrier wall and a groundwater extraction and treatment (GWET) system. The groundwater barrier wall physically separates the affected upland portion of the site and in-water Arkema Project Area and is located approximately 25 to 75 ft from the top of the bank. The barrier wall extends from approximately Dock 2 to the southern portion of the Salt Dock and the former Salt Pads (Figure 1-5). The groundwater barrier wall was constructed using bentonite slurry backfill and extends to the top of basalt bedrock. Construction of the barrier wall was completed in December 2012.

The GWET maintains hydraulic control to prevent groundwater from moving around or under the barrier wall. The GWET system consists of 22 extraction wells located immediately upgradient of the groundwater barrier wall (Figure 1-5). The extraction wells are screened in the shallow (13 wells) and intermediate (9 wells) groundwater zones. Extracted groundwater is treated using a number of physical, chemical, and biological processes to remove COCs. Treated groundwater is discharged to the river through Outfall 004 under National Pollutant Discharge Elimination System Waste Discharge Permit No. 103075. The GWET system construction was completed in May 2014.

1.2.4 Subaqueous Geology and Surface Sediment Grain Size

The following sections present a brief description of the subaqueous geology and surface sediment grain size in the Arkema Project Area.

1.2.4.1 Subaqueous Geology

The subaqueous geology in the vicinity of the Arkema Project Area consists of unconsolidated sediment overlying basalt bedrock. The sediment consists primarily of soft to very soft silt and sand with varying amount of silt. Gravel layers with varying amounts of sand and silt are present immediately overlying the basalt in some areas. The sediment is thicker (up to 50 ft) between Dock 1 and the Salt Dock and thins from west (shoreline) to east (toward the navigation channel) where the sediment is 2 to 10 ft thick (Figure 1-6). The sediment also thins from south (Salt Dock) to north (toward Outfall 004 where the sediment is 15 to 20 ft thick). The basalt surface generally slopes to the east, with the highest elevations in the vicinity of the shoreline adjacent to Outfall 004 (Figure 1-7)(Integral and ARCADIS 2011).

The increased thickness of sediment on the landward side of the Arkema docks is likely due to several factors, including natural deposition/sedimentation, enhanced deposition because of the sheltering effect of the docks, and filling activities in the vicinity of the docks. In general, the sediment represents a fining upward sequence (i.e., coarser sediments at the bottom and finer sediment at the top of the sequence) and becomes thinner toward the east.

1.2.4.2 Surface Sediment Grain Size

The grain-size data measured in surface sediment samples in Portland Harbor is presented on Map 3.1-5 in the Portland Harbor remedial investigation report (USEPA 2016a). In the absence of anthropogenic activities that affect sediment textures (e.g., vessel propwash), the physical characteristics of surface sediment are general indicators of the energy regime of the riverbed at that location (USEPA 2016a). Typically, fine-grained sediments (e.g., silts, clays) dominate in relatively low-energy environments where current velocities are low enough to allow fine particles to settle out of the water column and remain deposited. Coarse-grained sediments (e.g., sands, gravels) are indicative of higher energy environments where fines are kept in suspension in the water column and/or winnowed out of previously deposited material and transported away during transitory high-energy events (USEPA 2016a).

In and around the Arkema Project Area, the percent fines in surface sediment are highest in the vicinity of the upstream Willbridge Cove Area and in the vicinity of the Salt Dock and Dock 1 adjacent to the Arkema site, suggesting relatively low-energy environments . The percent fines are the lowest in the vicinity of the railroad bridge, suggesting a relatively higher-energy environment near the bridge where the river narrows slightly.

1.2.5 Hydrodynamic Conditions Overview

Numerous natural and anthropogenic factors associated with the hydrology of the lower Willamette River directly influence hydrodynamics and related sediment transport in the river. Examples include rain and snowmelt from the Willamette and Columbia river basins, tidal

fluctuation from the Columbia River estuary, the operation of dams on the Willamette and Columbia rivers, and channel modifications.

The Willamette River discharges approximately 33,000 cubic feet per second on average, but discharge varies considerably. The lowest flows occur during the late-summer dry season, and typically increase by a factor of 10 through the winter rainy season. A period of higher river stage usually occurs from late May through June when the Willamette River discharge is restricted by high flows in the Columbia River associated with the spring freshet, a result of snowmelt in the much larger Columbia River watershed (Anchor QEA et al. 2012). Under certain conditions, typically in the late summer and fall, the influence of the Columbia River causes periodic slack water and short-term flow reversals in the lower portion of the Willamette River.

River flows in the lower Willamette are regulated to some degree by a series of upstream dams; however, high-flow events of 200,000 cubic feet per second or more still occur every few years during large storms (USEPA 2016a). Further detail is provided in the final Portland Harbor remedial investigation report (USEPA 2016a).

The primary factors controlling river flow dynamics, sediment deposition and erosion, and riverbed character are the river cross-sectional area, navigation channel width, and local bathymetric features. The river widens as it enters the Portland Harbor study area (RM 11.8) and becomes increasingly depositional, most notably in the western portion of the river, until RM 6.8 (USEPA 2016a).

1.2.6 Groundwater Setting

The following sections present the regional and local groundwater settings.

1.2.6.1 Portland Harbor Area

Generally, groundwater flow adjacent to the PHSS is toward the river (i.e., groundwater discharges to the river). On the west side of the river, groundwater, creeks and channels along the east face of the Tualatin Mountains flow downward to the Willamette River. On the east side of the river, starting upstream of RM 4, a broad terrace divides the floodplains of the Willamette and Columbia rivers. Deep groundwater flows are influenced by the Columbia on the east side of the river, with effects increasing as distance from the Willamette River increases. Groundwater gradients are relatively flat in some areas along the east side of the Willamette River, due to both underlying geology and the influence of the Columbia River. The groundwater flow regimes bordering the Willamette River show seasonal patterns related to seasonal river stage and precipitation variations. In the absence of preferential pathways, groundwater discharge to the sediments and river will tend to be heavily influenced by the location and geometry of higher and lower permeability layers in relation to the river.

1.2.6.2 Arkema Project Area

Groundwater in shallow unconsolidated soil adjacent to the Arkema Project Area is similar to groundwater in other locations along the western margin of the lower Willamette River. Shallow groundwater in the fill and alluvial deposits is unconfined and flows generally to the northeast or north-northeast before discharging to the Willamette River. Shallow groundwater is recharged directly by precipitation and infiltration, and from upgradient areas to the west of the site. Groundwater potentiometric surface data indicate that there is a downward gradient to intermediate groundwater from the shallow groundwater system. Groundwater levels and fluxes in the shallow groundwater system are affected by seasonal Willamette River stage changes, and diurnal tidal influences during lower river stages, although because of the unconfined nature of the shallow zone, groundwater tidal fluctuations occur via bank storage and are usually limited to less than a 100 ft of the river margin. The presence of human-made low-permeability features, such as silt and clay dikes constructed to retain hydraulically placed dredge fill, cutoff walls, and retaining walls, can alter local groundwater flow in the shallow groundwater system (USEPA 2016a).

Intermediate depth groundwater is found within fine- to coarse-grained alluvial sands that underlie the shallow zone and are separated by a semi-confining silt or clay horizon that can range in thickness from a few inches to tens of feet in the Arkema Project Area. Intermediate zone groundwater is semi-confined to confined as a result of the upper confining silt or clay stratigraphic horizon. Similar to the shallow zone, intermediate zone groundwater flow is generally to the northeast or north-northeast before discharging to the Willamette River, below the river surface where more permeable strata (typically sand) daylight in the riverbed. Intermediate zone recharge is from downward seepage from the shallow zone, through the intervening aquitard, and more substantially from upgradient intermediate zone groundwater to the west of the site. Like the shallow groundwater zone, intermediate zone groundwater levels and fluxes are affected by seasonal Willamette River stage changes, and diurnal tidal influences during most lower stages. Because of the confined to semi-confined condition of the intermediate zone, tidal fluctuations are propagated faster and farther from the shoreline than fluctuations in the shallow zone, as a result of pressure head propagation from the seepage face through the aquifer. These diurnal pressure changes have been observed in monitoring wells located 300 ft or more from the river margin.

Deep groundwater is present in the interval between the intermediate depth groundwater and the underlying bedrock basalt (ERM 2010). This zone consists of predominately fine-grained deposits, and is characterized by significantly lower hydraulic conductivity than the shallow and intermediate zones. The top of the deep zone occurs at approximately 40 to 50 ft below ground surface (bgs) across the Arkema Project Area. The saturated thickness (approximately 5 to 45 ft) of the deep zone is generally controlled by the topography of the underlying basalt bedrock at the Arkema Project Area (ERM 2010).

1.2.7 Overview of Current Habitat Conditions

In 2010, a baseline salmonid habitat survey was conducted adjacent to the Arkema Project Area to support riverbank SCM studies being performed at the Arkema site (Integral 2010). Integral Consulting Inc. (Integral) performed a site walk to document baseline habitat conditions along the riverbank. While a variety of site characterizations previously had been performed to document the physical setting and general habitat types present, the site walk specifically was conducted to identify habitat types along the riverbank of relevance to the four main salmon habitat categories identified by National Marine Fisheries Service.

Based on the National Marine Fisheries Service relative ranking of habitat values used in this assessment, salmonid habitat quality along the riverbank in the Arkema Project Area is extremely limited.

1.3 CONCEPTUAL SITE MODEL

This section presents an overview of the key portions of the conceptual site model (CSM) relevant to the remediation of the Arkema Project Area. Significant surface and subsurface sediment and riverbank soil sampling has been conducted in the Arkema Project Area since 1997 (Figures 1-8a through c). These data, along with knowledge of the operational history of the Arkema site, other Arkema Project Area sources, and nearby and upstream sources, were used to refine the CSM. Additional details on the CSM, including release mechanisms and receptors, are presented in Section 4 of the Arkema engineering evaluation and cost analysis (EE/CA) work plan (Parametrix 2007).

1.3.1 Contaminant Sources

The following sections present a summary of primary and secondary contaminant sources at, near, and upstream of, the Arkema Project Area.

1.3.1.1 Primary Sources

The primary sources of COCs at, near, and upstream of the Arkema Project Area that are important to the remediation of the Arkema Project Area include the following (Parametrix 2007; ERM 2003; see Figure 1-4 for source locations in the Arkema Project Area):

- **Former Process Discharge Pipe/Stormwater Outfall**—In 1947, at the initiation of DDT manufacturing, manufacturing process residue (MPR) was discharged to floor drains connected to a stormwater system that drained into the Willamette River. This stormwater outfall is referred to as the "former process discharge pipe" on site figures (Figures 1-4 and 1-9). It was also used to discharge cooling water from upland production processes.

- **Former MPR Pond**—A shallow unlined pond was constructed in 1948 northeast of the manufacturing building, and MPR that formerly went to the floor drain was redirected to the pond. The pond was used until about 1954, when DDT manufacturing operations ceased. Major portions of the soil from the former MPR pond were removed to a depth of 12 ft bgs during a soil interim remedial measure in 2000.
- **Former MPR Trench**—In 1951 or 1952, a trench 8 ft wide by 285 ft long was constructed north of the MPR pond to increase its capacity. Use of the MPR trench ceased around 1954 when DDT operations ended. Elevated concentrations of chlorobenzene and DDT were found in this area prior to the two-phased soil removal and source control interim remedial measure implemented in 2000 and 2001. At that time, soil in the trench was removed to depths of up to 8 ft.
- **Former DDT Process Building**—DDT was manufactured in the former DDT process building from 1947 to 1954. Chemical base stocks used in the DDT manufacturing process included chlorobenzene, chloral, and sulfuric acid. Some DDT handling took place in Warehouse No. 2, in the northwest corner of the Acid Plant area.
- **Lot 1, Former DDT Trench**—Historical construction activities in the Acid Plant area generated soil with DDT residues that were reportedly disposed of in a trench on Lot 1 immediately south of the former asbestos trenches. Arkema excavated the trench on Lot 1 that contained DDT MPR in 1994 (ERM 2003).
- **Lot 1, Former Asbestos Trenches, and Pond**—Diaphragm cells were used in the Chlorate Cell Room. These cells utilized an asbestos-coated cathode and titanium anodes. The cells needed to be rebuilt periodically to improve their efficiency. During the rebuilding process, water was used to wash the asbestos diaphragm material from the cathode. The asbestos-containing residue was ultimately placed in 12 trenches on Lot 1. In 1992, the trenches were excavated and the asbestos material was disposed under the oversight and approval of Oregon DEQ.
- **Contaminant Deposition from Other Sources**—Sediment particle-associated contaminants (e.g., contaminated sediments) may be transported from known contaminated sites and sources upstream of the Arkema Project Area and subsequently deposited in the Arkema Project Area via fluvial processes. In addition, contaminant transport from sources immediately downstream of the Arkema Project Area can be transported upstream when the river flow direction reverses near high tide when the river stage is low (typically in the summer and fall). These sources include the following from downstream to upstream:
  - **Doane Creek (1965 to 1980; RM 6.85)**—Doane Creek discharged near the current location of City Outfall 22C from approximately 1965 to 1980. During the mid- to late 1960s, extensive documentation describes the connection from Bayer to the Willamette River via Doane Lake and Doane Creek as evidenced by the Chipman Chemical (predecessor to Bayer; ECSI #155) wastes that were found to be tainting

migratory fish that were passing through the lower Willamette River during this period (LSS 2010). Doane Creek discharged to the river near the current boundary of the NW Natural and Siltronic sites prior to 1965 and immediately downstream of the railroad embankment after the Doane Creek drainage was modified and diverted immediately north along the railroad embankment in about 1965. According to Bayer, the tainted migratory fish issue in the mid- to late 1960s was caused by the excavation of this ditch, which drained water from North Doane Lake to the Willamette River (Rhône Poulenc 1987). However, reports prior to 1965 also reported iodine tasting fish, suggesting that the connection to the river preceded the excavation of the 1965 Doane Creek channel.

- **City Outfall 22C (1980 to present; RM 6.85)**—Contaminated shallow groundwater from Bayer that discharges to North Doane Lake is seasonally discharged through a 72-in. culvert beneath the railbed into the conveyance system for Outfall 22C. The conveyance system bordering the former Koppers site (ECSI #2348) drains into the North Drainage Pond, where elevated PAH concentrations are found in sediment (City of Portland 2007). The North Drainage Pond drains directly to Outfall 22C through an 84-in. pipe. In addition, aerial spraying of DDT conducted by the City from 1947 to the 1960s likely would have included Basin 22C (Integral 2020a). Historical DDT use in the drainage basin would be an ongoing source of DDT in stormwater from Outfall 22C and to Willamette River sediments near the outfall.
- **City Outfall 22B (RM 6.90)**—Bayer groundwater plumes have historically infiltrated into the conveyance system for Outfall 22B. In addition, aerial spraying of DDT conducted by the City from 1947 to the 1960s likely would have included Basin 22B (Integral 2020b). Historical DDT use in the drainage basin would be an ongoing source of DDT in stormwater from Outfall 22B and to Willamette River sediments near the outfall.
- **Bayer Outfall WR-6 (RM 6.90)**—This private 6-in. steel outfall conveys treated stormwater/process water from the Bayer Site to the Willamette River immediately north of the Arkema Project Area. Elevated levels of Portland Harbor focused COCs have been observed near this outfall (Sections 2.3 and 2.4).
- **Saltzman Creek/City Outfall 22A (RM 7.55)**—Outfall 22A drainage has contributions and/or potential contributions from current and historical sources of contaminants to the Willamette River. These sources include highways and roadways (City of Portland and Oregon Department of Transportation), oil terminals (Chevron, ECSI #25; GATX, ECSI #1549; Shell Oil, ECSI #160), a former herbicide and pesticide manufacturer (Rhône-Poulenc, ECSI #155), the current Metro waste transfer facility (ECSI #1398), a roofing tile manufacturer (GS Roofing, ECSI #117) and others (Integral 2020b). In addition, the City conducted aerial spraying of DDT from 1947 to the 1960s, which would have included all or parts of the Saltzman Creek/ Outfall 22A drainage basin (Integral 2020a).

- **City Outfall 22 (RM 7.80)**—The drainage basin for Outfall 22 is predominantly heavy industrial (City of Portland 2013). In 2015, the City conducted a dry-weather flow, inline solids, and sediment investigation for Outfall Basin 22 (City of Portland 2015). This investigation was conducted in response to recurring reports of oil sheens in the vicinity of Outfall 22. This investigation found the Chevron (ECSI #1281) and Phillips 66 (ECSI #171 and #3395) facilities are potential sources of sheen being observed at the outfall (City of Portland 2015). Sheens from this outfall can contaminate Willamette River sediments near and downstream of Outfall 22, including in the Arkema Project Area.
- **Other Upstream Sources**—These include, but are not limited to, Bird Inc./GS Roofing (ECSI #117), facilities in the Willbridge Bulk Fuel Terminal (Kinder Morgan, ECSI #1549; Chevron, ECSI #25; Conoco Phillips, ECSI #171; Shell, ECSI #160; McCall, ECSI #134), Gunderson (ECSI #1155), and a number of potential sources of dioxins, including the former City of Portland Incinerator (ECSI #404) and paper mills located near Willamette Falls (Blue Heron Paper Company, ECSI #4811, #5717; and West Linn Paper Company, ECSI #263).

1.3.1.2 Secondary Sources

Secondary sources of COCs at, or affecting, the Arkema Project Area that are important to the remediation of the Arkema Project Area include upland surface and subsurface soil, groundwater plumes, and resuspended sediment. COCs contained in upland soil may have been transported to riverbank soil and groundwater via overland runoff from upland surface soil or via leaching, percolation, and infiltration from subsurface soil. The stormwater SCMs currently prevent stormwater contamination by untreated stormwater discharges.

The groundwater SCMs currently prevent migration of groundwater COCs (primarily chlorobenzene and DDx[1]) from the former MPR pond, trench, and DDT process building contained behind the groundwater barrier wall and treated in the GWET system. Sediment affected by historical upland stormwater and groundwater discharges of COCs could be resuspended and transported.

Bayer groundwater plumes are migrating across Lots 1 and 2 on the Arkema property. The plumes are present in multiple hydrostratigraphic units crossing the Arkema property from Front Avenue to the Willamette River. These plumes are well documented and Bayer has installed 18 wells across multiple groundwater zones on Lots 1 and 2 to monitor its plumes. These wells were most recently monitored in 2017 and 2018 as part of Golder's feasibility study

[1] DDx is the total of 2,4'- and 4,4'-dichloro-diphenyl-dichlorethane (DDD), dichloro-diphenyl-dichloroethene (DDE) and DDT.

data gaps investigation for the Rhône Poulenc site (Golder 2018). The groundwater plumes on Lots 1 and 2 are being addressed as part of Bayer's feasibility study.

1.3.2 Transport Pathways, CSM, and Arkema Project Area Reaches

The Arkema Project Area encompasses approximately 2,000 ft of riverbank frontage. The contaminant sources, transport pathways, depth to bedrock, sediment thickness, and hydraulic regimes vary across this area; hence, the COC types and distribution in sediment in each subarea are spatially variable. For these reasons, the Arkema Project Area is divided into four subreaches for discussion of the CSM, including transport pathways, which vary by reach and will be important for understanding remedial decision-making. The four reaches are as follows (Figure 1-2):

- **Upstream Reach**—Dock 1 to the upstream end of the Arkema Project Area, including a portion of Willbridge Cove and discharge of Saltzman Creek (approximately RM 7.4 to 7.6)
- **Dock 1 and 2 Reach**—Area between Docks 1 and 2 (approximately RM 7.3 to 7.4)
- **Outfall 004 Reach**—Area in the vicinity of Outfall 004, downstream of Dock 2 (approximately RM 7.1 to 7.3)
- **Downstream Reach**—Area downstream of the Outfall 004 reach (approximately RM 6.9 to 7.1).

The following sections briefly describe the CSM, including sources and transport pathways for each reach.

1.3.2.1 Upstream Reach

The Upstream Reach is located adjacent to the former Chlorate Plant Area and associated Salt Pads on the Arkema facility, GS Roofing, Saltzman Creek, and other Willbridge embayment sources (i.e., City Outfall 22). COCs in sediment include DDT and dioxins/furans in the downstream portions of the reach (near the Dock 1 and 2 Reach), but they generally decrease and become shallower upstream. Other non-Arkema-site related chemicals, believed transported in from upstream, including but not limited to PAHs and PCBs, are found in sediments upstream of the Salt Dock and in the Willbridge embayment.

The sediment thickness between Dock 1 and the Salt Dock is approximately 45 to 50 ft in the nearshore area, thinning to approximately 20 ft near the navigation channel (Figure 1-6). Sediment borings have been advanced to bedrock upstream of the Salt Dock, so the sediment thickness is known in this area.

Contaminants from upstream sources have been transported by river processes and deposited in the Arkema Project Area. GS Roofing, a roofing shingle manufacturer, has an outfall that discharges into the mouth of Saltzman Creek as the creek discharges into the Willamette River. GS Roofing contaminants (e.g., petroleum hydrocarbons and PAHs) could be transported to sediment in the Arkema Project Area by stormwater discharge and overland flow. Saltzman Creek/City Outfall 22A discharges into the upstream end of the Arkema Project Area and is a potential source of chemicals from a number of facilities within the Saltzman Creek drainage area, including Willbridge Bulk Fuel Terminal (e.g., PAHs, PCBs, DDT), and City of Portland and Oregon Department of Transportation streets and roadways (e.g., PAHs, PCBs, dioxins/furans). Historical contaminants from Bayer (the former Chipman Chemical facility; e.g., DDT, dioxins/furans, 2,4-D) were likely transported via stormwater runoff to drains discharging to Saltzman Creek. Upgradient of the industrial area in Saltzman Creek, Forest Park has historically contributed agricultural runoff from pesticides/herbicides (e.g., DDT) used on the City-owned land. City Outfall 22 discharges into Willbridge Cove at RM 7.8, immediately upstream of the Arkema Project Area. Other upstream Willamette River sources include, but are not limited to, Gunderson (PCBs), a former City incinerator (dioxins/furans), and paper mills (dioxins/furans).

Groundwater discharges from the Arkema facility into the Upstream Reach have been curtailed with the installation of the groundwater barrier wall, an element of the groundwater SCMs. Prior to groundwater SCM installation, groundwater discharge within this reach may have impacted sediments, but to a lesser degree than groundwater impacts within the Dock 1 and 2 Reach. Arkema treated hexavalent chromium and perchlorate in groundwater in the Upstream Reach. COCs in the vicinity of the former Chlorate Plant Area include chloride and perchlorate. These COCs are largely controlled or are not of concern with respect to sediment cleanup because they are conservative tracers and do not sorb to sediments.

The riverbank fill in this reach consists of concrete debris and spoils from dredging that occurred in the vicinity of the Salt Dock in 1956 (Figure 1-4). Riverbank soil in the upstream reach is armored with fill material containing concrete debris, so soil erodibility is limited (Figures 1-8a-c).

1.3.2.2 Dock 1 and 2 Reach

The Dock 1 and 2 Reach is adjacent to the area where historical DDT manufacturing occurred. The sediment thickness in this reach is approximately 30 to 40 ft in the nearshore area, thinning to approximately 10 to 15 ft near the navigation channel. This reach is a depositional area based on bathymetric changes and sediment COC concentrations. For example, the highest DDx concentrations are buried 10–12 ft below mudline (bml).

A CSM diagram showing contaminant sources, transport pathways, and groundwater source control measures between Docks 1 and 2 in the Arkema Project Area is presented in Figure 1-7.

Manufacturing process residue was discharged through the former discharge pipe during the startup of DDT manufacturing operations (i.e., less than 1-year duration). The manufacturing process residue would have contained chlorobenzene, DDT, and DDT metabolites. Based on COCs in sediment, the residue discharged through the former discharge pipe settled out of the water column near and immediately downstream of the pipe. Deposition of sediment in the vicinity of the former discharge pipe has buried the highest concentrations of DDT approximately 10–12 ft below the current mudline elevation.

As discussed in Section 1.2.3.2, groundwater SCMs (barrier wall and GWET system) were installed in 2012-13 along a portion of the shoreline. The groundwater on the riverward side of the barrier wall could be an ongoing source of chlorobenzene to sediments. However, the hydraulic gradient from the riverward side of the barrier wall to the river is expected to be greatly reduced or eliminated by the barrier wall. Prior to the groundwater SCM, groundwater from the former DDT manufacturing process area primarily flowed to the river in the Dock 1 and 2 Reach. The highest concentrations of chlorobenzene in the upland and Dock 1 and 2 Reach are within the intermediate zone or at an equivalent elevation in Willamette River sediment groundwater (Figure 1-7).

Sediments in this area have been impacted by contamination from both top down and bottom up processes.

Potentially contaminated erodible soil is present in some areas of the riverbank and could be an ongoing source of COCs to the river. In addition to focused COCs, riverbank soil in the vicinity of Lots 1 and 2 could have asbestos waste from the rebuilding of diaphragm cells on other portions of the site. Riverbank soil near the docks on Lots 3 and 4 is armored with fill material containing concrete debris, so soil erodibility is limited in these areas (Figures 1-8a-c).

1.3.2.3 Outfall 004 Reach

The Outfall 004 Reach is located downstream of the Dock 1 and 2 Reach. Former DDT manufacturing operations did not occur in this reach; however, Outfall 004 was one of four long-term outfalls that discharged stormwater during chlor-alkali facility operations. The sediment thickness is approximately 20 to 25 ft in the nearshore area, thinning to approximately 10 ft near the navigation channel (Figure 1-6). This reach is a depositional area based on bathymetric changes and sediment with elevated DDx that is buried 4 to 6 ft below current mudline. COCs from DDT manufacturing process residues are not a source to Outfall 004 Reach sediments via groundwater.

The Outfall 004 Reach has COCs from the former DDT manufacturing operations from the upstream Dock 1 and 2 Reach. In addition, COCs from Outfall 004 have been deposited in sediment immediately downstream of Outfall 004. The highest concentrations of DDx in sediment are much lower than in the Dock 1 and 2 Reach and are found at shallower depths

(ranging from 4 to 6 ft bml). The Outfall 004 Reach has limited groundwater contamination because it is located between the Arkema groundwater discharge in the Dock 1 and 2 Reach and downstream Bayer plumes.

The fill along the riverbank in this reach consists of concrete debris, slag, and dredge material. The riverbank soils may contain asbestos from chlorate cells that were formerly buried on Lots 1 and 2. Riverbank soil in this area is generally armored with fill material containing concrete debris, so soil erodibility will be limited (Figures 1-8a-c).

1.3.2.4 Downstream Reach

The Downstream Reach is located at the northwest end of the Arkema Project Area. The sediment thickness is estimated to be approximately 20 to 30 ft in the nearshore area, thinning to 10 to 20 ft near the navigation channel, but no sediment boreholes have been advanced to bedrock in this area (Figure 1-6). No manufacturing operations have been located on the uplands adjacent to the Downstream Reach throughout the history of the site.

The Downstream Reach has been more directly impacted by COCs from outfall discharges (e.g., DDT, dioxins/furans, PCBs). Bayer Outfall WR-6 is located within the Arkema Project Area just upstream of RM 6.9. Two City outfalls, Outfall 22B and 22C, and Doane Creek, located immediately downstream of the Arkema Project Area, may have also contaminated sediments in the Downstream Reach. The contaminants from these discharges could be transported upstream to the Arkema Project Area by tidal fluctuations during low river stages and sediment deposition, which has at times routed the outfall discharge channel in an upstream direction. Bayer groundwater plumes discharge chemicals (e.g., DDT, dioxins/furans, 2,4-D) from multiple hydrostratigraphic zones to Willamette River sediment in the Downstream Reach. Sediment COC concentration data (particularly subsurface data) are limited in this reach, so the distribution of potential COCs from upstream and downstream sources is not well defined in this area.

The fill along riverbank in this reach consists primarily of dredge material placed on Lots 1 and 2. The riverbank soils may contain asbestos from rebuilding chlorate cells on Lots 1 and 2. Riverbank soil in this area is not armored and could be erodible.

1.4 WORK PLAN ORGANIZATION

The remainder of this work plan is organized as follows:

- Section 2: Review of Existing Data—Presents an Arkema Project Area remedial investigation data summary, surface and subsurface sediment data, riverbank soil data, existing design support information, hydrodynamic conditions, current habitat

conditions, and a data gap analysis. This information provides the background and context for the proposed additional studies described herein.

- Section 3: Investigation Elements and Rationale—Describes the elements and rationale for investigating sediment chemistry, analyzing riverbank soil, assessing groundwater discharge and COC flux, conducting hydrodynamic evaluations, and collecting additional design support data.
- Section 4: Field Methodology—Briefly presents the methodology for investigating sediment chemistry, analyzing riverbank soil, collecting additional design support data, conducting hydrodynamic evaluations, and assessing groundwater discharge and sediment porewater.
- Section 5: Project Team and Responsibilities—Identifies the personnel that will execute the work under this work plan.
- Section 6: Schedule—Provides proposed schedule for executing the work under this work plan and reporting the results.
- Section 7: References—Presents the references cited in the document.
- Appendix A: Field Sampling Plan (FSP)—Provides the field methods and standard operating procedures (SOPs) for executing the work under this work plan.
- Appendix B: Quality Assurance Project Plan (QAPP)—Presents the analytical methodology for this work plan. The QAPP follows the methodology and protocols presented in the EPA-approved QAPPs for the Arkema EE/CA investigation (Integral 2009a) and the Portland Harbor remedial investigation (Integral and Windward 2004; Integral 2004b).
- Appendix C: Site-Specific Health and Safety Plan—Presents the site-specific health and safety plan designed to protect workers executing the work under this work plan.
- Appendix D: Emergency Response Plan—Presents emergency response and notification procedures for the field program.
- Appendix E: Figures from Previous Reports—Presents selected figures from previous reports.
- Appendix F: Geotechnical Data from the Arkema Project Area—Presents geotechnical data collected in the Arkema Project Area.
- Appendix G: PTW Threshold for HxCDF—Presents an assessment of the potential risk from the furan congener HxCDF.

2 REVIEW OF EXISTING DATA

The following sections present a review of existing data.

2.1 BACKGROUND

A review of the historical data for the Arkema Project Area is presented in Section 2. The majority of the data were collected between 1997 and 2007 during the Portland Harbor remedial investigation. These data were used to prepare the Portland Harbor RI/FS (USEPA 2016a,b). The RI/FS data set includes subsurface sediment samples from 77 locations within the Arkema Project Area (including the 2009 EE/CA data).

Additional surface and subsurface sediment sampling was performed between March and September 2018 in accordance with a work plan for a PDI prepared for the EPA by the Portland Harbor Pre-remedial Design Group (Pre-RD Group; Geosyntec 2017). The sampling plan included stratified random sampling throughout the PHSS, and additional targeted sampling to assess temporal changes at selected locations that had been previously sampled during the Portland Harbor RI/FS. The PDI data set was intended to support remedial design at individual SMAs and to provide a current and synoptic baseline for long-term monitoring following remedial actions. The PDI data set includes samples from 43 locations within the Arkema Project Area.

The identity of the focused COCs and the COC RALs were established in the ROD based on the RI/FS data. The 2018 PDI data supplement the earlier data sets, and where data are available, more accurately represent current surface sediment conditions.

It should be noted that the positional accuracy and overall usability of the existing data for design are highly variable. Positioning methods typically used in the late 1990s (excluding land survey methods) are not as accurate as methods commonly used today. In addition, some of the historical data have detections limits above RAL and/or PTW thresholds. These latter data were collected before RAL and PTW thresholds were developed for the Portland Harbor site, convey little or no information about conditions at the sample locations, and therefore will be excluded from consideration of PTW or RALs for remedial design (Figure 1-8a).

Riverbank soil in the Arkema Project Area has been identified as a potential source of COCs through erosion to the Willamette River (Integral and Arcadis 2011). Riverbank soil refers to the area and related sampling between +3.26 ft NAVD 88; -2 ft Columbia River Datum [CRD]) and the top of bank at approximately +32 ft NAVD 88. The riverbank along some portions of the Arkema Project Area is characterized by steep slopes that are covered with large pieces of rubble (industrial debris), including concrete and asphalt.

Several investigations of the riverbank soil in the Arkema Project Area were conducted between 1998 and 2007. These investigations focused on select COCs, and data were compiled as part of an ecological risk assessment in 2008 (Integral 2009b). Data were divided into upland and riverbank areas based on the location of the top of bank. The scope of these investigations is presented below:

- In November 1998, beach sediment samples were collected from exposed river sediments at six stations (RB-1 through RB-6[2]) during a relatively low river stage. Surface samples were collected from 0 to 0.33 ft. Sediment cores were collected using a titanium drive corer. The maximum penetration depth was less than 1.1 ft, except at Station RB-6, where penetration reached 1.9 ft (Exponent 1999). Samples were analyzed for semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), pesticides, total organic carbon, and grain size.
- In August 2000, surface (0 to 0.5 ft) soil samples were collected from six riverbank sampling locations (RB-7 through RB-12) (ERM 2005). Samples were collected from three paired locations, with one sample location near the top of the slope and the second downslope from the first sample location. Samples were analyzed for organochlorine pesticides, SVOCs, and selected metals (cadmium, chromium, lead, and zinc).
- In March 2007, surface (0 to 6 in.) soil samples were collected from 13 riverbank stations (RBC-1 through RBC-13) along the entire property boundary, with the exception of the area between Docks 1 and 2, which had been adequately sampled during previous sampling events. The stations were located near the top of the bank, as well as between the top of bank and mean high water (approximately 12 ft NAVD 88). A single composite sample combining five discrete samples was collected from each station. In addition, five deeper (18 to 24 in.) soil samples were collected from select riverbank stations to characterize the shallow subsurface. Samples were analyzed for organochlorine pesticides, SVOCs, PCBs, dioxins/furans, total petroleum hydrocarbons diesel range, total petroleum hydrocarbons gasoline range, VOCs (analysis conducted only on two samples that demonstrated the possible presence of volatile organics by photoionization detector field screening), and selected metals (arsenic, cadmium, chromium, lead, and zinc).

In this work plan, consistent with EPA's feasibility study (USEPA 2016b), surface sediment samples are defined as samples collected between 0 and 1 ft (0 and 30 cm) bml, and subsurface sediment samples are defined as sediment samples collected at depths greater than 1 ft bml.

[2] Note that RB-2 and RB-6 are included in the Portland Harbor feasibility study database.

2.2 USE OF RALS AND PTW FOR SCREENING AND REMEDIAL DECISION-MAKING

For the purposes of data review in Section 2.3 and later sections of the work plan, chemical concentrations of focused COCs are presented in text and figures relative to their respective RAL and PTW concentrations (from ROD Table 17, associated errata, and ESD). The focused COCs are PCBs, total PAHs, DDx, and three dioxin/furan congeners—2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD), 1,2,3,7,8-pentachlorodibenzo-*p*-dioxin (PeCDD), and 2,3,4,7,8-pentachlorodibenzofuran (PeCDF). In addition to the focused COCs, the ROD defined two additional contaminants with PTW threshold values, but not RAL values. The two additional contaminants are dioxin/furan congeners—2,3,7,8-tetrachlorodibenzofuran (TCDF) and 1,2,3,4,6,7,8-hexachlorodibenzofuran (HxCDF). According to the EPA feasibility study, the five dioxin/furan congeners contribute greater than 85 percent of the estimated cancer risk and non-cancer hazard associated with fish consumption site wide. In the Arkema Project Area, most of that risk was associated with PeCDF (62%) and TCDF (21%), with about 8% of the risk from HxCDF.

Sample locations within the Arkema Project Area that have one or more sediment samples that exceed PTW thresholds are shown in Figure 1-3b. For 7 of the 8 focused COCs and additional contaminants, the area of PTW is consistently demonstrated to be between approximately the Salt Dock to just downstream of Outfall 004 with an additional area of PTW near Bayer Outfall WR-6. However, due to conflicting information in the feasibility study, the "additional contaminant" HxCDF expands the PTW area well beyond the PTW boundary based on the other COCs, and included a much larger area between Outfall 004 and RM 6.9 (see yellow squares on Figure 1-3b).

The feasibility study, reports two different risk contributions for HxCDF for the Arkema Project Area. Appendix B of the feasibility study reports that HxCDF contributes about 8% of the dioxin/furan risk in the Arkema Project Area (and presumably less to the total chemical risk in this area). Whereas, Appendix J of the feasibility study reports that essentially 100% of the total chemical risk is from HxCDF at RM 7W. The Appendix B calculations were found to be better aligned with the findings of the distribution and toxicity of HxCDF and the results of the BHHRA, and are the appropriate basis for defining areas containing PTW.

Further analysis shows that HxCDF is highly correlated with 2,3,4,7,8-PeCDF and TCDF congeners. Thus, targeting the locations at RM 7W exceeding the PTW sediment concentration for PeCDF (the highest contributor to PCDD/F risk in this river mile), which is also significantly correlated with elevated concentrations of TCDF (the next highest contributor to PCDD/F risk) and with HxCDF (Figure 1 of Appendix G), would capture all PCDD/F PTW within the Arkema Project Area. Equally as important, not specifically targeting HxCDF outside of the PeCDF PTW footprint, will have no impact on Arkema Project Area PTW identification as it relates to EPA's risk management framework (Appendix G). For this

reason, the area of PTW defined by the focused COCs and additional contaminant TCDF will be used to appropriately define sediment management options in accordance with the ROD decision tree.

2.3 SURFACE SEDIMENT AND RIVERBANK SOIL

Riverbank soil may be eroded and deposited as surface sediment within the Arkema Project Area, and the remedial design will address contamination in both riverbank soil and sediment. Because of this linkage, surface sediment and riverbank soil are summarized together in this section. A summary of surface sediment and riverbank soil data is provided below, broken out by COC.

2.3.1 DDx

Figure 2-1a presents DDx concentrations in surface sediment and soil in the Arkema Project Area. The highest DDx concentrations in surface sediment, exceeding the PTW threshold (97,050 μg/kg), are located between Docks 1 and 2 and immediately upstream of Dock 1. Concentrations that exceed the RAL (160 μg/kg) are found from the Salt Dock downstream throughout the Arkema Project Area, with concentrations decreasing downstream with distance below Outfall 004. The DDx concentrations in surface sediments upstream of the Salt Dock are generally low (below the RAL).

Riverbank soil in the area of Dock 2 (samples RB-9 and RB-10) have elevated concentrations of DDx, with most samples exceeding the PTW threshold. This area is adjacent to the area of highest DDx in surface sediment. Other bank soil samples exceed the RAL between the Salt Dock and Lot 2 (Figure 1-4).

2.3.2 2,3,4,7,8-PeCDF

Figure 2-1b presents the PeCDF concentrations in surface sediment in the Arkema Project Area collected during the RI/FS and PDI investigations. The highest concentration of PeCDF in surface sediment is between Docks 1 and 2. There are several exceedances of the PTW threshold (0.2 μg/kg) in this area. There is also an exceedance of the PTW threshold at Outfall 004 and in one sample immediately downstream of Outfall 004. Surface sediment concentrations of PeCDF are low (<0.01 μg/kg) within the Arkema Project Area downstream of Outfall 004, but increase further downstream at the location of the current and historical Bayer outfalls and the City of Portland Outfall 22B (0.02 to 1 μg/kg).

The concentrations of PeCDF in riverbank soil are highest in the area of Dock 2 (samples RB-9) and RB-10), which is adjacent to the area of elevated PeCDF in the sediment at Dock 2.

The concentrations of PeCDF in riverbank surface soil are all below the RAL. Riverbank surface soil do not appear to be a potential source of PeCDF to sediment in the Arkema Project Area.

2.3.3 1,2,3,7,8-PeCDD

Figure 2-1c presents the PeCDD concentrations in surface sediment within and adjacent to the Arkema Project Area. Most of the surface sediment samples have concentrations below the RAL, but several locations with concentrations above the RAL in surface sediment are in the area of Docks 1 and 2, and between Dock 1 and the Salt Dock. Concentrations decrease with distance downstream, but include several exceedances of the RAL. Concentrations increase again just upstream of the railroad bridge in the area of Bayer outfall WR-6; the only exceedance of the PTW threshold is in this area. The concentration at Outfall 004 is below the RAL threshold.

Of 11 riverbank surface soil samples, two have detected concentrations above the RAL, two have detected concentrations below the RAL, and seven are nondetect with detection limits above the RAL. Riverbank surface soil is a potential source of PeCDD to sediment in the Arkema Project Area, particularly in areas close to Outfall 004.

2.3.4 2,3,7,8-TCDD

Figure 2-1d presents the concentrations of TCDD in surface sediment in and adjacent to the Arkema Project Area. Two samples between Docks 1 and 2 have concentrations above the RAL. Exceedances of the RAL and of the PTW threshold are also found downstream at the location of the current and historical Bayer outfalls (located near the railroad bridge) and the City of Portland Outfall 22B. No exceedances of the RAL are found in the vicinity of Outfall 004.

Of 11 riverbank surface soil samples, two have detected concentrations above the RAL, six have concentrations below the RAL, and three are nondetect with detection limits above the RAL. The two samples with detected concentrations above the RAL are the same as those with PeCDD detected above the RAL.

2.3.5 Total PCBs

Figure 2-1e presents total PCBs concentrations in surface sediment in the Arkema Project Area. Interference from DDx with the PCB Aroclor analysis resulted in elevated detection limits (i.e., >1 mg/kg) for PCBs measurements in the RI/FS data set. A subset of 2009 archived surface sediment samples collected from 0 to 2 ft bml were, therefore, analyzed in 2014 for PCB congeners to eliminate analytical interference issues and attain lower detection limits. In general, the PCBs in the archived sediment samples were detected at low concentrations

(generally <0.2 mg/kg) in surface and shallow subsurface sediment adjacent to the Arkema site. Elevated measurements of PCBs, exceeding the RAL with some exceedances of the PTW threshold, are found in areas near and downstream of the Salt Dock. These elevated measurements are commingled with concentrations below the RAL. Total PCBs measurements have higher variability over short spatial scales than any other focused COC. Only two samples between Docks 1 and 2, and two samples at the downstream end of the Project Area near the Bayer outfall, have detected concentrations above PTW. The PCB concentration data and spatial distribution show that PCB detections in sediment within the Arkema Project Area are sporadic, generally consistent with historical urban and industrial use of the river, and unlikely related to any use of PCBs at the Arkema site.

Total PCBs in riverbank surface soil are mostly below the RAL. One exceedance of the RAL occurs on the riverbank of Willbridge Cove, and exceedances are found in the two samples that are furthest north along the riverbank in Lot 1. There is no clear relationship between RAL exceedance in riverbank surface soil and surface sediment, which is consistent with the absence of known upland PCB sources from Arkema operations.

2.3.6 Total PAHs

Figure 2-1f presents concentrations of total PAHs in surface sediment within and adjacent to the Arkema Project Area. Concentrations are below the RAL throughout the Arkema Project Area except for two exceedances of the RAL between Docks 1 and 2 (in the same location as the highest concentrations of DDx).

Total PAHs are below the RAL in all riverbank surface soil, consistent with the absence of known sources of elevated PAHs in the upland area.

2.3.7 Chlorobenzene

Figure 2-1g presents chlorobenzene concentrations in surface sediment in the Arkema Project Area. Of the 49 surface sediment samples, three samples exceed the chlorobenzene PTW threshold of 320 μg/kg. Chlorobenzene PTW was identified in front of Dock 2 at AP02DPG and OS003, and in front of Dock 1 at AP04D. All three of these samples were collected between 1999 and 2005, prior to implementation of the groundwater SCMs. Chlorobenzene PTW is in a subarea of DDx PTW in surface and/or subsurface sediment.

Chlorobenzene has not been measured in riverbank surface soil within the Arkema Project Area; however, no chlorobenzene is anticipated in surface or near-surface riverbank soil because the potential pathway for chlorobenzene transport is from upland source areas (e.g., the former MPR pond and trench) to sediment via groundwater in accordance with the CSM discussed in Section 1.3.

2.4 SUBSURFACE SEDIMENT

The following sections discuss the distributions of COCs in subsurface sediment. DDx exceeds the RAL in subsurface sediments throughout a larger portion of the Arkema Project Area than any other COC, with the highest concentrations, exceeding the PTW threshold, ranging from the Salt Dock to just downstream of Outfall 004. Elevated concentrations of other COCs are generally also found in the area of the docks but not clearly associated with Outfall 004.

2.4.1 DDx

The highest levels of DDx (>100 mg/kg) in subsurface sediment are in the area between Docks 1 and 2 at a depth of approximately 10–15 ft bml (Figure 2-2a). There are two locations with DDx concentrations above the PTW threshold between Dock 1 and the Salt Dock. The area downstream of Dock 2 to just downstream of Outfall 004 also has DDx concentrations (generally 1 to 100 mg/kg) above PTW levels in subsurface sediment to depths of 10–12 ft bml. DDx concentrations are generally lower and below the PTW threshold (most samples <0.3 mg/kg) in subsurface sediments downstream of the immediate Outfall 004 area. However, some elevated DDx concentrations (1 to 5 mg/kg) are present in subsurface sediments at the location of the current and historical Bayer outfalls and the City of Portland Outfall 22B.

DDx exceeds the RAL in subsurface riverbank soil between the Salt Dock and Dock 2. Concentrations below the RAL are found upstream of the Salt Dock and downstream of Outfall 004.

2.4.2 2,3,4,7,8-PeCDF

Subsurface concentrations of PeCDF are highest (above the PTW threshold) between Docks 1 and 2 (Figure 2-2b). In contrast to DDx, the concentrations in this area are generally slightly higher in the shallower sediment than the deeper sediment. There are also some exceedances of the PTW threshold downstream of Outfall 004; concentrations below the PTW threshold are found in the same area.

Subsurface riverbank soil has PeCDF concentrations below the RAL, consistent with surface soil samples.

2.4.3 1,2,3,7,8-PeCDD

Subsurface concentrations of PeCDD are elevated above the RAL in the area of Docks 1 and 2, and in samples downstream of Outfall 004 (Figure 2-2c). Subsurface concentrations exceed the PTW threshold only at the very downstream end of the Arkema Project Area, at the location of the current and historical Bayer outfalls and the City of Portland Outfall 22B. Concentrations of PeCDD in subsurface riverbank soil were all undetected. Four of the five riverbank soil

samples had detection limits above the RAL, and the fifth soil sample had a detection limit below the RAL.

2.4.4 2,3,7,8-TCDD

Subsurface concentrations of TCDD in subsurface sediment exceed the RAL at locations between Docks 1 and 2, and at several locations downstream of Outfall 004 (Figure 2-2d). The PTW threshold is exceeded at the downstream end of the Arkema Project Area, at the location of the current and historical Bayer outfalls and the City of Portland Outfall 22B. The distributions of elevated concentrations of PeCDD and TCDD in subsurface sediment are similar.

In subsurface riverbank soil, no samples exceeded the RAL. Two nondetect samples between the Salt Dock and Dock 1 had detection limits above the RAL. All three samples downstream of Dock 2 had concentrations below the RAL.

2.4.5 Total PCBs

Subsurface concentrations of total PCBs exceed the PTW threshold in one location between Docks 1 and 2 and one location between the Salt Dock and Dock 1 (Figure 2-2e). The remaining PTW and RAL exceedances are immediately upgradient and downgradient of the Arkema Project Area and along the margins of the harbor, outside of the dock line.

Concentrations of total PCBs in subsurface riverbank soil were all below the RAL, consistent with the absence of known sources of PCBs in the upland area resulting from Arkema operations.

2.4.6 Total PAHs

Subsurface concentrations of total PAHs exceed the RAL at three locations near Docks 1 and 2, at or outside of the dock line, and at one location further downstream in the Arkema Project Area (Figure 2-2f). There are no total PAHs exceedances of the PTW threshold.

Concentrations of total PAHs in subsurface riverbank soil were all below the RAL, consistent with the absence of known sources of elevated PAHs in the upland area resulting from Arkema operations.

2.4.7 Chlorobenzene

Subsurface chlorobenzene concentrations exceed the PTW threshold between and around the face of Docks 1 and 2 (Figure 2-2g). Between the docks, the highest chlorobenzene sediment concentrations are generally found at depths between 6 and 20 ft bml, with lower

concentrations both above and below these intervals. In front of the docks, the highest chlorobenzene concentrations are generally between 0 and 6 ft bml.

2.4.8 Maximum Depth of RAL Exceedances

The maximum depth of RAL and PTW threshold exceedances are important for assessing potential remedial design options. Figures 2-3a-d show the maximum depth of RAL and PTW thresholds exceedances for the Arkema Project Area, riverbank area, and navigation channel up to the centerline.

2.5 NAPL

Since 2002, nonaqueous-phase liquid (NAPL) has been assessed in more than 60 sediment boreholes that were advanced and continuously sampled from the mudline surface to bedrock or gravel refusal in sediment within the Arkema Project Area. These investigations consisted of the following:

- 25 boreholes advanced as part of the 2002-2003 Phase II Stage 1 and 2 investigations between or immediately adjacent to Docks 1 and 2, an area that is adjacent to the portion of the Arkema site where historical DDT manufacturing occurred.
- 36 boreholes advanced to bedrock as part of 2009 sediment EE/CA studies with EPA field oversight inspecting for evidence of NAPL. Sheens, blebs, and globules were observed only at selected locations in the Arkema Project Area, consistent with the earlier investigations and typical of a navigable river area that has been industrialized for more than 100 years.

EPA's contractor, CDM Smith, prepared a technical memorandum titled *Arkema Offshore NAPL Evaluation* (CDM Smith 2013). This memorandum concluded that NAPL appears to be present in the in-water sediment adjacent to the Arkema site. The primary line of evidence for the presence of NAPL that CDM Smith considered was visual observations of blebs, globules, dark brown oily material, or other similar terms as documented on existing sediment core logs. CDM Smith also based its finding of NAPL presence on a 1 percent solubility rule of thumb. The 1 percent solubility rule of thumb is not a definitive finding of NAPL; it is more typically used to screen initial sample data to determine if NAPL investigation may be warranted. The locations of the boreholes with potential NAPL based on CDM Smith's evaluation are presented on Figure 1-3b.

Recent quarterly groundwater monitoring (4th quarter 2019 and 1st quarter 2020) shows elevated levels of chlorobenzene in monitoring wells located on the river side of the groundwater barrier wall between Docks 1 and 2, particularly in the intermediate and deep

groundwater zones. These recent data are presented in the following section and considered in the assessment of data gaps related to NAPL below in Section 2.10.2.7.

2.6 GROUNDWATER

The following sections present a summary of the chlorobenzene distribution in groundwater on the river side of the barrier wall and the groundwater flux to the river in the vicinity of the Arkema docks.

2.6.1 Groundwater between Acid Plant Area and Top of Bank

Quarterly groundwater monitoring was recently conducted to evaluate changes in groundwater COC concentrations in the vicinity of the groundwater SCMs. Two monitoring events were conducted, 4th quarter 2019 (ERM 2019) and 1st quarter 2020 (ERM 2020). The following sections present the analytical results for chlorobenzene in monitoring wells located on the river side of the groundwater barrier wall near the docks. Chlorobenzene concentration maps from the quarterly monitoring events are presented in Appendix E.

2.6.1.1 Shallow Zone Groundwater

Chlorobenzene concentrations in shallow zone groundwater on the river side of the barrier wall were relatively low during both quarterly monitoring events. The highest concentrations were detected between Docks 1 and 2 at wells MWA-2 (1.9*J* to 360 µg/L), MWA-61 (140 to 200 µg/L), and MWA-69 (120 to 1,900 µg/L). The chlorobenzene concentrations were within the range of historical concentrations detected in these wells. Chlorobenzene is generally not detected in groundwater downgradient of the barrier wall northwest of Dock 2 and southeast of Dock 1.

2.6.1.2 Intermediate Zone Groundwater

The highest chlorobenzene concentrations on the river side of the barrier wall were in the intermediate zone during both recent quarterly monitoring events. Similar to the wells screened in the shallow zone, the highest concentrations were observed in wells located between Docks 1 and 2. The chlorobenzene concentrations were as follows: MWA-8i (1,400 µg/L during both events), MWA-64i (2,300 to 13,000 µg/L), and MWA-66i (38,000 *J+* to 52,000 µg/L). The highest concentration of chlorobenzene detected in the intermediate zone wells (52,000 µg/L) is approximately 10% of the solubility of chlorobenzene. This is the area near the former MPR pond and trench where the highest concentrations are expected. Although the chlorobenzene concentrations have fluctuated, they are within the range of historical concentrations detected in these wells. Chlorobenzene concentrations are much lower immediately northwest of Dock 1 and southeast of Dock 2. Chlorobenzene is generally

less than 1 µg/L or not detected in groundwater downgradient of the barrier wall south of the Salt Dock.

2.6.1.3 Deep Zone Groundwater

Chlorobenzene concentrations in deep zone groundwater on the river side of the barrier wall during the recent quarterly monitoring events, are lower than chlorobenzene detected in the intermediate zone. Similar to the wells screened in the intermediate and shallow zones, the highest chlorobenzene concentrations were observed in wells located between Docks 1 and 2. The concentrations in wells between Docks 1 and 2 ranged from 9,300*J*- to 8,300 µg/L in well PA-19d and 27,000 to 38,000 µg/L in well PA-21d. The highest concentration of chlorobenzene detected in the deep zone wells (38,000 µg/L) is approximately 8% of the solubility of chlorobenzene. This is the area near the former MPR pond and trench where the highest concentrations are expected. Chlorobenzene is generally not detected in groundwater downgradient of the barrier wall outside of the Dock 1 and 2 area.

2.6.2 Groundwater Flux to River

Groundwater discharge was evaluated in the Arkema Project Area by the LWG during a pilot study in 2004 and the Round 2 groundwater pathway assessment in 2005 (Integral 2006). The following sections present the results of the direct measurement of groundwater flux using the UltraSeep system during these two studies. The UltraSeep system employs an automated seepage meter that uses an ultrasonic flow meter to measure groundwater flux over the period of deployment. It produces direct quantitative measurements, even at very low seepage rates (Integral 2006). The unit rests on the sediment surface, requiring diver deployment and retrieval.

2.6.2.1 Groundwater Pilot Study (2004)

The UltraSeep system was deployed at three locations in the Arkema Project Area in November 2004, two in the area downgradient of the former Acid Plant area and one in the area downgradient of the former Chlorate Plant area to measure groundwater flux (Integral 2005). Note this was prior to the installation of the groundwater SCM barrier wall and GWET system. At all three UltraSeep locations, both positive and negative seepage rates were observed over the 24-hour (minimum) period that seepage was measured. The magnitude of specific discharge,[3] as measured in all three deployments, indicates low seepage rates, on the order of a few centimeters per day. The magnitude of both the peak positive and negative seepage rates can be related to sediment texture at each deployment location, with coarse-grained sediment tending to have higher seepage rates than finer-grained sediment. The

[3] Specific discharge is defined as the groundwater flow rate per cross-sectional area. The specific discharge units are often expressed in cm/day ([length^3/time)/(length^2] = length/time).

location with the highest discharge (maximum reading 6.11 cm/day) was Station CP07B, a sandy area. Station AP04B, a sandy silt area, exhibited the second highest specific discharge (maximum reading 1.97 cm/day). Finally, the lowest discharge (maximum reading 0.47 cm/day, an overall negative value indicating water flowing into the sediment, though many of the measurements were near the limits of detection for the meter) was observed at Station AP04D, a location with silty sediment.

2.6.2.2 Round 2 Groundwater Pathway Assessment (2005)

In August 2005, UltraSeep system meters were installed at four sites within the Arkema Project Area to assess seepage rates. Note this study was also prior to the installation of the groundwater SCM barrier wall and GWET system. The UltraSeep system was deployed for approximately 24 hours at 11 locations in the Arkema Project Area. Near the shoreline, sandy and silty-sand locations displayed higher discharge rates relative to other locations, with average specific discharge rates of 4.0, 3.1, 7.0, and 2.1 cm/day (Integral 2006). The maximum specific discharge rates recorded at these locations were 16.0, 17.4, 31.5, and 3.1 cm/day. The average specific discharge rate at the remaining locations away from the shoreline in silts and silty sands was low (<0.5 cm/day). In general, the nearshore sand and silty-sand sediment was found to have higher relative discharge rates, consistent with site stratigraphy and the conceptual model of shallow groundwater flow (Integral 2006). The seepage meters farthest offshore, located slightly offshore of the dock structures, showed near-zero average discharge rates (from 0.5 to −1.2 cm/day).

Reported COCs detected in transition-zone water (TZW) in the Arkema Project Area included chlorobenzene, DDx, and perchlorate (Integral 2006, Appendix C2).

The results of the UltraSeep survey indicated that, although the specific discharge rates at individual stations fluctuate between positive and negative values (i.e., groundwater discharge and recharge, respectively), a net positive discharge was recorded at most stations within the Arkema Project Area over the period of monitoring, but the magnitude of the average specific discharge was generally small (Integral 2006).

It is anticipated that the installation of the groundwater SCM barrier wall and GWET system has decreased these flow rates.

2.7 EXISTING DESIGN SUPPORT INFORMATION

This section summarizes existing data related to the engineering design of a sediment and riverbank remedy for the Arkema Project Area.

The three existing docks (the Salt Dock, Dock 1, and Dock 2) are no longer in use and will be removed as part of the remediation work.

These data will need to be evaluated to determine suitability for use in design and include:

- Land surveys (bathymetric and topographic)
- Geology and geomorphology
- Geotechnical
- Characterization for hazardous materials and waste disposition purposes
- Structural condition, integrity and usability
- Surface and subsurface debris
- Property use and constraints
- Existing and former outfalls and other utilities
- Existing slurry wall along portion of riverbank at the site.

2.7.1 Bathymetric and Topographic Survey

Several bathymetric surveys were conducted previously and are potentially useful in evaluating deposition or erosion rates that may be anticipated at the Arkema Project Area over time. Data to date have generally shown the Arkema Project Area to be depositional.

2.7.1.1 Early Studies (1999–2009)

Five bathymetric surveys were conducted in the Willamette River adjacent to the Arkema Project Area between 1999 and 2004 (Exponent 1999; Anchor 2003; SEA and DEA 2003; LWG 2004). The surveys were conducted in February 1999, January 2002, September 2002, May 2003, February through March 2004, and January 2009. Three bathymetric survey difference maps were generated for the data; the one covering the longest time interval between surveys covers 26 months (January 2002 through March 2004; LWG 2004).

2.7.1.2 Recent and Ongoing Studies (2018–2019)

The Pre-RD Group conducted a bathymetric survey of Portland Harbor in 2018 (Figure 2-4a) and used the 2004 bathymetric survey for comparison (Figure 2-4b). Legacy Site Services LLC (LSS), agent for Arkema Inc. also conducted a separate focused survey at the Arkema site in 2018-2019 (Figure 2-4a). The Arkema survey has two components, a LIDAR survey during low river levels in October 2018 and a bathymetric survey during higher river levels in 2019. One of the points of focus for the Arkema survey was the area downstream of Dock 2 and upstream of the railroad bridge. This latter area is of particular interest because past surveys have not provided adequate bathymetric coverage in this entire area due to the presence of pilings and shallow water that historically limited the extent of the multibeam equipment. The 2018 Arkema LIDAR survey was designed to include overlap between a low river stage land-based

survey and a high river stage bathymetric survey in this area to provide complete coverage. Analysis of these newer bathymetric survey results has not been completed, but the data will be utilized in the assessment of sediment stability and natural recovery during pre-remedial design.

2.7.1.3 Topographic Survey

The most recent topographic survey of the uplands area (excluding the shoreline area covered by the 2018 LIDAR survey) is a LIDAR survey that was conducted by Metro in 2014 after completion of several upland property modifications, including construction of the subsurface slurry wall groundwater remedial measure and the stormwater passive treatment and control system.

2.7.2 Geology

The remedial investigation for the Arkema site summarized geology as follows (ERM 2005; Integral 2004a):

- Surficial geology is characterized by fill and alluvial deposits of the Willamette River.
- The eastern portion of the upland site, generally between Docks 1 and 2, has been filled with debris consisting of asphalt, concrete, pipe, soil, and fill from other sources (e.g., City of Portland). These materials occur from the surface to depths of approximately 25 ft bgs. The area from Dock 1 to the upstream end of the property was filled primarily with materials dredged to accommodate the Salt Dock. Figure 1-4 shows the approximate extent of fill in the Arkema Project Area.
- The native soil profile is generally characterized by laterally discontinuous, alternating layers of dark gray-brown sand, with various amounts of silt and thinner silt layers containing various amounts of fine sand. The layers vary from massive to finely laminated.
- Underlying the deepest silt layer, at a depth of approximately 35 ft bgs, is a sand layer with black sands adjacent to the river in the Acid Plant area, and dark gray-brown sands toward the southern end of the plant.
- Columbia River basalt is present below the fill and alluvium at the upland portion of the site at depths of up to approximately 90 ft bgs and is shallower near the river edge.

Multiple geologic units were identified in the subaqueous explorations and chemistry boreholes. Two predominant units are described in sediments in the Arkema Project Area:

- **River Sediment**
  - Generally consisting of two sediment types: very soft to soft organic silt and silt, and very loose to loose sand with various amounts of silt.

  - Gravel layers, containing various amounts of sand and silt, encountered in a few of the boreholes (typically directly overlying the basalt bedrock). These gravel layers were predominantly less than 3 ft thick; exceptions are discussed in the final removal action characterization (RAAC) report (Integral and ARCADIS 2011).
  - Stratigraphy varies significantly across the Arkema Project Area in terms of the layering of the sand and silt units. Generally, the following typical sediment profiles were encountered: predominantly sand, predominantly silt, significant sand layer over silt deposit, and significant silt layer over sand deposit.

- **Columbia River Basalt Group Bedrock**
  - Basalt bedrock at depths ranging from approximately 4 to 49 ft bml. A basalt elevation map and sediment thickness map are provided in Figures 2-5 and 2-6, respectively.
  - Fracturing and weathering generally decreased with depth.

2.7.3 Geotechnical Investigations

Previous studies have included geotechnical evaluations of sediment in the Arkema Project Area; however, the scope and complexity of these analyses varied. Informative data were gathered as a result of studies in the late 1990s and early 2000s; however, more detailed sampling and analysis were prescribed under the EE/CA work plan (Parametrix 2007) and collected during the EE/CA investigation in 2009. These latter data are described in detail in the final RAAC report (Integral and ARCADIS 2011).

In general, the data collected during the 2009 geotechnical investigation are divided into the following categories:

- *In situ* test data consisting of cone penetration test and standard penetration test (SPT) data—these data are included for reference during design in Appendix F.
- Laboratory test results—Kleinfelder performed geotechnical laboratory testing as part of the RAAC report (Integral and ARCADIS 2011). Test reports are provided in Appendix F.

A summary of the existing index property data for sediment includes:

- The fine grain sediment that was encountered in the geotechnical boreholes was predominantly classified as organic silt of high plasticity.
- Moisture contents of up to 203 percent were recorded, consistent with the presence of organic material in the samples. Organic contents ranged from 4.6 to 9.2 percent.

Consolidation and hydraulic conductivity testing were performed on relatively undisturbed sediment samples. Results showed:

- A recompression index of 0.150, a compression index of 0.03, and an estimated pre-consolidation pressure of 3,900 pcf for SPT-2 at a depth of 22.5 ft.
- Hydraulic conductivity values ranged from 4.5×10^{-9} to 8.5×10^{-7} cm/sec (at 20°C) for SPT-1 (sample depth 13–15 ft) and SPT-2 (sample depth 20.5–22.5 ft), respectively.

Point load tests and unconfined compressive strength tests were performed on core SPT-1. Summary results of these tests include:

- $I_{s(50)}$ [corrected point load strength index] values ranged from 229.21 to 853.61 psi at depths of 30 to 31.5 ft and 37 to 39 ft, respectively.
- σ_{uc} [uniaxial compressive strength] values ranged from 5,616 to 20,913 psi at depths of 30 to 31.5 ft and 37 to 39 ft, respectively.
- Compressive stress values ranged from 3,500 psi (with axial strain of ~0.004 inch/inch) up to 22,000 psi (with axial strain of ~0.012 inch/inch) at depths of 30 to 31.5 ft and 37 to 39 ft, respectively.
- Blow count information to assess dredgability of the various sediments is very limited in the work performed to date.

2.7.4 Characterization for Hazardous Materials and Waste Disposition

The following sections provide toxicity characteristic leaching procedure (TCLP) and asbestos testing results that may have implications for waste disposal handling and costs for worker safety in handling of asbestos-containing materials.

2.7.4.1 Toxicity Characteristic Leaching Procedure Testing

To properly manage the contaminants present and identified via sediment and bank sampling in the Arkema Project Area, federal regulations (40 CFR §261.24) require an understanding of the potential for contaminant mobility in landfill conditions, as part of waste designation. The TCLP procedure is one method for simulating leaching potential. A total of 14 composite sediment samples were analyzed by TCLP as part of the 2009 EE/CA investigation (Integral and ARCADIS 2011). The following is a summary of those TCLP results:

- Herbicides were not detected.
- Multiple metals were detected.

  - The federal TCLP regulatory limit was exceeded only for lead in a single sample, ARK-WB-39 from 0 to 8 ft bml, at a concentration of 11 mg/L (lead TCLP regulatory limit is 5 mg/L).
- gamma-Hexachlorocyclohexane was the only pesticide detected.
  - No samples exceeded the corresponding TCLP regulatory limit.
- Phenols were not detected.
- Hexachlorobutadiene and 1,4-dichlorobenzene were detected.
  - No samples exceeded the corresponding TCLP regulatory limits.
- Several VOCs were detected.
  - Two VOCs were detected above TCLP regulatory limits. Benzene (TCLP limit of 0.5 mg/L) was detected in one sample location, ARK-WB-37 from 0 to 6 ft bml, at a concentration of 0.6 mg/L. Tetrachloroethene (TCLP limit of 0.7 mg/L) was also detected in a single sample location, WB-42 from 6 to 14 ft bml, at a concentration of 0.75 mg/L.

2.7.4.2 Asbestos

Asbestos sampling and analysis was performed on sediment as part of the 2009 EE/CA investigation (Integral and ARCADIS 2011). Asbestos was detected in 8 of the 14 sediment samples in which it was analyzed, at concentrations ranging from 0.1 to 0.4 percent, with a median value of 0.3 percent (Integral and ARCADIS 2011). Chrysotile was detected in all four of the split sediments analyzed by the EPA for asbestos, ranging from a trace to 4.5 percent.

The discrepancy between the LSS analytical results and the EPA split analytical results for asbestos was discussed in correspondence between LSS and EPA. The data quality review of the quantitative analysis for the LSS results verified the accuracy of the point-count quantitation method used in the analysis of the LSS asbestos samples. EPA provided its data quality review for its analyses, which indicated that the asbestos quantitation combined both volumetric and weight quantitation methodologies for different asbestos size fractions. Based on LSS's review of both LSS's and EPA's analytical reports and data, no further asbestos analyses were required at that time, and the LSS asbestos quantitation was deemed sufficient for assessing asbestos concentrations in sediment.

2.7.4.3 X001 State-Designated Waste Pesticide Residue

After notification and discussion with Oregon DEQ, upland soil containing DDx from selected parts of the site has been managed as an Oregon State-designated waste pesticide residue (X001) during transport and disposal in Oregon. Oregon state-only pesticide residues are not a federally regulated hazardous waste. Historically, these wastes, when managed within

Oregon, have been disposed of at a Subtitle C landfill in Arlington, Oregon. More recently, these wastes have been disposed of out-of-state in Washington, where the Oregon X001 designation does not apply, and disposed of at a Subtitle D landfill under applicable federal and state laws and regulations.

Regarding sediments in the Arkema Project Area, EPA's 2017 ROD states the following:

> State-listed hazardous waste has been identified offshore within SDU 7W. Hazardous waste generated during remedial actions may be treated and temporarily stored at transload facilities pending final transport and disposition. A Materials Management Plan will be developed as part of the design addressing how State treatment and storage regulations will be complied with during the construction and operation of the transload facilities. Under the Selected Remedy, it is assumed that 901,000 cy of dredged sediment (excluding sediment dredged from SDU 6W) may be managed as state-listed waste for disposal in a Subtitle D landfill without treatment.

2.7.5 Dock Structures at the Arkema Site

As discussed in Section 1.2.2.2, in-water access to the Arkema site historically was provided from three existing docks—from upstream to downstream—the Salt Dock, Dock 1, and Dock 2 (Figure 1-5). Dock 1 was originally constructed in the 1940s and consists of a pier section that runs perpendicular to the river, and a dock section that runs parallel to the river, both with a timber walkway hung from the bottom of the pier or dock. Dock 2 was originally constructed in the late 1950s and early 1960s and has the same configuration and walkways as Dock 1, with the exception that the adjacent dolphins are timber piles and stairs lead under the dock to a small platform, which provided access to barges at low-river-stage elevations. The Salt Dock was built in the 1960s to support a conveyor belt system used to offload salt products from ships to the salt pads. To date, as-built drawings of the docks and related structures have not been located.

An inspection of the existing docks was performed on March 15, 2011, by an engineer with Parsons Brinckerhoff. The inspection was limited to a detailed visual inspection and sounding of the different components of the structure. Access was possible both by land and boat.

The inspection conclusions stated:

- The docks were in good condition and still had some useful life.
- Some repairs will be needed to replace the damaged elements.
- Drilling through some of the timber piles above and below the water will be needed if the facilities are put into use again.

- Structural assessment will be needed to check the demand versus capacity of the structural elements, should the facilities be put to use again.
- Dredging could be done around the docks, but must not impose any additional loads on the structural components nor damage the structures. No equipment should be supported on or tied to the structures during dredging, pending appropriate evaluations. The dredge depth should be limited, as needed, to avoid causing buckling to the piles. This could be done by calculating the critical buckling length of the piles. Dredging around the piles should also be done in a uniform way to prevent lateral loading on individual piles.
- These docks (the Salt Dock, Dock 1, and Dock 2) are no longer in use and will be removed as part of the remediation work.

2.7.6 Surface Debris in the Arkema Project Area

In October 2009, a visual surface debris survey was conducted to catalog and identify the locations of visible outfalls, pilings, concrete, and other debris within the preliminary remedial action area boundary (Figures 1-10a-c). The visual surface debris survey results are included in Appendix G and detailed in the final RAAC report (Integral and ARCADIS 2011). A brief summary of the surface debris observed on the riverbank and in-water portions of the Arkema Project Area is provided below:

- Downstream of Dock 2—The northern portion of this area includes a piling field from an old dock. Miscellaneous concrete debris, metal debris, and some logs were also observed. In addition, one active outfall and associated Parshall flume (Outfall 004) and an inactive historical outfall were observed (Figure 1-10a).
- Between Dock 1 and Dock 2—Surface debris consists primarily of concrete, historical pilings and dolphins, metal debris, logs, and other miscellaneous debris (Figure 1-10b). Blackberry bushes were particularly thick, which limited the amount of surface debris visible during the survey. Two active outfalls and associated Parshall flumes (Outfalls 002 and 003) were observed.
- Between Dock 1 and Salt Dock—Debris in this area consists primarily of concrete debris, with smaller amounts of scrap metal, logs, pilings, and a few dolphins also observed in this area (Figure 1-10c). One active outfall and associated Parshall flume (Outfall 001) were observed.

2.7.7 Arkema Property Use and Constraints

The Arkema property is currently not an active industrial facility. Several interim remedial measures to address contaminated soil, stormwater, and groundwater have been implemented, including past upland excavation and disposal to remove surface and subsurface soil, and past

vapor extraction and air sparging in the upland portion of the site. More recently stormwater and groundwater SCMs were implemented and have been ongoing since about 2012 (Figure 1-5). More information can be found in the 2012 EE/CA (Integral 2012) and in the stormwater and groundwater SCM reports (Integral 2011, ERM 2011).

2.7.7.1 Stormwater Remediation System

Site stormwater SCMs consist of collecting site stormwater, conveying it to a stormwater detention basin via two rock-lined channels, equalizing the storm volume, providing primary solids removal through sedimentation in the basin, and providing second stage treatment through a sand filtration system. Treated stormwater is then discharged to the river through Outfall 004. Additional SCMs include capping of selected areas of the site and the decommissioning of the remaining stormwater conveyance piping. Figure 1-5 shows the configuration of the stormwater treatment system.

2.7.7.2 Groundwater Remediation System

The groundwater SCMs consist of a groundwater barrier wall—a bentonite slurry wall extending down to the top of basalt bedrock layer—and a GWET system. The slurry wall is located near the top of the bank and aligned approximately from Dock 2 to the southern portion of the Salt Dock (Figure 1-5). The extraction system consists of a series of extraction wells located just upgradient of the groundwater barrier wall.

The Arkema site has direct rail access to BNSF Railway tracks via railway spur lines that enter the site near the Arkema site front gate at NW Front Avenue and NW 61st Avenue. The spur rail has not been used since industrial operations were discontinued at the site in about 2002. The condition of the remaining spur tracks has not been assessed; however, track reinforcement, reconstruction, or replacement are all available options if site rail access is needed.

2.8 HYDRODYNAMIC CONDITIONS

The river within the Arkema Project area reach, and in the rest of the Portland Harbor site, has been modified, redirected, filled, and deepened during the last century, as was required to make it navigable for commercial shipping operations. The riverbank along this reach reflects past nearshore dredging activities and bank stabilization. The hydrodynamics within the Arkema Project Area show a generally depositional environment. Local erosion and depositional patterns in the Arkema Project Area may be influenced by anthropogenic processes, including wave erosion generated by wind and vessel wake. A wave zone was defined for the Portland Harbor site—based on surface sediment elevations (Figure 5.4-1c, Anchor QEA et al. 2012; Appendix E)—showing sediment in the Arkema Project Area's nearshore area could be disturbed by these processes. The grain size pattern of surficial

sediments provides an indication of the river bed's energy regime and stability; low energy depositional environments tend to be dominated by fine-grained sediments such as silts and clays. Surface sediment percent fines distribution is presented in Map 3.1-12 of the final Portland Harbor remedial investigation report (USEPA 2016a). Areas of net sediment deposition typically coincide with areas of finer-grained material in the surface sediments. Available grain size data for the Arkema Project Area's surficial sediments (samples taken from the surface to a depth of up to 1 ft) had an average of 62 percent fines, which indicates the Arkema Project Area is located in a low-energy environment where sediment deposition is favored.

The three existing docks (the Salt Dock, Dock 1, and Dock 2) are no longer in use and will be removed as part of the remediation work. This will eliminate navigation areas associated with the docks within the Arkema Project Area and will change shoreline exposure to waves and currents.

2.8.1 Pre-Existing Hydrodynamic Data Summary

The PHSS draft feasibility study report Appendix Hc, "Capping Effectiveness and Stability Modeling," provides some hydrodynamic data and information for the Arkema Project Area (Anchor QEA et al. 2012).

2.8.2 PHSS Draft Feasibility Study Appendix Hc

The PHSS draft feasibility study report, Appendix Hc, Section 4 (Anchor QEA et al. 2012) provides a technical analysis describing potential erosive forces and armoring for PHSS. Although many of the evaluations were performed for PHSS as a whole (RM 1.9 to RM 11.8), some were tailored for individual areas of potential concern (AOPCs), including AOPC 14, which includes the current Arkema Project Area. Except where otherwise stated, the findings listed in this section are from Appendix Hc. The draft feasibility study report (Anchor QEA et al. 2012) provides more hydrodynamic information than the final EPA feasibility study report (USEPA 2016b).

2.8.2.1 Waves And Wakes

This section discusses wind-generated waves and vessel wakes and their possible impacts on future remedial actions in the Arkema Project Area.

Wind-Generated Waves—Methods and Analysis Assumptions

The height of wind-generated waves was estimated in the PHSS draft feasibility study using a hindcast model.[4] The hindcast was described in Appendix Hc, Section 4.1.2, for each PHSS AOPC using the following assumptions and methods:

- Wind data for the Portland International Airport obtained from the National Climatic Data Center and the Meteorological Resource Center were compiled into a single set. Wind speeds were adjusted to 2-minute averages at 10 m above ground elevation.
- A Rayleigh distribution curve was fitted to the annual maxima (from 1961 to 1964), and the 100-year return period wind speed was extrapolated for each of 12 wind direction zones.
- For each AOPC, fetch distances[5] were measured for each wind directional zone that could result in wind waves that impact the shoreline.

For each AOPC, 100-year return wind periods for each relevant directional zone were calculated based on the fetch-limited, restricted-fetch wave growth formulation in the Automated Coastal Engineering System (ACES) developed by the U.S. Army Corps of Engineers (USACE 1992).

Vessel-Generated Waves—Methods and Analysis Assumptions

Vessel-induced wave heights were estimated in Appendix Hc, Section 4.1.3, by evaluating ship traffic patterns and then calculating vessel wakes based on the type of vessel, operational speed of the vessel, and water depth based on the following information and approach:

- Information on waterway traffic in the vicinity of the AOPC sites was obtained from the USACE website, Port of Portland documentation on vessel arrivals and departures, Lower Willamette Group property owner Site Use Survey, as well as other sources. Commercial vessel traffic between Port of Portland Terminals 2 and 4 was used to represent commercial vessel operations along the entire PHSS area.
- The Weggel-Sorensen model[6] (Weggel et al. 1986) was used to calculate the wave height generated at a vessel bow as a function of the vessel speed, distance from the sailing line, water depth, vessel displacement volume, and vessel hull geometry.

[4] A wave hindcast predicts past wave conditions using observed wind fields (direction, frequency, velocity) to calculate potential wave heights based on wave growth and propagation equations.
[5] Fetch is the distance that wind can travel over a water body to create a wave. At the Portland Harbor site, the Willamette River's sinuosity (amount of curvature) limits the fetch relative to larger, more open water bodies. Wind waves can be fetch-limited or wind-(speed and duration) limited.
[6] The Weggel-Sorenson model is a vessel wave height prediction model developed in 1986 based on measured laboratory and field data.

A model developed by the Maritime Coastal Agency (2009) was used to estimate the height of waves generated by high-speed excursion boats (i.e., jet boats) traveling along the center line of the navigation channel, and for jet boats traveling halfway between the channel centerline and the bank.

Waves and Wakes—Applicability to Project Area

The wave heights presented in the PHSS draft feasibility study are the incident wave and wake heights at the shoreline. Additional effects such as wave reflection, refraction, shoaling, and wake and wave superposition (coincident waves) should be considered during design for both existing and potential future conditions. These factors should be addressed during remedial design based on the location and configuration of remedial actions.

For each AOPC, Tables 4-3 and 4-4 of Appendix Hc list the 100-year significant wind-generated wave height and period and associated 100-year wind speed. For the Arkema Project Area, the maximum wind-generated wave identified in Appendix Hc is 1.8 ft high, has a period of 2.3 seconds, and is caused by a 100-year wind speed of 59 mph from a heading sector of 91 to 120 degrees north.

For commercial vessel traffic, the maximum wake (vessel-generated wave) for all PHSS is calculated in Appendix Hc to range from 2.0 to 2.8 ft with periods on the order of 3 to 4 seconds. Selection of an Arkema Project Area-specific preliminary design commercial vessel wake based upon anticipated future uses and vessel traffic will be part of design.

The height of wakes from excursion vessels was estimated in Appendix Hc at 2.5 ft for a jet boat traveling along the centerline of the navigation channel, and 3.3 ft for a jet boat traveling halfway between the channel centerline and the bank. Periods for jet boat wakes are not presented in Appendix Hc, Table 4-7. These excursion jet boats reportedly "travel through the project reach several times daily during the summer season (approximately April through September)." The frequency of these vessel trips can be expected to vary over time and could also include larger or faster vessels at some future time. For the purpose of this assessment, an Arkema Project Area excursion vessel wake height of 2.9 ft, and a period of 4 seconds is appropriate based on information in Appendix Hc.

Appendix Hc, Section 4.1.4, defines the shoreline wave zone (or surf zone[7]) as "the region in the Lower Willamette River extending from the location where the waves begin to break to the limit of wave run-up on the shoreline slope." The text goes on to state: "Within the surf zone, wave breaking is the dominant hydrodynamic process. Outside of the surf zone, the wave-induced horizontal orbital velocities are the dominant force." As stated in Appendix Hc,

[7] Wave zone in this chapter is interchangeable with surf zone used in Appendix Hc.

Section 4.1.1, this "study was limited to the river water levels between minimum extreme stage (4.5 feet NAVD88) and 13 feet NAVD88, which is the administrative boundary for the project."

However, the wave zone can actually extend to approximately elevation 23 ft NAVD88 (ordinary high water 20.1[8] ft NAVD88 plus a wave height of 2.9 ft).

100-Year Flood Analysis Methods and Analysis Assumptions

As discussed in Appendix Hc, Section 4.3, a steady-state simulation of the 100-year flood in the lower Willamette River was performed for PHSS to evaluate the stable particle size associated with river currents during such a flood event. Representative particle sizes (diameters) to resist erosion associated with current velocities were computed to determine the approximate material size required to withstand the 100-year flow condition within each AOPC.

100 Year Flood Analysis: Applicability to Arkema Project Area

A summary of the reported results for the Arkema Project Area in Appendix Hc, Table 4-12, is shown below, with minimum and maximum depth-averaged river current velocities (i.e., one velocity representing the full depth of the water column) and associated stable particle size.

100-year Flood Velocity and Corresponding Stable Particle Size for Arkema Project Area.

Range	Flood Velocity (feet per second)	Stable Particle Size (in.)
Minimum	0.05	0.000017
Maximum	5.07	1.30

Source: Appendix Hc, Table 4-12 for AOPC 14.

2.8.2.2 Propeller Wash Analysis

Propeller Wash Methods and Analysis Assumptions

The Appendix Hc, Section 4.2, propeller wash analysis consisted of the following components:

- Obtaining information on the types of commercial and recreational vessels that operate in the PHSS area
- Obtaining the vessel characteristics, including draft and propeller type
- Selecting "representative reasonable conservative" vessels

[8] In the PHSS draft feasibility study, ordinary high water is shown as 19.8 ft NAVD88. Current ordinary high water for the Arkema Project Area is calculated as 20.1 ft NAVD88 based on a USACE (2014) report. This elevation should be established again at time of design and time of construction as elevation is dynamic and changes over time.

- Defining operating assumptions for the "representative reasonable conservative" case vessels
- Defining a range of general site conditions across AOPCs for each model run
- Estimating the range of particle sizes necessary to withstand the erosive forces associated with propeller wash at various water depths.

The standard predictive models for propeller-induced bottom velocities are based on jet flow for a stationary jet. Empirical relationships developed by Blaauw and van de Kaa (1978) were used for modeling. Although propeller wash is typically modeled as a stationary jet, this approach can be conservative because the vessel's sailing speed, nominal though it may be, limits the duration of impact at a given location.

The propeller-induced bottom velocities and associated grain size required to resist the long-term, steady-state propeller wash from vessels were calculated in Appendix Hc for each AOPC in the PHSS, based on the following design assumptions:

- The propeller wash equations are based on maneuvering vessels.[9]
- General vessel information is based on site-wide conditions augmented by field observations, offered by Integral (J. Moore) based on 4 years of experience conducting studies in and acquiring familiarity with operations in the area.
- The maximum operating horsepower is 30 percent of available horsepower for large ships and 80 percent for tugs.
- The estimated frequency of vessel operation varies among AOPCs.

Water depth in the operational area of each vessel in each AOPC is the shallowest water depth measured in bathymetric surveys of February and March 2004 by David Evans and Associates.

Propeller Wash Analysis—Applicability to Arkema Project Area

Table 4-10 in Appendix Hc presents a summary of general site vessel characteristics by AOPC. The Arkema AOPC is not specifically listed in Table 4-10 and as such the appendix does not include any prop wash estimates for the Arkema Project Area.

2.9 CURRENT HABITAT CONDITIONS

As discussed in Section 1.2.7, salmonid habitat quality along the Arkema Project Area riverbank is extremely limited. Consequently, virtually any remedial alternative in the

[9] The equations from the original referenced work cited in Appendix H_c are for maneuvering vessels; however, the text in appendix states: "It is important to note that the use of this methodology is conservative because the propeller wash equations are based on non-maneuvering vessels."

riparian zone that adds vegetated grass/shrub land would be an improvement to the existing condition.

The active channel margin has low existing salmonid habitat value in the Salt Pad and Dock 1 and Dock 2 areas due to the dominance of riprap in these areas. As a result, remedial alternatives that include unarmored or bioengineered slopes could result in improvement to the existing salmonid habitat. However, the proportion of unarmored habitat increases downstream. In these downstream areas, remedial alternatives may need to be designed in recognition of existing habitat conditions, with appropriate consideration of any mitigation or enhancements that may be needed to offset potential salmonid habitat losses and gains.

Primary factors that affect shallow water habitat quality are structures (docks) in the Salt Pad and Dock 1 and 2 areas and pilings primarily in the Lot 1 and 2 area. Again, in these areas, remedial alternatives may need to be designed in recognition of existing habitat conditions, with appropriate consideration of any mitigation or enhancements that may be needed to offset potential salmonid habitat losses. The existing docks are planned for removal as part of the remedial action.

Other factors will become important as this process continues from a conceptual evaluation of alternatives to a remedial design with a more focused understanding of SCM alternatives, engineering specifications, and their costs. A critical factor in this evaluation will be balancing the net environmental benefits or losses that may accrue against actual costs of remedial alternatives.

2.10 DATA GAP ANALYSIS

The existing data set developed from investigations spanning nearly 20 years provides information that can be used to establish the spatial scope of the remedial design investigation in the Arkema Project Area. These historical data were used to identify data gaps and aid in focusing the remedial design investigation in the Arkema Project Area.

The Arkema Project Area features the defined areas of riverbank, shallow, intermediate, and Nav-FMD consistent with the ROD and technical guidance:

- Navigation Channel: The navigation channel refers to the federally authorized navigation channel.
- Future Maintenance Dredge Areas: FMD areas are those locations in the river that are periodically dredged to allow continued marine activity such as vessel activity, shipping, docking, and other activities.

At the Arkema Project Area, the FMD areas are associated with the three existing docks. These docks are no longer in use and will be removed as part of the remediation work, eliminating the underdock and FMD areas.

- Intermediate Region: The intermediate region is defined as outside the horizontal limits of the navigation channel and FMD areas to the riverbed elevation of approximately −2 ft CRD.
- Shallow Region: The shallow region is defined as shoreward of the riverbed elevation of approximately −2 ft CRD.

The following sections present a brief data gaps analysis for selected COCs in surface and subsurface sediment, as well as potential riverbank soil and subsurface NAPL, groundwater discharge and porewater, deposition rates downstream of Dock 2, geotechnical evaluation, and structural analysis.

2.10.1 Surface Sediment and Riverbank Soil

An extensive data set provides an understanding of the distribution of focused COCs in surface sediments in the Arkema Project Area. Surface sediment and riverbank data for DDx, PeCDF, PeCDD, TCDD, total PCBs, and total PAHs are presented in Figures 2-1a-f. Therefore, in general, there are no data gaps that need to be filled with respect to focused COC surface sediment concentrations within the Arkema Project Area.

There are portions of the Arkema Project area where subsurface data are sparse and data gaps have been identified (see Section 2.11.2). One example is the area upstream of the Salt Dock that is part of the SMA as defined by ROD RAL footprints for DDx, PeCDF, and total PCBs. Surface sediment data for DDx, PeCDF, and total PCBs in this portion of the Arkema Project Area are below RALs, as shown in Figures 2-1a, 2-1b, and 2-1e, respectively. If sampling to fill subsurface sediment data gaps shows that focused COCs are below RALs, then additional surface sampling may be required for remedial decision-making.

The existing data set provides information about the concentrations of focused COCs in riverbank soil. Riverbank soil that has COCs exceeding RALs, is potentially erodible, and is adjacent to sediment cleanup areas will need to be considered as part of remedy design for protectiveness and remedy longevity. The following sections present a data gap analysis for the focused COCs in riverbank soil.

2.10.1.1 DDX

Riverbank soil samples collected near the top of bank show that DDx soil concentrations exceed PTW levels between Dock 2 and the Salt Dock (Figure 2-1a). Upstream and downstream of the docks, DDx riverbank soil concentrations mostly exceed the RAL. At one

location near the downstream end of Lot 2, DDx soil concentrations exceed the PTW in surface soil. At one location near the Lot 3/Lot 4 boundary, DDx soil concentrations are below the RAL.

Additional surface DDx soil concentration data are needed in selected portions of the riverbank to further define potentially erodible soil adjacent to sediment remediation areas to evaluate protectiveness and remedy longevity and to further support remedial decision-making.

2.10.1.2 2,3,4,7,8-PeCDF

Riverbank soil samples collected near the top of bank show that PeCDF surface soil concentrations are below the RAL along the entire Arkema Project Area riverbank boundary (Figure 2-1b). No additional surface PeCDF data are needed along the riverbank to support remedial decision-making.

2.10.1.3 1,2,3,7,8-PeCDD

Riverbank soil samples collected near the top of bank show that PeCDD surface soil concentrations exceed RALs at two locations between Dock 2 and Outfall 004 (Figure 2-1c). In two downstream locations at the top of the riverbank near Lots 3 and 4, PeCDD is below the RAL. PeCDD is not detected in the remaining locations where analyzed; however, detection limits exceed the RAL concentration in seven soil samples.

Additional PeCDD surface soil concentration data are needed in selected portions of the riverbank to further define potentially erodible soil adjacent to sediment remediation areas to evaluate protectiveness and remedy longevity and to further support remedial decision-making.

2.10.1.4 2,3,7,8-TCDD

Riverbank soil samples collected near the top of bank show that TCDD soil concentrations are below the RAL, except in the area from the Dock 2 to Outfall 004 (Figure 2-1d). TCDD surface soil concentrations are below the RAL in the remaining areas of the riverbank, where sampled. There are no TCDD surface soil samples between Docks 1 and 2.

Additional TCDD surface soil data are needed between Docks 1 and 2 to further define potentially erodible soil adjacent to sediment remediation areas to evaluate protectiveness and remedy longevity and to further support remedial decision-making.

2.10.1.5 Total PCBs

Riverbank soil samples collected near the top of bank show that PCB surface soil concentrations are below the RAL in all sampled areas with the exception of one RAL exceedance upstream of the Salt Dock and one RAL and one PTW exceedance at the top of bank in Lot 1 (Figure 2-1e).

Additional PCB surface soil data are needed in the Lot 1 and upstream Salt dock area portions of the riverbank to further define potentially erodible soil adjacent to sediment remediation areas to evaluate protectiveness and remedy longevity and to further support remedial decision-making.

2.10.1.6 Total PAHs

Riverbank soil samples collected near the top of bank show that PAH surface soil concentrations are below the RAL along the entire Arkema Project Area riverbank (Figure 2-1f). No additional subsurface PAH soil data are needed along the Arkema Project Area riverbank to support remedial decision-making.

2.10.2 Subsurface Sediment and Riverbank Soil

During previous investigations, a total of 75 sediment cores have been collected within the Arkema Project Area from approximately RM 6.9 to 7.6 (Figure 1-6b). The following sections summarize the spatial distribution of data and data gaps for selected COCs in subsurface sediment based on the existing data set.

2.10.2.1 DDX

More than 600 subsurface sediment samples have been analyzed for DDx in the Arkema Project Area. The existing sediment data set provides a good representation of the nature and extent of DDx in sediment in the Arkema Project Area (Figure 2-2a). The highest DDx concentrations are found in sediment samples between Docks 1 and 2, with PTW exceedances found to depths of 12 to 24 ft bml. DDx sediment concentrations generally decrease rapidly below the base of the PTW. Although the base of PTW is generally delineated, because of the variation in the depth profile of the PTW exceedances, a more regularly gridded sampling program is needed to define the base of the anticipated dredge prism between Docks 1 and 2. Similarly, cores downstream of Dock 2 and extending about 200–300 ft downstream of Outfall 004 have defined an area of DDx PTW in subsurface sediment. In this area, PTW exceedances are found to depths of 4 to 10 ft bml. For the same reason as between Docks 1 and 2, a more regularly gridded subsurface sediment sampling program is needed to define the base of the anticipated dredge prism in the Outfall 004 area.

Fewer subsurface sediment samples have been collected in the region downstream of Outfall 004 to the edge of the Arkema Project Area, between about RM 7 and 6.9. Subsurface DDx concentrations in this region are lower than the Outfall 004 area immediately upstream. No subsurface sediment samples exceed DDx PTW concentrations in this area. DDx concentrations both above and below the DDx RAL have been measured in subsurface sediment. Additional subsurface DDx concentration data are needed in this part of the Arkema Project Area to support remedial decision-making.

Upstream, between Dock 1 and the Salt Dock, three subsurface sediment samples exceed PTW concentrations. The PTW exceedances for the two samples immediately between the docks are found at depths up to 4 ft bml. The third sample with a subsurface DDx PTW exceedance is located outside of the dock face between a depth of 8 and 12 ft bml and was collected during the LWG Round 3 subsurface sediment sampling program in 2004. Additional subsurface DDx concentration data are needed in this part of the Arkema Project Area to verify the depth and spatial distribution of DDx near sediment core C359 and to support remedial decision-making between Dock 1 and the Salt Dock.

There are few subsurface sediment samples in the region upstream of the Salt Dock to the upstream edge of the Arkema Project Area (RM 7.6). The few subsurface DDx concentration measurements in this region are below and above the DDx RAL. Additional subsurface DDx concentration data are needed in this part of the Arkema Project Area to support remedial decision-making.

Riverbank subsurface soil samples collected near the top of bank show that DDx soil concentrations exceed PTW levels between Dock 2 and the Salt Dock. Upstream and downstream of the docks, DDx riverbank subsurface soil concentrations are both above and below the RAL. At one location near the downstream end of Lot 2, DDx soil concentrations exceed the PTW. Additional subsurface DDx soil concentration data are needed in selected portions of the riverbank to further define potentially erodible soil adjacent to sediment remediation areas to evaluate protectiveness and remedy longevity and to further support remedial decision-making.

2.10.2.2 2,3,4,7,8-PeCDF

More than 150 subsurface sediment samples have been analyzed for PeCDF. There is a high spatial density of PeCDF measurements in subsurface sediment from the Salt Dock downstream to below Outfall 004. Fewer samples have been analyzed for PeCDF in the downstream (RM 7.1 to 6.9) portion of the Arkema Project area. There are also no subsurface PeCDF concentration data upstream of the Salt Dock in the Arkema Project Area (Figure 2-2b).

PeCDF concentrations exceed PTW concentrations between Docks 1 and 2; however, PTW exceedances are generally at shallower depths than DDx. Because the remedial design for DDx

between Dock 1 and Dock 2 will also capture and remove PeCDF PTW, no additional design sampling is required in this area specific to PeCDF. However, PeCDF sediment sample analyses will be conducted for samples between Docks 1 and 2 at the base of the remedial design dredge prism to provide confirmation that PeCDF RAL exceedances will be addressed by the remediation between Docks 1 and 2.

Upstream of Dock 1 there are no exceedances of the PeCDF RAL in subsurface sediment. Downstream of Dock 2, PeCDF concentrations are generally below the RAL, except for an area immediately downstream of Outfall 004, where there are three subsurface samples that exceed the PTW level. Subsurface sediment near Outfall 004 is also not bounded below the RAL along the navigation channel, so these are important areas to characterize in support of remedy selection and remedial design.

Upstream of the Salt Dock and downstream of approximately RM 7, the PeCDF subsurface sample data density are sparse. Additional subsurface PeCDF concentration data are needed in these parts of the Arkema Project Area to support remedial decision-making.

Riverbank subsurface soil samples collected near the top of bank show that PeCDF subsurface soil concentrations are below the RAL along the entire Arkema Project Area riverbank . No additional subsurface PeCDF data are needed along the Arkema Project Area riverbank to support remedial decision-making.

2.10.2.3 1,2,3,7,8-PeCDD

More than 150 subsurface sediment samples have been analyzed for PeCDD. There is a high spatial density of PeCDD measurements in subsurface sediment from the Salt Dock downstream to below Outfall 004. Fewer samples have been analyzed for PeCDD in the downstream (RM 7.1 to 6.9) portion of the Arkema Project Area. There are also no subsurface PeCDD concentration data upstream of the Salt Dock in the Arkema Project Area (Figure 2-2c).

Between Docks 1 and 2, PeCDD concentrations exceed the PeCDD RAL. The planned remedial design sampling for DDx in the Dock 1 and 2 area will address the PeCDD RAL exceedances, therefore, no additional design sampling is required in this area specific to PeCDD. However, PeCDD sediment sample analyses will be conducted for samples at the edge of the Docks 1 and 2 remedial design dredge prism to provide confirmation that PeCDD RAL exceedances will be addressed by the remediation between Docks 1 and 2.

With one exception, downstream of Dock 2 there are no PeCDD RAL exceedances. The one location on the outside face of Dock 2 is within the Dock 2 pre-remedial design investigation area and therefore sampling for PeCDD will be conducted near this location to support remedial design.

Downstream of Outfall 004 to the downstream edge of the Arkema Project Area (RM 6.9) there are fewer PeCDD subsurface data. The PeCDD data that are available exceed the PeCDD RAL, and one location near Bayer's outfall WR-6 exceeds the PeCDD PTW concentration. Additional subsurface PeCDD concentration data are needed in these parts of the Arkema Project Area to support remedial decision-making.

Between Dock 1 and the Salt Dock, no sediment samples exceed the PeCDD RAL. Upstream of the Salt Dock there are no PeCDD subsurface sample data. Additional subsurface PeCDD concentration data will be collected in this part of the Arkema Project Area to support remedial decision-making.

Riverbank subsurface soil samples collected near the top of bank show that PeCDD subsurface soil concentrations exceed RALs at all locations sampled with the exception of one area at the top of the riverbank downstream of Outfall 004. Additional subsurface PeCDD soil concentration data are needed in selected portions of the riverbank to further define potentially erodible soil adjacent to sediment remediation areas to evaluate protectiveness and remedy longevity and to further support remedial decision-making.

2.10.2.4 2,3,7,8-TCDD

More than 150 subsurface sediment samples have been analyzed for TCDD within the Arkema Project Area. There is a high spatial density of subsurface TCDD measurements from the Salt Dock downstream to about 200 ft downstream of Outfall 004 (Figure 2-2d). There are no subsurface TCDD data in the Arkema Project Area upstream of the Salt Dock. Downstream of Outfall 004, between about RM 7.1 and 6.9, subsurface TCDD data are relatively sparse.

TCDD RAL exceedances are found between Docks 1 and 2, and are generally collocated with the area of DDx PTW and RAL exceedances. One TCDD PTW exceedance is located in the Dock 1 and 2 area, on the outside face of Dock 1. Subsurface sampling in the Dock 1 and 2 area will include analysis for TCDD to support remedial decision-making.

Downstream of Dock 2 to below Outfall 004, most subsurface sediment samples do not exceed the TCDD RAL. Three samples in this area exceed the RAL, two outside of Dock 2 and one downstream of Outfall 004. Additional subsurface TCDD concentration data are needed near these samples to support remedy selection and remedial design.

At the furthest downstream portion of the Arkema Project Area from about RM 7.1 to 6.9, TCDD concentrations increase and exceed RALs at several locations and PTW at one location near Bayer's outfall WR-6. Additional subsurface TCDD concentration data are needed in this reach of the Arkema Project Area to support remedy selection and remedial design.

Upstream, between Dock 1 and the Salt Dock, there are no subsurface TCDD RAL exceedances. Even though not required for remedial design purposes, subsurface sampling in the Dock 1 and 2 area will include analysis for TCDD to support remedial decision-making.

Upstream of the Salt Dock there are no subsurface TCDD data. Additional subsurface TCDD concentration data are needed in this area to support remedial decision-making.

Riverbank subsurface soil samples collected near the top of bank show that TCDD subsurface soil concentrations are below the RAL. Data are sparse in the area from the Salt Dock to Dock 1. Additional subsurface TCDD data are needed in this latter area to support remedial design.

2.10.2.5 Total PCBs

More than 190 subsurface sediment samples have been analyzed for PCBs within the Arkema Project Area. The highest density for subsurface PCB data is from the Salt Dock downstream to about RM 7.1, downstream of Outfall 004 (Figure 2-2e). At a number of locations within the Arkema Project Area, PCBs were not detected, but the PCB detection limit was elevated because of a known interference between PCB Aroclor and chlorinated pesticide analytical methods. There is no interference between chlorinated pesticide and PCB congener methods, from which many of the later PCB results were generated. The existing data set is adequate to generally assess PCB concentrations in subsurface sediment in the Arkema Project Area.[10]

From the Salt Dock to Dock 2, six subsurface sediment samples exceed the PCB PTW. The PCB PTW samples are all near the Arkema dock line. Two subsurface sediment samples also exceed the PCB RAL between the Salt Dock and Dock 1. These samples are on the channel side of the Arkema dock line but within the Arkema Project Area. Additional subsurface PCB concentration data will be collected in the PCB PTW and RAL exceedance areas to support remedy selection and remedial design.

Downstream of Dock 2 to downstream of Outfall 004 (about RM 7.1), subsurface PCB data show that PCB concentrations in subsurface sediment do not exceed the PCB RAL. PCB data are sparser between about RM 7.1 and the downstream edge of the Arkema Project Area. Additional subsurface PCB concentration data are needed in this latter area to support remedial decision-making.

Interior to the Salt Dock there are a number of subsurface sediment samples that show PCBs are below the PCB RAL. Upstream of the Salt Dock there are no subsurface PCB data to the upstream limit of the Arkema Project Area. Additional subsurface PCB concentration data are needed in this latter area to support remedial decision-making.

[10] Total PCBs is not a focused COC for the Arkema Project Area.

Riverbank subsurface soil samples collected near the top of bank show that PCB subsurface soil concentrations are below the RAL along the entire Arkema Project Area riverbank. No additional subsurface PCB data are needed along the Arkema Project Area riverbank to support remedial decision-making.

2.10.2.6 Total PAHs

A total of 236 subsurface sediment samples have been analyzed for PAHs within the Arkema Project Area. There is a high spatial density of total PAHs data for subsurface sediments in the Arkema Project Area (Figure 2-2f). Subsurface PAH sediment concentrations are below the RAL at all sample locations, with the exception of four samples. Like PCBs, the four locations with RAL exceedances are at or near the Arkema dock line. No subsurface sediment samples interior of the Salt Dock to downstream of Outfall 004 have PAH concentrations exceeding the RAL. Total PAHs are also not a focused COC for the Arkema Project Area; however, the three PAH RAL exceedances at Dock 1 and Dock 2 are within the remedial design sampling area for DDx. Additional subsurface PAH concentration data will be collected in these areas to support remedial decision-making.

Downstream of Outfall 004, from about RM 7.1 to 6.9, there are fewer subsurface PAH data. Additional subsurface PAH concentration data will be collected in this area to support remedial decision-making.

Upstream of the Salt Dock, there are two locations with subsurface PAH sediment data. Additional subsurface PAH concentration data will be collected between the Salt Dock and the upstream Arkema Project Area boundary to support remedial decision-making.

Riverbank subsurface soil samples collected near the top of bank show that PAH subsurface soil concentrations are below the RAL along the entire Arkema Project Area riverbank . No additional subsurface PAH soil data are needed along the Arkema Project Area riverbank to support remedial decision-making.

2.10.2.7 NAPL and Chlorobenzene PTW

NAPL is defined in the ROD as a PTW source material. Chlorobenzene NAPL has been identified in a portion of the upland area of the Arkema site in the Acid Plant Area, which is located between Docks 1 and 2 (ERM 2005, 2006). However, chlorobenzene NAPL has not been identified in sediment during previous investigations. The upland groundwater pathway has been isolated from the river as a result of groundwater SCMs; however, as noted in Section 2.6.1, recent quarterly groundwater monitoring shows elevated levels of chlorobenzene in monitoring wells located on the river side of the groundwater barrier wall between Docks 1 and 2, particularly in the intermediate and deep groundwater zones.

Chlorobenzene in groundwater at concentrations that cause sediment to exceed 320 μg/kg is considered not reliably contained PTW in the ROD. Chlorobenzene concentrations in sediment and in groundwater beneath the riverbank area need to be evaluated to inform PTW determination and for other parts of remedial design. In areas where NAPL is suspected, the presence or absence of NAPL also defines whether sediment will be considered PTW for remedial design. The definition of these latter areas is presently a data gap for remedial design.

For many years, the shoreline in the Arkema Project Area was used as a staging area for logs. Sheens due to organic material deposited in the sediment from these log rafts have been documented. In addition, the Arkema Project Area is located immediately downstream of a bulk petroleum fuel terminal and along an industrial waterway with many potential hydrocarbon sources. During previous investigations, sheens, blebs, and globules were observed in selected boreholes, which is consistent with a typical navigable river in an industrialized area. These latter sheens are not related to past industrial practices at the Arkema site and because they are not related to a NAPL source are not considered indicators of PTW in the Arkema Project Area.

2.10.3 Groundwater Discharge and Porewater

Understanding groundwater discharge and residual chemical flux will be required for remedial design. The post-remediation CSM for the Arkema Project Area is shown on Figure 1-7. Upon completion, remediation elements will include the existing groundwater SCMs (groundwater barrier wall and upgradient extraction wells), existing stormwater SCMs (stormwater detention basin and sand filtration system), and future erodible soil SCMs, along with the completed sediment remediation (dredged area with backfill and cap). Because of basic physical and engineering constraints, there will be some soil and groundwater beneath the Arkema Project Area riverbank that cannot be remediated by either the groundwater SCMs or sediment remedial measures. This area, shoreward of the barrier wall, may contain remnant dissolved-phase COCs, and it is labeled on Figure 1-7.

Key groundwater data gaps that remain are:

1. What are the COC concentrations in the upland shoreward of the barrier wall?
2. What is the current hydraulic gradient and groundwater flux to the Willamette River?
3. What will be the post-remediation COC flux to the Willamette River, if any?

Each of these data gaps and the rationale for filling them are discussed below.

2.10.3.1 Groundwater Discharge Data Gap 1—Residual COCs in Groundwater

Arkema groundwater SCMs consisting of a groundwater barrier wall and a GWET system were installed in 2012–2013 (see Section 1.2.3.2). Discharge of COCs in groundwater upgradient of the groundwater barrier wall has been controlled at the Arkema site for about 8 years; however, recent groundwater concentration measurements indicate that chlorobenzene and other chemicals are still present at elevated concentrations in groundwater downgradient of the groundwater barrier wall. Therefore, the potential for residual COCs in the area downgradient of the barrier wall to contribute to COC flux during and after sediment remediation is not currently known. Groundwater sampling to provide data to understand the distribution of COCs in this area is proposed to fill this data gap.

2.10.3.2 Groundwater Discharge Data Gap 2—Hydraulic Gradients and Groundwater Flux to River

No assessment of groundwater gradients and groundwater flux downgradient of the groundwater barrier wall has been conducted since groundwater SCMs were installed in 2012–2013. UltraSeep surveys were conducted in 2004 and 2005 (see Section 2.6), prior to implementation of the groundwater SCMs. The installation of the groundwater SCMs has altered the hydraulic flow system from the Arkema Project Area riverbank through the adjacent Willamette River sediments. Therefore, the 2004/2005 groundwater discharge data collected by the LWG are not representative of current conditions. A groundwater discharge study that includes measurement of groundwater potentiometric surfaces and gradients, calculation of groundwater discharge, and direct measurement of groundwater flux will be conducted to fill these data gaps.

2.10.3.3 Groundwater Discharge Data Gap 3—COC Flux to River

Understanding the potential post-remediation flux, if any, of COCs in groundwater to the river is essential for cap design considerations. TZW sampling was last conducted by the LWG in 2004 and 2005, prior to the construction of the Arkema groundwater SCMs. It is reasonable to assume that 7–8 years after groundwater SCM implementation, changes in TZW COC concentrations and flux have occurred. The lack of new data since groundwater SCM implementation is a data gap. Therefore, COC concentration data and groundwater flux measurements in surface sediment porewater will be collected to inform remedial cap design.

2.10.4 Sediment Deposition Rates

Several site-wide bathymetry surveys have been performed as part of the Portland Harbor remedial investigation. A comparison of 2004 and 2018 surveys characterizes bathymetric changes and allows for the calculation of corresponding sedimentation rates over the 14-year period. Figure 2-4b presents the bathymetric change between 2004 and 2018. The bathymetric

change is shown for the area that overlaps between the two surveys. During this period, the majority of the Arkema Project Area experienced 0.5 to 5 ft of deposition. The shoreline in the area downstream of Dock 2, however, is depicted as scouring on Figure 2-4b. This area is located in a low energy environment and is likely depositional, similar to the adjacent areas. The scouring near the shoreline depicted on Figure 2-4b is likely due to an artifact of the "edge effects" in the interpolation of the bathymetry data.

The bathymetry surveys conducted in the vicinity of the Arkema site were multibeam surveys that did not include shallow nearshore areas and areas near docks and other structures, which are critical sediment remedy areas in the Arkema Project Area. In addition, the existing bathymetry data are available only for a relatively short duration of time and cannot be used to estimate the long-term (e.g., 50 or more years) deposition rates. These are data gaps that need to be filled in support of pre-design.

Recent (2004–2018) sediment deposition rates (for the Portland Harbor site have been released and show that deposition is occurring in numerous locations throughout the harbor to varying degrees, depending upon local hydrodynamic conditions.

2.10.5 Geotechnical Evaluation

Although some geotechnical data exists, data specific to the intended riverbank and sediment remedies, consistent with the presence of the existing slurry wall and upland GWET system, will be necessary. The presence of the existing slurry wall may limit potential riverbank construction and long-term geotechnical stability. Geotechnical evaluation will include assessing potential construction in the vicinity of slurry wall and dredgability of sediments potentially requiring dredging.

2.10.6 Dock Investigations and Structural Analysis

The existing dock inspection information was a preliminary assessment and not intended as a comprehensive structural analysis. The inspection was performed in 2011, approximately 9 years ago, and concluded that "[s]tructural assessment will also be needed to check the demand versus capacity of the structural elements should the facilities be put to use again."

These docks (the Salt Dock, Dock 1, and Dock 2) are no longer in use and will be removed as part of the remediation work. Appropriate dock investigations and structural analysis will be performed to support dock removal activities. This will include:

- Structural inventory and analysis
- Hazardous material survey
- Utility survey.

3 INVESTIGATION ELEMENTS AND RATIONALE

The following sections present the elements and rationale for assessing sediment and soil chemistry, porewater chemistry, and groundwater discharge. Table 3-1 presents different groups of subsurface samples to be collected, the analyses to be conducted, and the purpose of each element of the sampling design. Most of the sampling will be conducted on Arkema property or in the Willamette River adjacent to the Arkema property. The project area extends downstream and upstream beyond the Arkema property boundary, and access agreements with other property owners will be obtained prior to sampling.

3.1 SEDIMENT AND SOIL CHEMISTRY SAMPLING

The existing sediment and soil data for the Arkema Project Area are summarized in Sections 2.3 and 2.4. Sediment and soil data gaps are summarized in Section 2.11. The following sections present the problem statements, study goals, and study design for additional characterization of sediment (Section 3.1.1) and riverbank soil (Section 3.1.2) within the Arkema Project Area.

3.1.1 Sediment Chemistry

The existing surface and subsurface sediment data for DDx, PeCDF, PeCDD, TCDD, and PCBs[11] relative to RALs and PTW criteria are presented in Figures 2-1a-f. Table 3-2 summarizes the data quality objectives (DQOs) for subsurface sediment sampling following EPA's seven-step process (USEPA 2006). The information in the tables is discussed in more detail below.

The existing docks (the Salt Dock, Dock 1, and Dock 2) are no longer in use and will be removed as part of the remediation work. For safety reasons, sediment data will not be collected under the docks, and adjacent sediment data will be used for remedial design based on consistent application of remedial technology from adjacent areas to the areas where docks will be removed.

3.1.1.1 Problem Statements

The primary purpose for collecting additional data within the Arkema Project Area is to more accurately define the lateral and vertical extent of RAL and PTW exceedances for remedy design in the Arkema Project Area.

Existing DDx and polychlorinated dibenzo-*p*-dioxin/furan (PeCDF/TCDD) data for surface and subsurface sediment are insufficient to define the horizontal and vertical remedial extent for the

[11] No data gaps were identified for PAHs. There are only a very limited number of locations with exceedances of the PAH RAL in the Arkema Project Area. The exceedances are located near Docks 1 and 2 and one isolated location between Outfall 004 and the railroad bridge.

focused COCs and additional contaminants in sufficient detail to prepare a remedial design. Historical data sets include relatively few subsurface measurements within the Arkema Project Area in areas outside of the Arkema docks, and the nature and extent of subsurface focused COCs in those areas is not well characterized. Additional surface and subsurface chemistry data are needed for remedial design to better define the areas of contaminated sediments in the Arkema Project Area.

Existing data outside of the area of highest concentrations are of a lower spatial density than the samples adjacent to Arkema.

3.1.1.2 Goals of the Study

This study is being conducted to provide an updated and refined assessment of the distribution of focused COCs and other contaminants in sediment to pre-define the elevation of contamination using high-quality sediment core data integrated into a digital terrain model of the Arkema Project Area for remedial design. The study has the following goals:

1. Determine concentrations for focused COCs and other contaminants in the Arkema Project Area with sufficient horizontal and vertical resolution to refine the remedy footprint and support a cost-effective pre-remedial design. The vertical resolution should be sufficient to establish the elevation of contamination (i.e., the elevation of the deepest sediment found to be contaminated) with a high degree of accuracy for input into the dredging plan.
2. Provide data to aid in the assessment of the effectiveness of upland SCMs within the Arkema Project Area.
3. Provide baseline data for future remedy effectiveness evaluations and monitoring.
4. Obtain data with sufficiently low detection limits (i.e., below RALs) for PCBs in sediment in selected locations using EPA Method 1668c.

3.1.1.3 Study Design

To meet the goals of the study, sediment collection will employ a rigorous sampling program with a high spatial density of samples in areas planned for remediation, will achieve 80 percent recovery for subsurface cores, and will include depth corrections to establish accurate estimates of elevation of contamination. Sediment will be collected for chemical analysis using the following sampling schemes:

- Subsurface sediment sampling will consist of 71 sediment cores collected on an approximate 50- by 100-ft grid spacing from the Salt Dock to downstream of Outfall 004. An additional 23 cores upstream and downstream of the gridded spacing area will provide supplementary information about the nature and extent of focused COCs

outside of the gridded spacing within the Arkema Project Area. Also, four sediment cores will be collected in the navigation channel adjacent to the Arkema Project Area.

- Additional sediment chemistry sampling and analyses may be conducted during the second phase of design investigation (see Section 3.10) based on the results of the first phase of investigation. During Phase 2, sediment cores may be collected to provide greater spatial resolution for remedial design. For example, additional coring on 50-ft centers may be conducted in selected areas, based on Phase 1 data, where one of any pair of adjacent cores has concentrations above the RAL and the other does not. All core samples will be analyzed for focused COCs.

Phase 1 and conceptual Phase 2 sediment sampling locations are shown on Figure 3-1. These same locations are shown at a higher spatial resolution in Figures 3-2a-b. Samples will be analyzed in accordance with the subsurface sediment sample decision tree in Figure 3-2c.

Sediment core samples will be collected with a vibracorer to refusal. Cores will be sectioned into separate horizons. Horizons will be a maximum of 2 ft in length below 1 ft bml; smaller horizons may be sampled if the information is deemed necessary for more accurate vertical control during remedial dredging. General field protocols for sample collection are provided in the FSP (Appendix A).

If needed, surface sediment samples will be collected during Phase 2 using a vessel-deployed power grab or equivalent sediment sampler following standard protocols and guidelines (PSEP 1996) and in accordance with the FSP (Appendix A). Surface samples will consist of sediments from 0 to 1 ft bml.

Selected subsurface sediment samples will be analyzed for the following analytes in accordance with the subsurface sediment sample analysis decision tree presented in Figure 3-2c:

- DDx by EPA Method 8081B
- PCBs by EPA Method 1668C
- Dioxins and furans by EPA Method E8290
- PAHs by EPA Method 8270/D
- Chlorobenzene by EPA Method 8260C (selected cores between Docks 1 and 2 only).

Field sampling will follow procedures and protocols described in the FSP (Appendix A). Analytical methods and quality assurance and quality control protocols are presented in the QAPP (Appendix B).

Use and Interpretation of Subsurface Sediment Chemistry Data

Sediment core data from immediately downstream of the Salt Dock to just downstream of Outfall 004 will be evaluated to determine the maximum depths of RAL and PTW exceedances for the focused COCs. The results will be used to establish the elevation of contamination and quantity estimates for sediment volume to inform the remedial design and sediment treatment and/or disposal options.

Sediment core data from outside of the gridded sampling area will be used to fill data gaps regarding subsurface sediment chemistry to understand the nature and extent of focused COCs, and in particular whether there are exceedances of RALs or PTW thresholds in some of these parts of the Arkema Project Area. Based on the results of these latter sediment sample data, additional surface sampling may be conducted to support remedial decision-making.

Use and Interpretation of Surface Sediment Chemistry Data

If needed, surface sediment data will be collected and used to identify the boundary of the remedial footprint in accordance with the ROD technology application decision tree (Figure 1-3c). This would apply in a case where subsurface sediment data collected to fill data gaps demonstrates that sediment less than 5 ft bml does not exceed PTW or RALs. If collected, surface sediment chemistry data can also be used to provide a baseline for future evaluations of remedy effectiveness and to evaluate natural recovery.

3.2 RIVERBANK SOIL

Riverbank soil that contains COCs exceeding RALs and potentially erodible soil requires remedial action for remedy protection. The problem statement, study goals, and study design are discussed in the following sections. Table 3-3 summarizes the riverbank soil DQOs following EPA's seven-step DQO process. Proposed riverbank soil sample stations are shown on Figure 3-1. These same locations are shown at a higher spatial resolution in Figures 3-2a-b.

3.2.1 Problem Statement

Riverbank soil chemistry data have identified areas that are potential erodible soil sources of focused COCs to the Willamette River (Section 2.11). Based on the available data, there is uncertainty regarding the nature and extent of selected focused COCs exceeding RALs or PTW in riverbank soil. The remedy design will require surface and subsurface soil data that define the limits of the extent of COCs exceeding RALs in riverbank soil adjacent to the sediment portion of the Arkema Project Area.

3.2.2 Goals of the Study

The goals of this study are to identify areas of the riverbank soil with COCs that exceed RALs and have the potential to mobilize to the sediment portion of the Arkema Project Area through erosion or bank failure. These data will also be used to inform remedy selection and design and to establish pre-remedial baseline conditions adjacent to the sediment portion of the Arkema Project Area.

Consistent with the Riverbank Guidance, debris on the shoreline must also be considered as it relates to evaluating erodibility and the steps for physical characterization of soil and sediment, and the geomorphic configuration. This step was started as part of earlier investigations, as described in Section 2.7.6.

3.2.3 Study Design

Discrete soil samples will be collected at riverbank locations shown on Figures 3-2a-b. Locations were selected based on riverbank soil data gaps identified in Section 2.11. Soil samples will be collected using a hand auger at 1 ft intervals to a depth of 4 ft bgs or refusal, whichever comes first. Soil samples will be collected from discrete intervals and prepared for shipment to the analytical laboratory using procedures and protocols described in the FSP (Appendix A). Select soil samples will be analyzed for DDx, PCB congeners, dioxins and furans, and asbestos in accordance with the riverbank soil sample analysis decision tree in Figure 3-2d. Analytical methods and quality assurance and quality control protocols are presented in the QAPP (Appendix B).

3.3 NAPL

The problem statement, study goals, and study design are discussed in the following sections. Table 3-4 summarizes the DQOs following EPA's seven-step DQO process.

3.3.1 Problem Statement

NAPL is defined in the ROD as a PTW source material. Chlorobenzene NAPL has been identified in a portion of the upland area of the Arkema site in the Acid Plant Area, which is located between Docks 1 and 2 (ERM 2005, 2006). However, chlorobenzene NAPL has not been identified in Arkema Project Area sediment during previous investigations. The upland groundwater pathway has been isolated from the river as a result of groundwater SCMs; however, as noted in Section 2.6.1, recent quarterly groundwater monitoring shows elevated levels of chlorobenzene in monitoring wells located on the river side of the groundwater barrier wall between Docks 1 and 2, particularly in the intermediate and deep groundwater zones.

Portions of the Arkema Project Area near Outfall 004 and Docks 1 and 2 are designated as "PTW – Source Material (NAPL)" in Figure 8 of the Portland Harbor ROD (USEPA 2017). These areas will be appropriately evaluated for chlorobenzene NAPL as part of the PDI. The chlorobenzene NAPL evaluation will include visual assessment, ultraviolet (UV) fluorescence, and shake tests with a hydrophobic dye. Sediment samples with evidence of chlorobenzene NAPL, based on the visual assessment, UV fluorescence, and shake tests will be centrifuged in an analytical laboratory and the supernatant then subjected to the UV screening protocols. If chlorobenzene NAPL is identified in the supernatant based on the UV screening, the NAPL will be extracted from the supernatant and tested for physical parameters (density and viscosity) and COCs (NWTPH-Dx, NWTPH-Gx, and VOCs). If chlorobenzene NAPL is not found in the supernatant, it will not be considered in the design process. If chlorobenzene NAPL is found in the supernatant, it will be considered PTW source material and the physical and chemical properties of the NAPL will be considered in the design process for dredging (e.g., mobility based on physical parameters) and capping (e.g., potential breakthrough based on COCs).

Other than chlorobenzene NAPL identification and testing, this NAPL study does not specifically address sediment chlorobenzene concentrations or dissolved chlorobenzene concentrations in groundwater or sediment TZW. Studies described in Section 3.1.1 and Section 3.6 of this pre-design work plan address these two remedial design data requirements.

3.3.2 Goals of the Study

The goal of this study is to identify and characterize NAPL, if observed, regardless of source, in subsurface sediment adjacent to the Arkema Project Area. The focus will be to determine whether there is a potential presence of NAPL in Arkema Project Area sediment and to evaluate the potential need for additional characterization and consideration during remedial design.

Data will be collected to meet the following objectives:

- Locate sampling stations in the vicinity of "WB series" boreholes to evaluate the presence or absence of NAPL (5 stations).
- Evaluate the presence or absence of NAPL in the vicinity of Dock 2 (2 stations).
- Evaluate the presence or absence of NAPL between Dock 1 and the Salt Dock (1 station) and near the mouth of Saltzman Creek (4 stations).

3.3.3 Study Design

Sediment cores will be collected in Phase 1 using a vibracorer from 12 locations to evaluate potential subsurface NAPL in the Arkema Project Area (Figures 3-1 and 3-2a-b). Based on the results of the Phase 1 investigation, additional sampling to assess potential subsurface NAPL

may be conducted in Phase 2 using either a vibracorer (depths up to 15 ft) or sonic drill rig (depths greater than 15 ft).

The cores will be advanced to 15 ft bml or refusal, whichever comes first. The characterization of sheen, globule, and NAPL will consist of the following sequence of steps to be conducted under the supervision of an Oregon-registered geologist or Oregon-registered professional engineer with experience logging sediments:

1. Conduct unaided visual inspection, logging, and photo-documentation of the entire core.
2. Conduct UV fluorescence examination and photo-documentation of the entire core.
3. If potential NAPL[12] was identified in Steps 1 or 2 above, conduct a sediment-water shake test with hydrophobic dye on these portions of the sediment cores.
4. If the sediment-water shake test reveals potential NAPL, or other lines of observational evidence indicate potential NAPL presence (e.g., sheen, odor, photoionization detector reading), collect a sediment sample that contains the potential NAPL for laboratory analysis.

The FSP (Appendix A) provides a detailed description of each step. Figure 3-3a illustrates the corresponding decision process that will be used to guide the evaluation. The following sections provide background and an overview of each step.

3.3.3.1 Unaided Visual Assessment

Each core will be visually assessed and logged, and high-resolution photographs will be taken of each 2-ft section of core. The outside of the core will be removed by using a decontaminated stainless steel spoon or spatula to scrape off sediment that may be smeared on the outer core surface from a shallower depth. The visual assessment will include a physical description (e.g., color and consistency) of any sheens, globules, and the thickness of residual or mobile NAPL, if present. Details on the unaided visual assessment and key questions that will be addressed based on the observations are provided in the FSP (Appendix A).

3.3.3.2 Ultraviolet Fluorescence

Fluorescence refers to the spontaneous emission of visible light resulting from a concomitant movement of electrons to higher and lower energy states when excited by UV radiation (Cohen and Mercer 1993). Fluorescence spectra and data for numerous organic chemicals indicate that many NAPLs fluoresce, including nearly all crude oils and petroleum products (except for saturated aliphatic compounds such as paraffins), many unsaturated aliphatic hydrocarbons

[12] The term "potential NAPL" is used because the presence of NAPL has not been positively identified through laboratory tests.

(such as trichloroethene and tetrachloroethene), and nearly all aromatic and polyaromatic hydrocarbons (having one or more benzene rings, such as chlorobenzene) (Cohen et al. 1992).

UV fluorescence can produce false positives from non-target fluorescent materials like shell fragments or organic-rich material, including decaying wood debris that is present in sediment within the Arkema Project Area from log raft storage that predated and continued through portions of the chlor-alkali operations at the site. The shake test with a hydrophobic dye, discussed below, will provide an additional line of evidence that will allow differentiation from non-target fluorescent materials and can positively identify the presence or absence of NAPL.

Details on the UV fluorescence tent construction and screening protocols are shown in Figure 3-3b and presented in the FSP (Appendix A).

3.3.3.3 Shake Test with Hydrophobic Dye

Shake tests with sediment, water, and a hydrophobic dye such as Sudan IV can be used to determine the presence or absence of NAPL. Sudan IV is a reddish brown powder that dyes organic fluids red upon contact, but is practically insoluble in water at ambient temperatures (Cohen et al. 1992). A study conducted by Cohen et al. (1992) showed that mixing a small amount of hydrophobic dye with NAPL-contaminated soil and water was a simple and effective means for identifying the presence of NAPL in soil. Hydrophobic dye was previously used effectively to identify soil horizons that contained residual NAPL during the Upland Remedial Investigation at the Arkema site. In addition, this method can be used to determine NAPL density relative to water as well as to estimate the NAPL volume. Cohen et al. (1992) recommended that the dye shake tests be conducted in plastic containers such as polypropylene tubes because hydrophobic NAPLs generally wet plastic better than glass, thereby enhancing NAPL detection on the container wall.

Details on the preparation of shake test standards and shake test protocols are presented in the FSP (Appendix A).

3.3.3.4 Laboratory Assessment

The following sections briefly describe the laboratory analyses that will be conducted on sediment samples with potential NAPL. Sample volume may be limited, so priority will be given to the analysis of COCs.

Sediment Physical Parameters

All samples with evidence of NAPL will be tested for grain size by ASTM International (ASTM) D422 to assess any correlation between NAPL and grain size and to identify preferential transport pathways, if any. In addition, each sample will be analyzed for total organic carbon

by ASTM D4129 to assess any correlation of NAPL with areas of higher organic carbon content, if any.

NAPL Physical Parameters

All sediment samples with evidence of NAPL will be centrifuged in an analytical laboratory. If there is sufficient NAPL, the NAPL will be tested for density by ASTM D1481 and viscosity by ASTM D445 to assess NAPL physical characteristics and potential mobility.

Analysis of Contaminants of Concern

Sediment samples will be collected from 0–1 ft and every subsequent 1 ft to the total depth of the borehole and submitted to the analytical laboratory for analysis, or to be archived. Sample intervals for characterization of potential NAPL will be selected in consultation with EPA representatives in the field. Sediment samples with potential NAPL will be centrifuged at the analytical laboratory. If NAPL is present, the supernatant will be analyzed by the following methods:

- Diesel range organics by NWTPH-Dx
- Gasoline range organics by NWTPH–Gx
- VOCs by EPA Method 8260C.

The samples will be analyzed in accordance with the QAPP (Appendix B).

3.4 SEDIMENT STABILITY

If necessary based on the results from the Phase 1 investigation, sediment cores will be advanced during Phase 2 at two locations to assess historical deposition rates downstream of Dock 2, just upstream of Outfall 004, and approximately 400 ft downstream of Outfall 004 in the vicinity of the historical dock (Figure 3-1 and 3-2a-b). The problem statement, study goals, and study design are discussed in the following sections. Table 3-5 summarizes the DQOs following EPA's seven-step DQO process.

3.4.1 Problem Statement

The current assessment of the depositional regime in the Arkema Project Area, which is based on available bathymetric data collected as part of the Portland Harbor RI/FS and 2018 PDI, is inconclusive due to gaps in coverage for the nearshore area in this portion of the Portland Harbor site. However, the following lines of evidence indicate that natural recovery is occurring in the Arkema Project Area, including the area downstream of Dock 2:

- The presence of fine-grained surface sediment (e.g., silts and clays) indicative of relatively low-energy (depositional) environments
- Higher concentrations of COCs in subsurface than in surface sediment, indicating deposition of relatively cleaner material over sediment impacted by historical discharges
- Historical records indicating periodic maintenance dredging adjacent to the site docks, demonstrating that the area in the vicinity of the docks is a net depositional environment.

Additional information is needed to support consideration and incorporation of natural recovery into the remedial design.

3.4.2 Goals of the Study

The goal of this study is to assess the sediment deposition rate in the area downstream of Dock 2. Indication of a depositional regime through use of geochronology can provide an additional line of evidence to confirm and assess natural recovery processes and support consideration of this technology during remedial design. These additional data will support incorporation of remedial technologies such as monitored natural recovery or enhanced natural recovery to address the area downstream of Dock 2 where COC concentrations are substantially lower than between Docks 1 and 2.

3.4.3 Study Design

Two sediment cores will be collected from each of two locations downstream of Dock 2, in the vicinity of Outfall 004 and the historical dock. The sediment cores will be collected over water using a vessel-deployed vibracorer equipped with 15-ft core tubes. Samples from the first core will be collected at 2-in. intervals, homogenized, and submitted to the analytical laboratory for either analysis or archive. Initially, every third sediment sample (i.e., 4–6 in., 10–12 in., 16–18 in., 22–24 in., etc.) will be analyzed for the following constituents:

- DDx by EPA Method 8081B
- Cesium-137 by TBE-2005 SOP
- Lead-210 by TBE-2015 SOP.

A second core will be advanced at each location and the sediment will be submitted to the analytical laboratory to be archived. The core will be cut into manageable lengths (e.g., 2- to 3-ft-long sections), and each end will be securely capped. The cores will be placed in a cooler with ice and shipped to the analytical laboratory under chain-of-custody protocols (see Section 4.2).

The core collection, core processing, and sample handling methods will follow the FSP (Appendix A).

3.5 ADDITIONAL DESIGN SUPPORT DATA

Site-specific studies are required to support the selection and design of remedial technologies for remedial actions at the Arkema Project Area. These include (but may not be limited to) structural analysis, additional geotechnical investigation, topographic and bathymetric survey, a pre-dredge bathymetric survey, and additional debris survey as described below.

3.5.1 Structural Analysis

Inspection and analysis of existing onsite structures will occur, including the offshore docks and onshore buildings.

3.5.1.1 Problem Statement

There are three existing docks in the Arkema Project Area, a slurry wall near the bank line and a GWET facility located near the top of bank. The current composition and condition of these structures is relatively unknown. These docks (the Salt Dock, Dock 1, and Dock 2) are no longer in use and will be removed as part of the remediation work. Analysis of the current condition of the docks and the design components of each structure (i.e., footings, piling depth) plus hazardous material survey and utility surveys will inform the design of dock removal.

3.5.1.2 Goals of the Study

The objective of the structural assessment is to evaluate the potential effects of dredging and fill on the existing waterfront and shoreline structures (e.g., GWET building, slurry wall) related to dock removal. This assessment includes:

- Compile existing design drawings, reports, as-builts, and other descriptive materials that exists for the dock structures and building
- Visually inspect the existing structures
- Evaluate the application of remedial technologies below or adjacent to in-water and upland structures.
- Perform hazardous material inventory
- Perform utility survey.

3.5.1.3 Study Design

For this evaluation, a certified professional structural engineer, familiar with this type of dock construction and removal will analyze existing data, perform a site visit for inspection of the structures, and evaluate the current condition of the docks and shoreline structures.

Study of Existing Documents

Prior to visiting the site for inspection, the engineer conducting the assessment will review all relevant, necessary, and available documents and drawings including the preliminary assessment previously performed.

A review of these documents will provide the engineer an understanding of the layout, configuration, and original specified design loading of the structures, as well as identify any additions or alterations from the original condition, and identify critical areas to inspect in person.

Site Assessment

The engineer conducting the assessment will perform a site visit and onsite inspection of the structures. Supporting visual information such as figures and photographs are not sufficient to replace an onsite visit and inspection.

The visual site assessment will be performed to identify Dock construction methods and materials, and approaches to structure removal.

Evaluation of Effects on Remedial Action

Docks and shoreline structure findings will be used to support design of structure removal as part of the remedial action. The findings of this study will be provided in the final design report.

3.5.2 Survey

Accurate land survey data (upland topographic and sub-tidal bathymetry with appropriate overlap) are required for slope analysis, design of the remedy, and to obtain preconstruction baseline conditions. For design, a comprehensive topographic and bathymetric survey is required. Prior to construction, a pre-dredge bathymetric survey is required.

3.5.2.1 Problem Statement

Recent bathymetric and Lidar surveys were performed for the Pre-RD Group and LSS, respectively, and are available for current in-water elevations. Accurate shallow, riverbank, and upland topography is required for slope stability analysis, debris mapping, remedial design, and construction planning.

Additionally, a pre-dredge bathymetric survey will be required immediately prior to construction to verify the final project design elements and, more importantly, to establish an accurate project baseline sediment condition. The pre-dredge survey is the surface to which post-dredge and backfill surveys can be compared, and the required dredge depth and backfill thickness confirmed.

3.5.2.2 Goals of the Study

The goals of the survey study are to perform an accurate evaluation of current conditions at the Arkema Project Area, a design level evaluation of potential remedy components, and the design of a final, effective remedy in the Arkema Project Area.

3.5.2.3 Study Design

The recent Pre-RD Group bathymetric survey was combined with the Arkema LIDAR data, and will be combined with an upland topographic survey, as needed. The final surface will comprise the offshore river regions, from the navigation channel to the shallow river region, and extend up the riverbank into the adjacent upland operational areas to NW Front Avenue. The shoreline area includes three dock structures and several stormwater outfalls.

3.5.3 Debris

Debris has been identified as present in the Arkema Project Area.

3.5.3.1 Problem Statement

Years of industrial use in the Portland Harbor site reach of the Willamette River has resulted in significant debris in the banks and riverbed. Typical debris often scattered along and buried in the riverbed includes individual pieces or clusters of large debris, smaller undifferentiated debris, and remnant structures or pilings. Individual and undifferentiated debris often comprises sunken logs and pilings; large rocks, rubble, and broken concrete; and other industrial and construction demolition debris. Remnant structures and pilings are also common and often include groups of pilings and stringers, vertical pile fields, and other remnant components of underdeck structures.

Debris can be detrimental to remedial actions. Large debris can breach the layers and/or preclude placement of sufficient cap or cover material. During dredging, debris can obstruct access to target sediment, as well as prevent a dredging bucket from fully closing. Loss of sediment from the unclosed bucket dramatically increases resuspension/turbidity, and in turn causes increased generated residuals on the riverbed. Additionally, large debris that is embedded into oversteepened slopes can reduce slope stability when removed. Remnant structures such as standing piles can prevent access for floating remedial construction

equipment. Groups of remnant pilings will interfere with the dredge bucket, limiting or preventing access to the sediment, and cause incomplete removal around and between pilings. Remnant pilings will also interfere with consistent placement of cover material.

A visual surface debris survey was conducted in 2009. A summary of the surface debris observed on the riverbank and in-water portions of the Arkema Project Area at that time is provided in Section 2.7.6.

3.5.3.2 Goals of the Study

The objective of this study is to identify and map debris in the Arkema Project Area to the extent practicable. The debris mapping will be used during riverbank assessment for erodibility, as well as remedial design and remedial action to provide proper debris management.

3.5.3.3 Study Design

This study will consist of a detailed analysis of the multibeam bathymetric survey to identify anomalies indicating the presence of debris. An additional, low-water, visual and global positioning system (GPS) survey will be performed to accurately identify and map surface debris visible and accessible in the shallow water and shoreline areas. This analysis will be combined with existing visual debris survey information for use during remedial design and construction.

3.6 GROUNDWATER DISCHARGE AND COC FLUX

The following sections briefly describe the field methods to be used to collect data to fill the data gaps identified in Section 2.11.3. The problem statement, study goals, and study design are discussed. Table 3-6 summarizes the DQOs following EPA's seven-step DQO process. These data will be used to understand current groundwater conditions and potential for COC flux, and will be used for cap design.

3.6.1 Residual COCs in Groundwater

The problem statement, study goals, and study design for COCs in groundwater are presented below.

3.6.1.1 Problem Statement

Discharge of COCs in groundwater upgradient of the groundwater barrier wall has been controlled at the Arkema site for about 8 years; however, recent groundwater concentration measurements indicate that chlorobenzene and other chemicals are still present at elevated

concentrations in groundwater downgradient of the groundwater barrier wall. The potential for residual COCs in the area downgradient of the barrier wall to contribute to COC flux during and after sediment remediation is not currently known.

3.6.1.2 Goals of the Study

The goal of this study is to generate data that can be used to evaluate the COC concentrations that could potentially contribute to COC flux from the downgradient side of the groundwater barrier wall through Willamette River sediment.

3.6.1.3 Study Design

Groundwater samples will be collected from each of three well clusters at the top of the riverbank and analyzed for COCs (Figure 3-4). These samples may be collected as part of the ongoing quarterly groundwater monitoring conducted to evaluate changes in groundwater COC concentrations in the vicinity of the groundwater SCMs. In addition, groundwater samples will be collected from piezometers PZ-1 through PZ-4 to define COC concentrations between the riverbank and the point of discharge (seepage meters).

Samples will be collected from shallow wells MWA-2, MWA-61, and MWA-69; intermediate or shallow-intermediate wells MWA-8i, MWA-64i, MWA-67si, and MWA-66i; deep wells PA-19d and PA-21d; and piezometers PZ-1 through PZ-4 (Figure 3-4). The samples will be analyzed for the following:

- DDx by EPA Method 8081B
- VOCs by EPA Method 8260C.

The samples will be analyzed in accordance with the QAPP (Appendix B).

The resulting COC concentration data will be compared to historical COC concentration data to evaluate the change in COC concentrations since implementation of the groundwater SCMs. The new COC concentration data will also be used to evaluate the potential COC flux and cap design calculations.

3.6.2 Hydraulic Gradient and Groundwater Flux

The problem statement, study goals, and study design for hydraulic gradient and groundwater flux are presented below.

3.6.2.1 Problem Statement

No assessment of groundwater gradients and groundwater flux downgradient of the groundwater barrier wall has been conducted since groundwater SCMs were installed in 2012–

2013. UltraSeep surveys were conducted in 2004 and 2005 (see Section 2.6), prior to implementation of the groundwater SCMs. The installation of the groundwater SCMs has altered the hydraulic flow system from the Arkema Project Area riverbank through the adjacent Willamette River sediment. The 2004/2005 groundwater discharge data collected by the LWG are not representative of current conditions in the Arkema Project Area, and no data have been collected since 2012 to evaluate the current flow system.

3.6.2.2 Goals of the Study

The goal of this study is to generate data that can be used to evaluate the current groundwater flow system, including hydraulic gradients and groundwater flux to the Willamette River downgradient of the upland groundwater barrier wall.

3.6.2.3 Study Design

To evaluate the current groundwater flow system, a combination of monitoring wells at the top of the riverbank, piezometers at the toe of riverbank slope, and a stilling well measuring the Willamette River stage will be used to calculate groundwater gradients and flux.

Water level measurements will be collected from four well clusters along the top of the riverbank slope, but immediately downgradient of the groundwater SCM barrier wall. The well clusters to be monitored include Cluster 1—shallow well MWA-2, intermediate well MWA-8i, and deep well PA-19d; Cluster 2—shallow well MWA-61, shallow-intermediate well MWA-67si, and intermediate well MWA-64i; Cluster 3—shallow well MWA-69, intermediate well MWA-66i, and deep well PA-21d; and Cluster 4—shallow well MWA-46, intermediate well MWA-49i, and deep well MWA-56d (Figure 3-4). Water levels in four piezometers at the toe of the slope below each of these well clusters, piezometers P-1, P-2, P-3, and P-4, will also be monitored (Figure 3-4). The target screen elevation for the piezometers will be the intermediate groundwater zone as defined by stratigraphy, COC concentrations, and field screening using a photoionization detector. Historically, the intermediate groundwater zone has the highest concentrations of chlorobenzene.

Pressure transducers are already deployed in each monitoring well and the stilling well as part of the monitoring associated with the GWET system. Additional pressure transducers and data loggers will be placed in the toe-of-slope piezometers. Pressure readings will be collected every 15 minutes for a minimum of 71 hours (to allow for tidal influence filtering), and measurement times will be synchronized between the monitoring wells, piezometers, and stilling well. At the monitoring wells and piezometers, depth to water measurements will be collected at the surveyed mark at the top of each well casing during deployment and retrieval using an electronic water level meter with an accuracy of 0.01 ft. The manually collected groundwater level measurements will be used for potentiometric surface calculation verification and quality assurance. Piezometers and any other unsurveyed monitoring locations will be surveyed by an

Oregon-licensed surveyor. Data will be downloaded from each transducer and corrected for barometric pressure (if non-vented transducers are used).

3.6.3 COC Flux to the River

The problem statement, study goals, and study design for COC flux to the river are presented below.

3.6.3.1 Problem Statement

Understanding the potential post-remediation flux, if any, of COCs in groundwater to the river is essential for cap design considerations. TZW sampling was conducted by the LWG in 2004 and 2005; however, these studies were completed prior to the construction of the Arkema groundwater SCMs. It is reasonable to assume that 8 years after groundwater SCM implementation, changes in TZW COC concentrations and/or flux have occurred; however, no new TZW COC concentration or flux data have been collected since groundwater SCM implementation.

3.6.3.2 Goals of the Study

The goal of this study is to generate data that when combined with the COC concentration data (Section 3.6.1) and groundwater gradient and flux data (Section 3.6.2) can be used as inputs for remedial cap design.

3.6.3.3 Study Design

COC flux to the river will be calculated using data from monitoring wells, piezometers, and a Willamette River stilling well, as described in Sections 3.6.1 and 3.6.2. In addition, the current rate of groundwater flux and the COC concentrations in discharging TZW will be directly measured using seepage meters.

Eight seepage meters, SMS-1 through SMS-8 (Figure 3-4), will be deployed by divers in accordance with the FSP (Appendix A). Seepage meter placement is along transects from the shoreline towards the channel (e.g., SMS-5 to SMS-1, SMS-6 to SMS-2, SMS-7 to SMS-3, and SMS-8 to SMS-4). The target elevation for the seepage meters near the channel is the upland intermediate groundwater zone as defined by stratigraphy and COC concentrations. Historically and currently, the intermediate groundwater zone has the highest concentrations of chlorobenzene. Water flux measurements will be collected at least every 15 minutes. Concentrations of COCs will also be directly measured by collecting one groundwater/TZW sample from each seepage meter during deployment.

Transition zone samples will be collected from the eight seepage meter locations between Docks 1 and 2 (Figure 3-4). All transition zone samples will be analyzed for the following:

- DDx by EPA Method 8081B
- VOCs by EPA Method 8260C.

The samples will be analyzed in accordance with the QAPP (Appendix B).

Finally, the Trident Probe™ (or equivalent system) will be used to collect sediment porewater samples from three locations in support of sediment cap design (Figure 3-5). The samples will be collected at depths of approximately 1, 2, and 3 ft bml to assess any vertical gradients. The samples will be analyzed for the following:

- Dissolved organic carbon by APHA SM 5310B
- VOCs by EPA Method 8260C.

The samples will be analyzed in accordance with the QAPP (Appendix B).

3.7 HYDRODYNAMIC EVALUATIONS

The hydrodynamics of the Arkema Project Area are influenced by the rainfall and snow melt in the Willamette basin, the stage of the Columbia River, short-term stagnations and reversals in flow during periods of low river flow and extreme high tides, and the operation of dams in the Columbia and Willamette river basins. The resulting flow hydrodynamics are complex, and influence sediment transport.

3.7.1 Problem Statement

Sediment stability in the Arkema Project Area is a critical element in selecting and designing an appropriate remedy. The Arkema Project Area is located in a predominately depositional environment in the Portland Harbor study area, as confirmed by previous bathymetric surveys.

3.7.2 Goals of the Study

The goal of the hydrodynamic evaluation study is to assess how river dynamics related to flow patterns, wind-generated waves, vessel wakes, and propeller wash may impact future remedial actions in the Arkema Project Area. The potential for river dynamics (natural and anthropogenic) to impact remedial design will be evaluated. The existing docks (the Salt Dock, Dock 1, and Dock 2) are no longer in use and will be removed as part of the remediation work. The effects of their removal will be evaluated. The study will involve the following:

- Compile and review existing hydrodynamic data, studies, and evaluations, including reports for the Portland Harbor RI/FS and bathymetric data from Pre-RD Group, LWG, and USACE.

- Make field observations of site conditions including:
  - Vessel traffic, including vessel size, type, and typical sailing distance from dock face, and resulting wake generation and interaction of wake with shoreline.
  - Wind-driven wave interactions with the shoreline
  - Evidence of erosional areas, areas of wave focusing, or eddies.
- Tabulate hydrodynamic factors and discuss potential impacts specific to Arkema Project Area dredging and capping from ship wakes, wind-generated waves, propeller wash, river currents, and potential eddies.

3.7.3 Study Design

The hydrodynamic evaluation study will employ existing, available data from public sources, such as the U.S. Geological Survey, Portland Harbor studies, and other sites on the Willamette River. These historical evaluations that were conducted on a regional level will be evaluated in the context of their applicability to the Arkema Project Area.

3.7.3.1 Existing Hydrodynamic Data

Existing hydrodynamic data will be compiled and reviewed. Hydrodynamic data from the Portland Harbor feasibility study Appendix H (USEPA 2016b) and other locally available hydrodynamic data sources will be reviewed to determine their relevance to the Arkema Project Area. Analysis of the data will include review of assumptions, methods, modeling inputs, and field-collected data.

Portland Harbor Feasibility Study Appendix H

The Portland Harbor feasibility study Appendix H data will be reviewed for its applicability to Arkema Project Area including:

- Screening level analysis of caps (6 to 72 in. thick) and armoring requirements
- Wind- and vessel-generated wave analyses that included design water levels, evaluation of wind-induced waves, vessel-generated wave (wake) analysis, shoreline armor layer evaluation, proposed shoreline geometry, and stable particle size offshore of the shoreline to resist waves
- Propeller wash analysis of vessels across a range of conditions and operations
- 100-year flood analysis of the stable particle size associated with these river currents in a steady-state simulation
- Calculated erosion and deposition rates between multibeam hydrographic surveys.

3.7.3.2 Site Visit and Observation

A site visit will be conducted to observe and record site conditions over multiple (greater than 2) days and to visually assess hydrodynamic conditions at the Arkema Project Area. It is anticipated that conditions will vary along the Arkema Project Area.

3.7.3.3 Hydrodynamic Evaluation

Based on the review of existing hydrodynamic data and the site visit and observations, site-specific conclusions will be developed regarding the potential hydrodynamic impacts on Arkema Project Area remedial design.

Available data for each of the hydrodynamic factors specific to the Arkema Project Area will be tabulated and presented as listed below:

- Ship wakes
- Wind-generated waves
- Propeller wash
- River currents and potential eddies
- River bed and bank erosion and deposition.

3.8 GEOTECHNICAL EVALUATION

A site-specific geotechnical evaluation is required to support the selection and design of remedial technologies for the Arkema Project Area. Table 3-7 summarizes the DQOs following EPA's seven-step process.

3.8.1 Problem Statement

Bank erosion has been recognized as a potential recontamination pathway, and bank steepness and stability are remedy design factors; therefore, an offshore investigation will be performed to establish sediment conditions across the Arkema Project Area.

Dredging performed on oversteepened or otherwise unstable slopes can result in slope failures and potential undermining of riverbanks and adjacent offshore and nearshore structures. Dredging in the vicinity of structures and pilings can reduce the amount of available soil to resist lateral loading and can potentially undermine relatively shallow piles. The geotechnical characteristics of the sediment will also be evaluated in conjunction with the structural analysis for assessing implementability limitations regarding dredging setbacks from docks and in-water structures. This evaluation will provide design level data that will identify remedial action implementability concerns associated with sediment and riverbank slope stability.

Site-specific data are needed to perform engineering evaluations of static and seismic slope stability, dredge methods and dredged material processing and disposal, and cap design.

3.8.2 Goals of the Study

The objective of the geotechnical assessment will be to establish sediment conditions across the Arkema Project Area by advancing a limited number of sediment borings. This information will be used as a basis for providing geotechnical design information for the remedial action. This assessment includes:

- Compilation of existing geotechnical information and reports from previous Arkema Project Area studies, including slurry wall construction data and as-builts
- Evaluation of offshore sediment conditions to depths appropriate for dredging design purposes
- Characterization of sediment physical parameters to evaluate sediment retrieval, handling, and disposal methods
- Characterization of sediment physical parameters and geotechnical engineering to evaluate slope stability
- Evaluation of potential effects of planned dock removal.

Data from this evaluation will also be used to present a discussion of seismic liquefaction and lateral spreading hazards (not an assessment) for contingency-level earthquake events as required in the ROD.

3.8.3 Study Design

Sediment borings will be advanced at seven locations (Figure 3-6). SPTs will be performed on split spoon samples to obtain blow-count data. Samples of the sediment will be collected for laboratory index testing of physical parameters, including moisture content, grain size distribution, Atterberg Limits (plasticity), total organic carbon, and bulk density. Shelby tube samples will be collected at selected depth intervals to obtain intact samples for laboratory testing of engineering properties such as shear strength and consolidation. Locations are selected to be representative of varying substrates within the potential dredging areas, based on previous studies.

Along the riverbank, shallow test pit explorations will be excavated at six locations using a track-mounted backhoe or excavator to a depth of approximately 6 ft bgs (Figure 3-6). Select soil samples will be analyzed for the following physical properties: moisture content, grain size analysis, Atterberg limits, and organic content.

3.9 PHASED PRE-DESIGN INVESTIGATION APPROACH

The PDI will be conducted in two phases to optimize sample collection and analysis and use of data for remedial decision-making. The purposes of the phased approach is to collect data that meet DQOs and to focus the remedial design investigation, as needed, and directed by the data, and in consultation with EPA. Detailed rationale for phasing has been provided in selected parts of Section 3. In summary, the elements of the PDI will be phased as follows:

Phase 1

- Subsurface sediment chemistry
- NAPL investigation
- Riverbank soil investigation
- Porewater sampling
- Groundwater discharge study

Phase 2

- Geotechnical sediment cores
- Geotechnical soil test pits
- Surface sediment, if needed
- Geochronology cores, if needed
- Additional subsurface sediment chemistry or NAPL investigation, if needed, for improved remedial design boundary delineation.

4 FIELD METHODOLOGY

This section presents the methodology for the surface sediment, subsurface sediment, riverbank soil, additional design support data, hydrodynamic evaluation, groundwater discharge, and porewater chemistry investigations. Additional details on the sampling and analytical methodology are presented in the FSP and QAPP (Appendices A and B, respectively). All work will be conducted in accordance with the site-specific health and safety plan presented in Appendix C. Emergency response procedures will follow the emergency response plan in Appendix D.

4.1 SURFACE SEDIMENT

If needed for Phase 2, surface sediment (0–1 ft bml) samples for chemistry analyses will be collected using a vessel-deployed power grab or equivalent sediment sampler. Three subsamples will be collected within a 5-ft radius from each station and homogenized into a composite sample.

4.2 SUBSURFACE SEDIMENT

Subsurface sediment samples are being collected for the evaluation of focused COCs and any NAPL for remedial design. The following sections discuss sonic, mud-rotary, and vibracore sediment sample collection.

4.2.1 Sonic Drilling

If needed for Phase 2, boreholes will be advanced using a track- or rubber tire-mounted sonic drill rig mounted on a barge. The boreholes will be advanced through moon holes on the barge. During advancement of the over-water boreholes, the river stage/barge deck elevation will be monitored using a survey-grade differential GPS unit on the barge deck, and the sample intervals will be adjusted based on the river stage changes. The river stage and sample interval calculations will be displayed on a white board near the drill rig so the drilling crew can refer to them prior to collecting each sediment sample.

Sediment samples will be collected in 2.5-ft drives with an Osterberg piston-type sampler. The Osterberg sampler will be equipped with a split spoon or 2.5-ft-long by 3-in.-diameter Shelby Tube, which will allow for the collection of relatively undisturbed samples that will be useful for assessing any NAPL. The 6-in.-diameter casing will be advanced when the bearing capacity of the sediments is sufficient to support the weight of the casing. The casing will be advanced to the top of the sample interval prior to sample collection.

Once the casing is advanced to the approximate top of the sample interval, the Osterberg sampler will be advanced ahead of the end of the casing to collect a representative sediment sample. Once the sampler is retrieved, the casing will be advanced to the bottom of the previously sampled interval while potable water is pumped at high pressure through the casing to keep sediment from entering the casing. The sample intervals/casing depths will be adjusted as needed approximately every 15–30 minutes to compensate for tidal or river stage fluctuations in the Willamette River.

4.2.2 Mud-Rotary Drilling

Sediment borings for geotechnical analysis will be advanced to dense soil or bedrock at seven locations using barge-mounted mud-rotary drill equipment. During advancement of all overwater boreholes, the river stage/barge deck elevation will be monitored using a survey-grade GPS unit on the barge deck, and the sample intervals will be adjusted based on the river stage changes. The river stage and sample interval calculations will be displayed on a white board near the drill rig so the drilling crew can refer to them prior to collecting each sediment sample.

Mud-rotary borings are advanced by grinding the subsurface material (in this case sediments) using a drill bit attached to a rapidly rotating drill string consisting of hollow steel rods. During drilling, drilling mud is forced downward through the hollow drill string to keep the hole open, prevent caving, and prevent heaving. The mud exits the drill string through the drill bit and pushes the sediment cuttings to the annular space surrounding the drill bit. Mud, along with the sediment cuttings, is then transported upward through the annulus surrounding the drill string out of the boring and into a settling tank at the surface equipped with screens that remove some of the cuttings prior to the mud being recirculated. To maintain separation of drilling fluid from the surrounding water column, temporary conductor casing will be used within the drilling string. A bentonite based drilling fluid may be used during drilling to keep the borehole open and to remove cuttings. The samples will be collected using a split spoon sampler (disturbed samples) or Shelby tube (relatively undisturbed samples of cohesive material). Additional details on the sampling methodology is presented in the FSP (Appendix A).

4.2.3 Vibracore Sediment Sampling

Vibracore sediment sampling will be conducted from a vessel using 16-ft core tubes. The vibracorer uses a hydraulic system that vibrates and drives a 4-in. outside diameter aluminum core tube into the sediment. A continuous sediment sample is retained within the tubing with the aid of a core cutter/catcher attached to the bottom of each tube. The core tube will be driven to the target depth of 16 ft bml or refusal, whichever comes first, and retrieved. The core will be deemed acceptable if the sediment recovery inside the core tube is at least 80 percent of the penetration depth. If the core is deemed acceptable, it will be cut into two equal lengths (i.e.,

approximately 8 ft long) using a decontaminated pipe cutter or similar device. Prior to the core tube being cut, the depth bml will be labeled at 1-ft intervals, and a label that includes the station ID, core section, time, and date will be securely attached to the top of each section. The cores will be capped and stored in a refrigerated trailer in a vertical position prior to field screening and processing.

4.3 RIVERBANK SOIL

The following sections discuss the field methodology for hand auger boreholes and test pit explorations.

4.3.1 Hand Auger Boreholes

Soil borings will be advanced at 31 locations using a hand auger to a depth of 4 ft bgs. Soil samples will be collected at 1-ft intervals for chemical analysis or archive. A small portion of soil will be retained for field screening of organic vapors using a photoionization detector or equivalent organic vapor monitoring instrument.

4.3.2 Test Pit Explorations

Shallow test pit explorations will be excavated using a track-mounted backhoe or excavator at six locations in the riverbank area to a depth of approximately 6 ft bgs. The upper 1–2 ft of soil from the test pit area (approximately 6 ft wide by 8 ft long) will be removed and placed to one side of the excavation. The excavation will be continued using the excavator, placing the excavated soil on the opposite side of the excavation until the appropriate depth and width are obtained. Soil samples greater than 3 ft bgs will be collected using the backhoe or excavator bucket.

4.4 GROUNDWATER DISCHARGE STUDY

The following sections briefly describe the field procedures for installing piezometers, groundwater monitoring, and using seepage meters.

4.4.1 Piezometer Installation

Four piezometers will be installed along the toe of the riverbank slope to a target depth of approximately 20 to 30 ft bgs using a track-mounted Sonic drill rig. The piezometers will be installed by a well driller licensed in Oregon. The piezometers will be 2-in.-diameter and constructed with 5 ft of Schedule 40 Type 304 stainless steel 0.010-in. slot screen and Schedule 40 PVC that will extend 2–3 ft above ground surface. The top of piezometer casing will be surveyed by a professional land surveyor licensed in Oregon. The elevation of the top of the

piezometer casing and the ground surface will be surveyed within 0.01 ft, and the horizontal location of each piezometer casing will be surveyed to an accuracy of 0.1 ft.

4.4.2 Groundwater Monitoring

Pressure transducers are already deployed in each monitoring well and the dock stilling well as part of the monitoring associated with the GWET system. Pressure readings will be collected every 15 minutes for at least 71 hours and the measurement times will be synchronized between the monitoring wells and stilling well. Depth to water measurements will be collected at the notch on each well casing during deployment retrieval activities at each well using an electronic water level meter with an accuracy of 0.01 ft. The data will be downloaded from each transducer and corrected for barometric pressure (if non-vented transducers are used).

Groundwater sampling will be conducted using low-flow sampling techniques. The monitoring wells and piezometers will be purged and water quality parameters (temperature, pH, oxidation reduction potential, and specific conductance) will be recorded. A peristaltic pump or equivalent will be used to purge and sample the wells. Sample parameters will be allowed to stabilize prior to sampling.

4.4.3 Seepage Meters

UltraSeep seepage meters will be deployed by divers at eight locations. The UltraSeep system will be programmed to collect continuous flow data and multiple TZW samples from each of these stations over the course of 24 hours. At the end of the deployment period, divers will retrieve the UltraSeep system and associated TZW samples.

4.5 SEDIMENT POREWATER

The Trident Probe™ (or equivalent system) will be deployed from a small, well-anchored vessel using an aluminum push rod, along with a submersible air-hammer to assist in driving the probe into the sediment. The Trident Probe™ will be used to collect sediment porewater samples from three locations to measure dissolved organic carbon and VOCs in support of sediment cap design (Figure 3-5). The samples will be collected at depths of approximately 1, 2, and 3 ft bml to assess any vertical gradients in dissolved organic carbon and VOCs.

4.6 ADDITIONAL DESIGN SUPPORT DATA

Field procedures for the additional design support data will be performed in accordance with the standards and acceptable practices of the professionals in their fields, and as briefly described in the following sections.

4.6.1 Dock Structural Analysis

A wide range of different assessment procedures exists with varying complexity, and the choice of the appropriate procedure largely depends on the specified requirements of assessment. The professional engineer performing the structural analysis is required to demonstrate knowledge and experience in the materials of the structures; methods associated with constructing and demolishing the structures; typical failure mechanisms; and general structural engineering and analysis.

For the structural analysis, the engineer performing the assessment will perform an onsite visual inspection that will include the following, at a minimum:

- Access to the docks
  - Access to the underside of the dock provided by boat
  - Access to the deck side of the docks by land
- Visual inspection
  - Photographs
  - Diagrams
- Reporting
  - Conclusions
  - Recommendations.

4.6.2 Survey

Base mapping will be at a scale as requested, with an associated terrain model sufficient to define contours at 1.0-ft intervals, and errors shall not exceed 0.5-ft contour intervals. The control network will have a closure of 1:10,000 or better. The details are as follows:

- Control Network—The horizontal datum will be based on the Oregon Real Time GPS Network, State Plane Oregon North Coordinates NAD 83 2011(2010) Oregon Coordinate Reference System, Portland zone, or existing control from previous phases of work. The vertical control will be on the NAVD 88 (Geoid 12B).
- Topographic Survey Base Map—Topographic information will be provided on all general features within the boundary of the existing Arkema Project Area. The contractor will collect data within the Arkema Project Area using terrestrial or GPS methods. The base map will include the following:
  - Location of structures, man-made and natural features, fence lines, etc.

- Location of significant trees and type (6-in. in diameter or greater), landscaping, hedges, planters, walls, etc.
- All visible utility lines and facilities showing inverts and rim elevation, as accessible
- Buried utilities that are identified by utility locating services
- Existing ground shots, including any grade breaks, as required to define the existing ground surface
- Existing rail tracks
- Existing wells.

4.6.3 Debris

Field procedures during the low water visual survey will include:

- Visual identification of debris:
  - Notes on description
  - Diagram of approximate location
  - Photographs
- GPS location of visible, accessible debris on shoreline and as accessible into shallow water regions (i.e. using hip waders).

4.7 HYDRODYNAMIC EVALUATIONS

Field procedures for the hydrodynamic evaluations will be performed in accordance with the standards and acceptable practices of the professionals in their fields, and as briefly described in the following sections.

The existing docks (the Salt Dock, Dock 1, and Dock 2) are no longer in use and will be removed as part of the remediation work. Their removal will need to be included in the hydrodynamic evaluation.

4.7.1 Site Visit and Observations

Personnel will visit the Arkema Project Area to make visual observations. Access will be arranged through the site manager and all access protocols will be followed. As available, the following will be observed:

- Vessel traffic and types
- Wake generation

- Wave interaction with shoreline and structures
- Any visual indications of large scale eddy conditions.

As part of the site visit, interviews will be conducted with facility personnel and other river users, as available, regarding their experiences on the river in this area.

4.7.2 Reporting

The hydrodynamic evaluation report will include the following:

- Summary of publicly available Portland Harbor data applicable to the Arkema Project Area
- Arkema Project Area maps showing areas of potential site-specific impacts from various hydrodynamic factors including:
  - Ship wakes
  - Wind generated waves
  - Propeller wash
  - River currents and potential eddies
  - River bed and bank erosion and deposition
- Discussion of the potential impacts of hydrodynamic factors on remedial design
- GIS/CAD files for provision to EPA upon request.

5 PROJECT TEAM AND RESPONSIBILITIES

The following sections present the project coordinator, supervising contractor, and investigation team.

5.1 PROJECT COORDINATOR AND SUPERVISING CONTRACTOR

The project coordinator is **Mike Pinto with LSS, agent for Arkema**. Mr. Pinto will be responsible for overseeing work plan implementation and will coordinate all activities with EPA and Oregon DEQ project coordinators. Mr. Pinto will be responsible for contracting with and directly supervising the environmental consultants who will conduct the field, laboratory, analysis, and reporting tasks. He will direct the consultants on a day-to-day basis and provide primary review of all reports and other work products. Mr. Pinto will also coordinate with EPA regarding the ASAOC.

The supervising contractor is **Eron Dodak** of Integral. Mr. Dodak will supervise the work and ensure that a quality assurance system is followed that complies with ASQ/ANSI E4:2014, "Quality management systems for environmental information and technology programs - Requirements with guidance for use" (ASQ/ANSI 2014).

5.2 INVESTIGATION TEAM

The investigation team will be led by Dalton Olmsted & Fuglevand (DOF) for engineering matters and Integral for chemistry and other analyses.

5.2.1 DOF Team

The DOF team will be led by **Rob Webb**, a professional engineer in Oregon. Mr. Webb is the DOF principal-in-charge and will serve as the point of contact for LSS for all engineering matters. He will be responsible for implementing and executing the technical, quality assurance, and administrative aspects of the engineering investigations. Mr. Webb will be responsible for the quality and timeliness of DOF documents. He will be assisted by **Tasya Gray**, a registered geologist in Oregon, the engineering investigation project/quality assurance manager. Ms. Gray is responsible for ensuring that the work plan components related to engineering design are implemented in accordance with applicable plans and guidelines.

5.2.2 Integral Team

The Integral team will be led by **David Livermore**, a registered geologist in Oregon. Mr. Livermore is the Integral principal-in-charge and will serve as the point of contact for LSS

for all chemistry and other non-engineering related matters. He will be responsible for implementing and executing the technical, quality assurance, and administrative aspects of the chemistry and other non-engineering investigations. Mr. Livermore will be responsible for the quality and timeliness of Integral documents. He will be assisted by **Eron Dodak**, a registered geologist in Oregon, the project/quality assurance manager for the chemistry and other non-engineering investigations. Mr. Dodak is responsible for ensuring that the work plan is implemented in accordance with applicable plans and guidelines. He will communicate all technical, quality assurance, and administrative matters to the Integral, DOF, and LSS project managers. He will ensure that any deviations from the approved work plan are documented, communicated to LSS, and approved before implementation.

The overall management of the project-specific quality assurance activities is the responsibility of the lead chemist, **Glenn Esler**. Mr. Esler is responsible for implementation of site-specific quality assurance activities, including field and laboratory quality control. In addition, Mr. Esler will coordinate with the Integral and DOF project and task managers and other project staff, as applicable, during the reduction, review, and reporting of analytical data.

Jane Sund, a professional engineer in Oregon, will be the field operations manager and will advise the project staff on health and safety issues, conduct health and safety training sessions, and monitor the effectiveness of the health and safety program conducted in the field. As the field operations manager, Ms. Sund will be responsible for managing and supervising the field investigation program and providing consultation and decision-making on day-to-day issues relating to the sampling activities. She will monitor the sampling to ensure that operations are consistent with plans and procedures and that the data acquired meet the analytical and data quality needs. When necessary, Ms. Sund will document any deviations from the plans and procedures for approval. She will be assisted in the field by other technical personnel to be determined.

6 SCHEDULE

The schedule presented in Section VI of the Arkema Statement of Work in the ASAOC provides a remedial design timeline under which all deliverables and tasks must be submitted or completed. It is the intention of LSS to prepare the deliverables according to an efficient remedial design schedule. The proposed schedule for the deliverables and tasks through the final PDI evaluation report is as follows:

- Submit draft PDI work plan to EPA—June 18, 2020
- EPA review of draft PDI work plan—July 18, 2020 (assumes 30-day review period)
- Final PDI Work Plan—September 16, 2020 (assumes 60 days after EPA comments on the draft PDI work plan)
- EPA review and approval of final PDI work plan—October 16, 2020 (assumes 30-day review period).

(The following activities are contingent upon approval of the final PDI work plan on October 16, 2020, and contractor availability.)

- Phase 1 Field Investigation—Fall 2020 and Winter 2021
- Phase 1 Data Analysis and Review—Winter and Spring 2021
- Draft Phase 2 Scope of Work Memorandum—May 2021
- EPA review of draft Scope of Work Memorandum—June 2021 (assumes 30-day review period)
- Final Phase 2 Scope of Work Memorandum—July 2021
- Phase 2 Field Investigation—August and September 2021
- Phase 2 Data Analysis and Review—Fall 2021 and Winter 2022
- Draft PDI Evaluation Report—90 days after validation of Phase 2 data
- Final PDI Evaluation Report—60 days after EPA's comments on the draft PDI evaluation report.

7 REFERENCES

AECOM and Geosyntec. 2019. Pre-remedial design footprint report, Portland Harbor pre-remedial design investigation and baseline sampling, Portland Harbor Superfund Site, Portland, OR. AECOM, Portland, OR. Geosyntec Consultants, Seattle, WA. January 7.

Anchor. 2003. Sediment stake erosion/accretion monitoring report, Round 1A, Portland Harbor RI/FS. Prepared for Lower Willamette Group, Portland, OR. Anchor Environmental, LLC, Seattle, WA.

Anchor QEA, Windward, Kennedy/Jenks, and Integral. 2012. Portland Harbor RI/FS draft feasibility study. Prepared for the Lower Willamette Group, Portland, OR. March 30.

ASQ/ANSI. 2014. Quality management systems for environmental information and technology programs—Requirements with guidance for use. Prepared for the American National Standards Institute. ASQ Quality Press, Milwaukee, MI. 80 pp.

Blaauw, H.G., and E.J. van de Kaa. 1978. Erosion of bottom and banks caused by the screw race of maneuvering ships. Publication No. 202, Delft Hydraulics Laboratory, Delft, The Netherlands, presented at the Seventh International Harbor Congress, Antwerp, May 22-26.

CDM Smith. 2013. Arkema offshore NAPL evaluation. Technical memorandum to S. Sheldrake, U.S. Environmental Protection Agency, from L. Peterson and S. Dent, dated June 25, 2013. CDM Smith Inc.

City of Portland. 2007. City Outfall Basin 22C Northwest Drainage Pond Evaluation. Technical Memorandum No. OF22C-3, dated April 18, 2007.

City of Portland. 2013. Completion summary for City of Portland Outfall Basin 22. City of Portland. December.

City of Portland. 2015. Outfall Basin 22 dry-weather flow, inline solids, and sediment investigation. Technical Memorandum No. OF 22-2, City of Portland Outfall Project, ECSI No. 2425. July.

Cohen, R.M., and J.W. Mercer. 1993. *DNAPL site evaluation*. CRC Press, Inc., Boca Raton, FL.

Cohen, R.M, A.P. Bryda, S.T. Shaw, and C.P. Spalding. 1992. Evaluation of visual methods to detect NAPL in soil and water. *Groundwater Monitoring Review* 12(4)132–141.

ERM. 2003. Environmental summary report, Lots 1 and 2, Atofina Chemicals, Inc., Portland, OR. ERM-West, Inc., Bellevue, WA. July 23.

ERM. 2005. Upland remedial investigation report, Lots 3 &4 and Tract A, Revision 1, Arkema, Inc. Portland Facility. Environmental Resources Management, Portland, OR. December 2005.

ERM. 2006. Draft Acid Plant area DNAPL sampling summary report, Arkema, Inc. Portland Facility. Environmental Resources Management, Portland, OR. December 2005.

ERM. 2010. Sitewide groundwater monitoring report – August 2009 monitoring event, Arkema, Inc. Facility, Portland, Oregon. Prepared for Legacy Site Services LLC. Prepared by ERM-West, Inc., Portland, OR. February.

ERM. 2011. Groundwater Source Control Measure, Groundwater Extraction and Treatment System Pre-Final Design, Arkema Inc. Facility, Portland, OR. Prepared for Legacy Site Services LLC, Exton, PA. Prepared by ERM-West Inc., Portland, OR. February.

ERM. 2019. Arkema quarter 4, 2019, groundwater monitoring report, Arkema Inc. Facility, Portland, OR. Prepared by ERM-West, Inc. Portland, OR. February.

ERM. 2020. Arkema quarter 1, 2020, groundwater monitoring report, Arkema Inc. Facility, Portland, OR. Prepared by ERM-West, Inc. Portland, OR. May.

Exponent. 1999. Elf Atochem acid plant area remedial investigation, interim data report. Prepared for Elf Atochem North America, Inc., Portland, OR. Exponent, Inc., Lake Oswego, OR.

Geosyntec. 2017. Work plan, Portland harbor pre-remedial design investigation studies, Portland Harbor Superfund Site. Prepared for U.S. Environmental Protection Agency, Region 10, Seattle, WA. Prepared by Geosyntec Consultants, Seattle, WA. December 14.

Golder. 2018. Feasibility study data gaps report – Former Rhone-Poulenc Site, Portland, Oregon. Prepared for SLLI. Golder Associates, Inc.

Integral. 2004a. Portland Harbor RI/FS field sampling plan, groundwater pathway assessment pilot study. Prepared for The Lower Willamette Group, Portland, OR. Integral Consulting Inc., Mercer Island, WA. December 16.

Integral. 2004b. Portland Harbor RI/FS Round 2 quality assurance project plan, Addendum 2: PCB congener analysis in sediment samples. Prepared for The Lower Willamette Group, Portland, OR. Integral Consulting Inc., Mercer Island, WA. November 1.

Integral. 2005. Portland Harbor RI/FS round 2 groundwater pathway assessment sampling and analysis plan, Appendix b: pilot study data report. Draft. Prepared for the Lower Willamette Group, Portland, OR. Integral Consulting Inc., Mercer Island, WA.

Integral. 2006. Portland Harbor RI/FS round 2 groundwater pathway assessment transition zone water sampling report. Draft. Prepared for the Lower Willamette Group, Portland OR. Integral Consulting Inc., Mercer Island, WA.

Integral. 2009a. Arkema early action EE/CA work plan, work plan addendum. Prepared for Legacy Site Services LLC, Exton, PA. Integral Consulting Inc., Portland, OR. May 15.

Integral. 2009b. Arkema upland level II screening ecological risk assessment. Prepared for Legacy Site Services LLC, Exton, PA. Integral Consulting Inc., Portland, OR. January 16.

Integral. 2010. Baseline salmonid habitat survey, Arkema Facility, Portland, OR. Prepared for Legacy Site Services LLC, Exton, PA. Integral Consulting Inc., Portland, OR. August 12.

Integral. 2011. Final design report stormwater source control measures, Former Arkema Inc. Facility, Portland, Oregon. Prepared for Legacy Site Services LLC, Exton, PA. Integral Consulting Inc., Portland, OR.

Integral. 2012. Draft engineer evaluation and cost analysis, Arkema early action. Prepared for Legacy Site Services LLC, Exton, PA. Integral Consulting Inc., Portland, OR. July 26.

Integral. 2016. Pre-remedial design investigation work plan, final draft, Arkema Early Action. Prepared for Legacy Site Services LLC, Exton, PA. Integral Consulting Inc., Portland, OR. February 29.

Integral. 2020a. City of Portland Saltzman Creek/Outfall 22C source control decision comments. Prepared by Integral Consulting Inc., Portland, OR. May 29.

Integral. 2020b. City of Portland Saltzman Creek/Outfall 22A source control decision comments. Prepared by Integral Consulting Inc., Portland, OR. May 29.

Integral and ARCADIS. 2011. Final removal action characterization report, Arkema early action. Prepared for Legacy Site Service LLC, Exton, PA. Integral Consulting Inc., Portland, OR and ARCADIS, Portland, OR. October 14.

Integral and Windward. 2004. Portland Harbor RI/FS Round 2 quality assurance project plan. Prepared for The Lower Willamette Group, Portland, OR. Integral Consulting Inc., Portland, OR, and Windward Environmental, LLC, Seattle, WA. June 24.

LSS. 2010. Review and evaluation of historical source information and assessment of historical connections to Doane Lake, Doane Creek, and Saltzman Creek, Former Rhone Poulenc Portland Site. Legacy Site Services LLC. February 25.

LWG. 2004. Winter 2004 precision bathymetric survey. Transmittal letter to Chip Humphrey and Eric Blischke, U.S. Environmental Protection Agency, Region 10, from Gene Revelas, Integral Consulting Inc., for The Lower Willamette Group, Portland, OR.

Maritime and Coastal Agency. 2009. A physical study of fast ferry wash characteristics in shallow water, final report. Research Project 457. Maritime and Coastal Agency.

Parametrix. 2007. Arkema early action EE/CA work plan. Prepared for U.S. Environmental Protection Agency Region 10, Environmental Cleanup Office, Seattle, WA. Parametrix, Portland, OR.

PSEP. 1996. Puget Sound Estuary Program: Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound. Prepared for U.S. Environmental Protection Agency, Region 10, and Puget Sound Estuary Program Seattle, WA. Tetra Tech and HRA, Inc., Bellevue, WA.

Rhône Poulenc. 1987. Rhone-Poulenc AG Company, Portland Plant, Environmental Status Review. Rhone-Poulenc AG Company, Corporate HS & EA Department, Portland, OR. July 7, 1987.

SEA and DEA. 2003. Multibeam bathymetric survey report. Prepared for Lower Willamette Group. Striplin Environmental Associates, Inc., Olympia, WA, and David Evans Associates, Inc., Portland, OR.

Serfes. 1991. Determining the mean hydraulic gradient of ground water affected by tidal fluctuations. *Ground Water* 29(4), July–August.

USACE. 1992. Automated Coastal Engineering System (ACES). Technical Reference by D.E. Leenknecht, A. Szuwalski, and A.R. Sherlock, Coastal Engineering Center, U.S. Department of the Army, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

USEPA. 2001. Administrative Order on Consent for Remedial Investigation/Feasibility Study for Portland Harbor Superfund Site. U.S. Environmental Protection Agency, Region 10, Portland, OR.

USEPA. 2006. Guidance on systematic planning using the data quality objectives process. EPA/240/B-06/001. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC. February.

USEPA. 2016a. Portland Harbor RI/FS Remedial Investigation Report. Final. U.S Environmental Protection Agency, Seattle, Washington. February 8.

USEPA. 2016b. Portland Harbor RI/FS Feasibility Study Report. Final. U.S Environmental Protection Agency, Seattle, Washington.

USEPA. 2017. Record of decision, Portland Harbor Superfund Site, Portland, Oregon. U.S. Environmental Protection Agency, Region 10, Seattle, WA. January.

USEPA. 2019. Explanation of significant differences, Portland Harbor Superfund Site, Portland, OR. Prepared by U.S. Environmental Protection Agency, Region 10, Seattle, WA. December 9.

USEPA. 2020. Remedial design guidelines and considerations, Portland Harbor Superfund Site, Portland, OR. Prepared by U.S. Environmental Protection Agency, Region 10, Seattle, WA. February 28.

Weggel, J.R., and R.M. Sorensen. 1986. A ship wave prediction for port and channel design. In proc. of the Ports '86 Conference, Oakland, CA, May 19-21, 1986. P.H. Sorensen (ed). American Society of Civil Engineers, New York, NY. pp. 797–814.

Figures

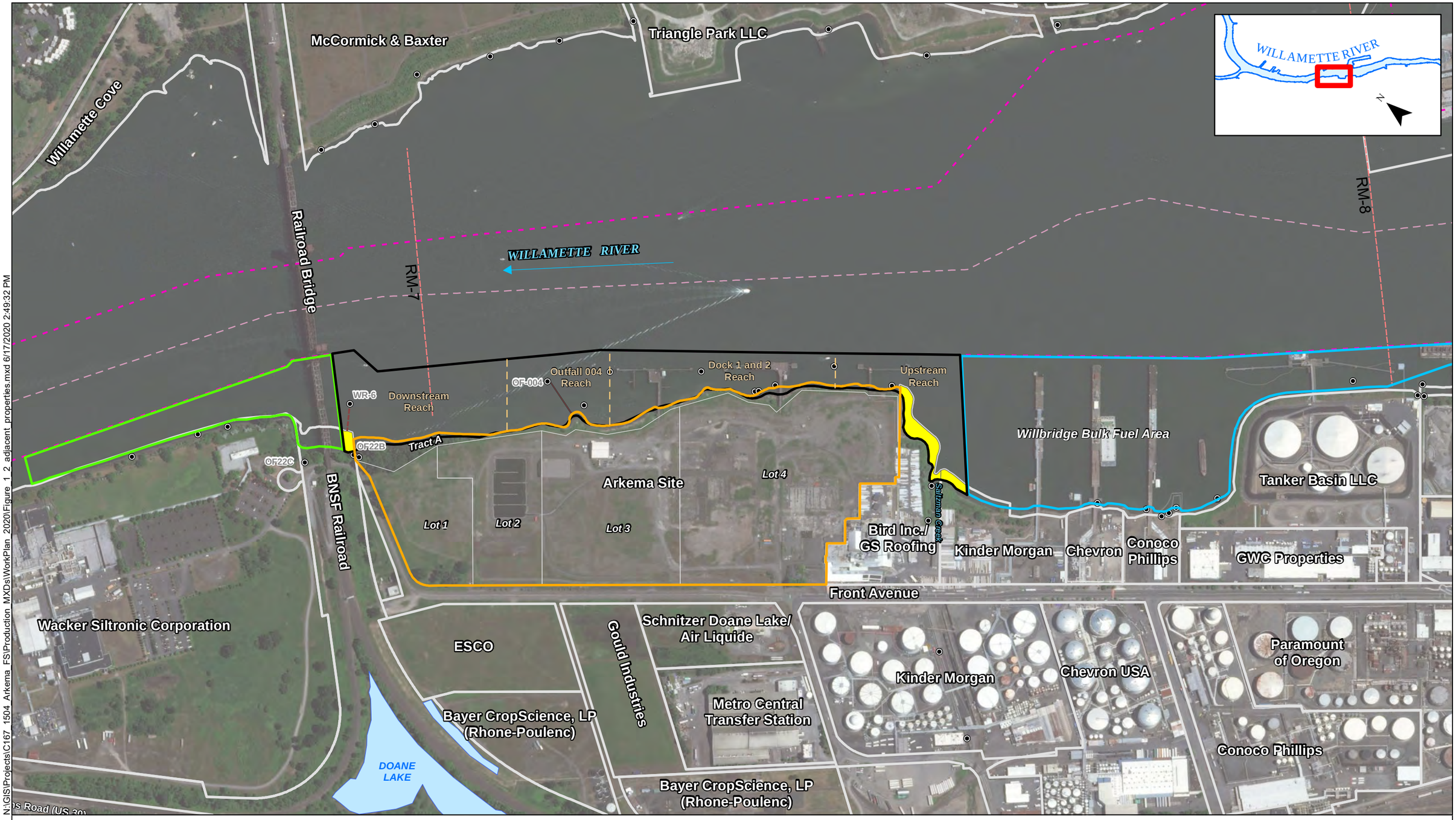
P:\Projects\C167 1504 Arkema FS\Production MXDs\Workplan 2020\Figure 1_1 SiteLocation.mxd 4/21/2020 2:55:08 PM

integral consulting inc.

FEATURE SOURCES:
Property Boundaries and Transportation Features: Metro RLIS, 2010

DRAFT

Figure 1-1.
Site Location
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167 1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 1_2 adjacent properties.mxd 6/17/2020 2:49:32 PM

integral consulting inc.

Sources:
Aerial: ESRI, Metro, 2017
Property Boundaries: Metro RLIS

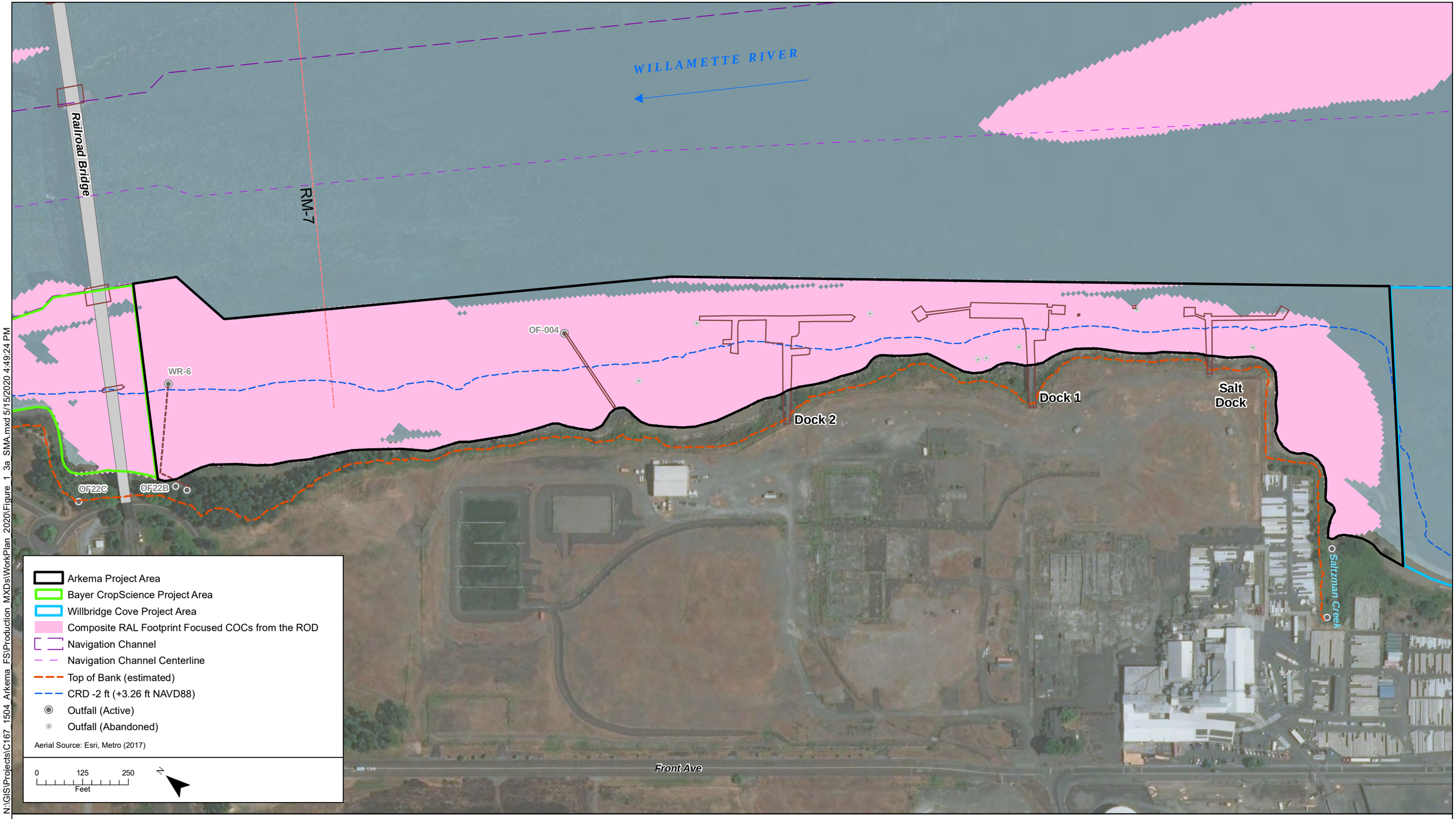
0 250 500
Feet

N

- Arkema Project Area
- Arkema Property
- Bayer CropScience Project Area
- Willbridge Cove Project Area
- Portions of Adjacent Properties within Arkema Project Area
- Navigation Channel Centerline
- Navigation Channel
- Waterfront Taxlot
- Doane Lake (Current)
- Outfall

DRAFT

Figure 1-2.
Arkema Project Area, Arkema Site, and Adjacent Properties
Arkema Project Area Pre-design Investigation Work Plan

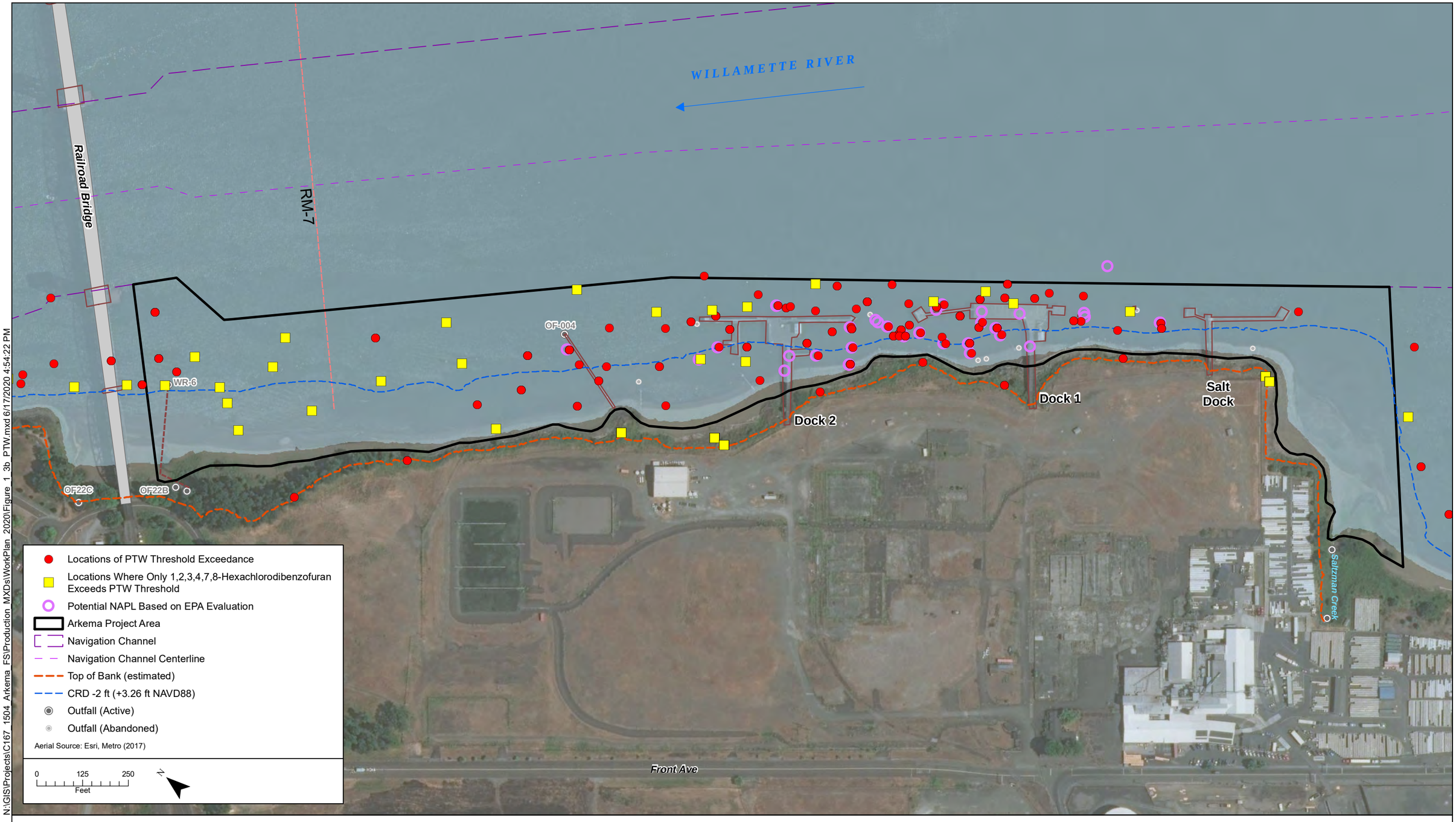


N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_1_3a_SMA.mxd 5/15/2020 4:49:24 PM

integral consulting inc.

DRAFT

Figure 1-3a.
SMA Footprint from the ROD
Arkema Project Area Pre-design Investigation Work Plan

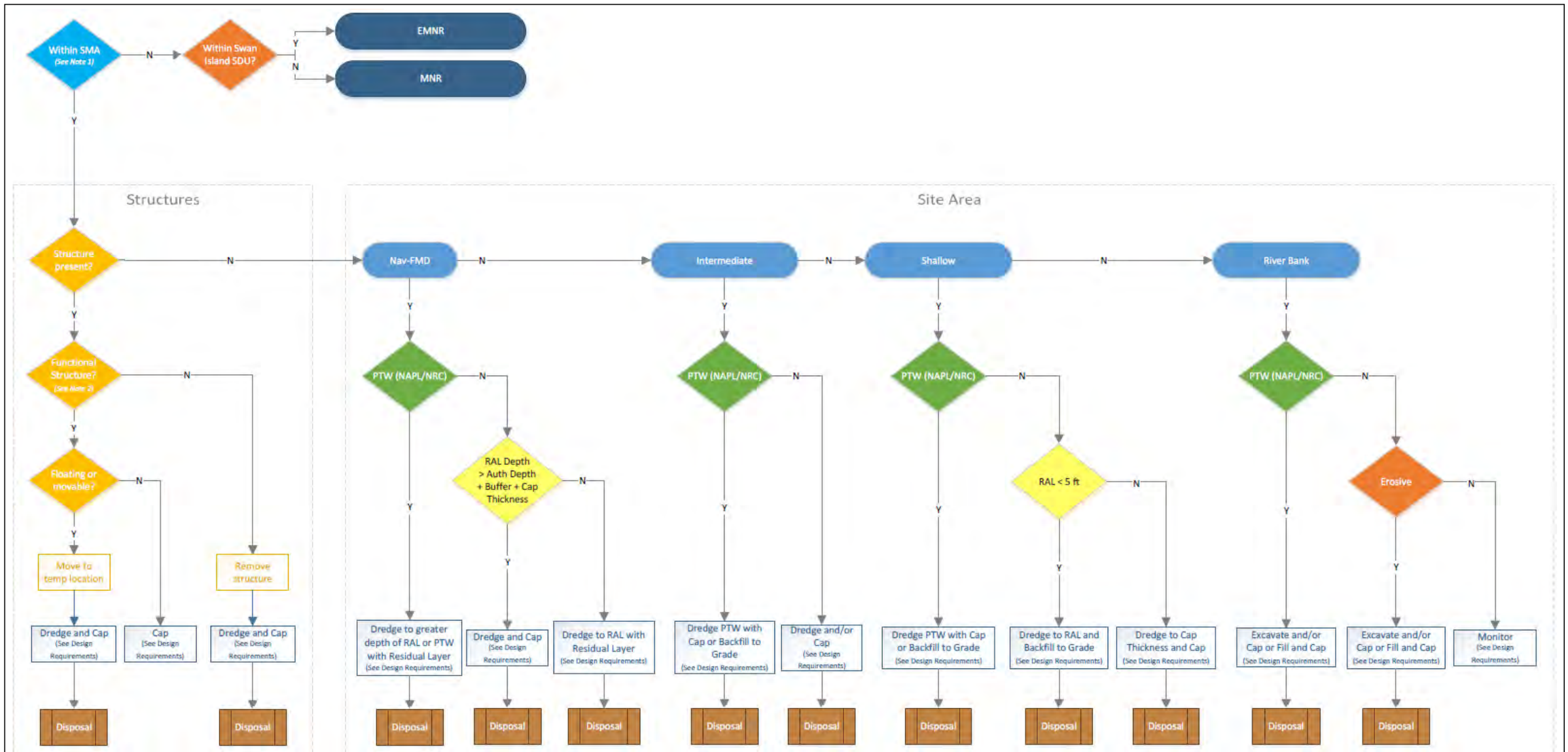


N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_1_3b_PTW.mxd 6/17/2020 4:54:22 PM

integral consulting inc.

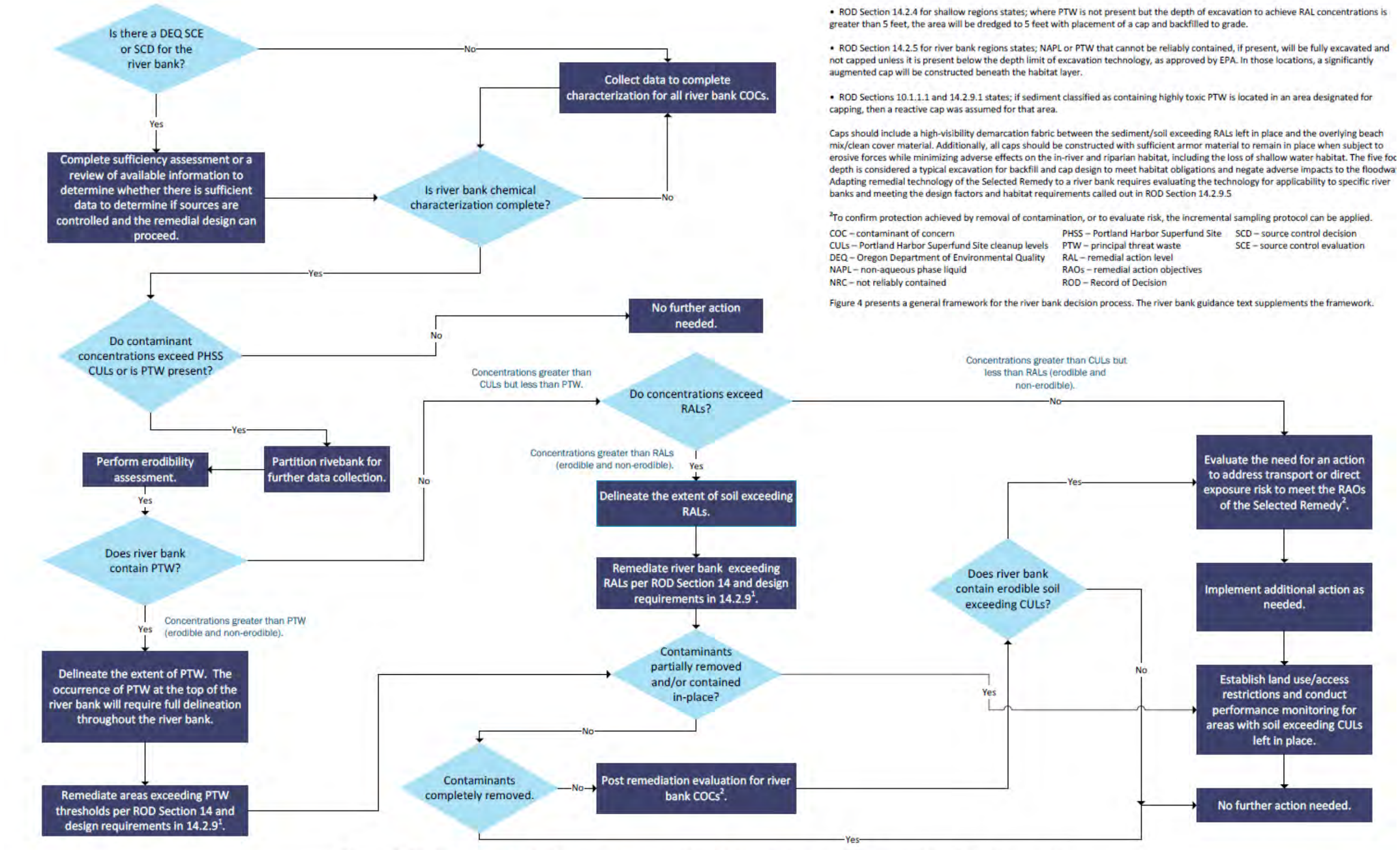
DRAFT

Figure 1-3b.
Locations of PTW Threshold Exceedances and Potential NAPL
Arkema Project Area Pre-design Investigation Work Plan



Notes:
(1) Contamination is defined in three dimensions.
(2) Currently operating or used to stabilize bank. Service life > 50 yrs.

Figure 28. Technology Application Decision Tree
Portland Harbor Superfund Site



- ROD Section 14.2.4 for shallow regions states; where PTW is not present but the depth of excavation to achieve RAL concentrations is greater than 5 feet, the area will be dredged to 5 feet with placement of a cap and backfilled to grade.

- ROD Section 14.2.5 for river bank regions states; NAPL or PTW that cannot be reliably contained, if present, will be fully excavated and not capped unless it is present below the depth limit of excavation technology, as approved by EPA. In those locations, a significantly augmented cap will be constructed beneath the habitat layer.

- ROD Sections 10.1.1.1 and 14.2.9.1 states; if sediment classified as containing highly toxic PTW is located in an area designated for capping, then a reactive cap was assumed for that area.

Caps should include a high-visibility demarcation fabric between the sediment/soil exceeding RALs left in place and the overlying beach mix/clean cover material. Additionally, all caps should be constructed with sufficient armor material to remain in place when subject to erosive forces while minimizing adverse effects on the in-river and riparian habitat, including the loss of shallow water habitat. The five foo depth is considered a typical excavation for backfill and cap design to meet habitat obligations and negate adverse impacts to the floodwa Adapting remedial technology of the Selected Remedy to a river bank requires evaluating the technology for applicability to specific river banks and meeting the design factors and habitat requirements called out in ROD Section 14.2.9.5

[2]To confirm protection achieved by removal of contamination, or to evaluate risk, the incremental sampling protocol can be applied.

COC – contaminant of concern
CULs – Portland Harbor Superfund Site cleanup levels
DEQ – Oregon Department of Environmental Quality
NAPL – non-aqueous phase liquid
NRC – not reliably contained
PHSS – Portland Harbor Superfund Site
PTW – principal threat waste
RAL – remedial action level
RAOs – remedial action objectives
ROD – Record of Decision
SCD – source control decision
SCE – source control evaluation

Figure 4 presents a general framework for the river bank decision process. The river bank guidance text supplements the framework.

Figure 4. Decision Guide for Characterizing and Implementing Remedial Action for ROD River Banks

Source: USEPA (2020)

Portland Harbor Superfund Site

integral consulting inc.

DRAFT

Figure 1-3d.
Decision Guide for Characterizing and Implementing Remedial Action for ROD River Banks
Arkema Project Area Pre-design Investigation Work Plan

WILLAMETTE RIVER

RM-7

Proposed 1977, 1984, and 1993 dredge areas

Estimated location of 1956 dredging activities

Estimated Acid Plant Area Riverbank Fill

Approximate location of former DDT pond and trench

Dock #1

Dock #2

Outfall 001

Outfall 002

Outfall 003

Outfall 004

Tract A

Tract A

Acid Plant Area

Approximate Location of Former Process Discharge Pipe

Old Caustic Tank Farm

Former Salt Storage Area

Estimated fill area from the 1956 dredging activities

Former Asbestos Ponds

Warehouse No. 2

Former Ammonia Plant Area

Former Chlorate Plant Barge Loading Overhead Pipeline

New Caustic Tank Farm

Acid Plant Area

Boiler Room

Former location of asbestos trenches

Former brine mud pile and pond area

Lot 1

Lot 2

Lot 3

Lot 4

Former DDT Process Building

Chlorate Plant Area

Former DDT Trench

Warehouse No. 1

BPA Substation Annex

BPA Main Substation

New Chlorine Cell Room (1962-2001)

Old Chlorine Cell Room (1946-1971)

Saltzman Creek

CB-001-01
CB-001-02
CB-001-03
CB-001-04
CB-001-05
CB-001-06
CB-001-07
CB-002-01
CB-002-02
CB-002-03
CB-003-01
CB-003-02
CB-003-03
CB-003-04
CB-003-05
CB-003-06
CB-003-07
CB-003-08
CB-004-01
CB-004-02
CB-004-03

Catch Basins
Overhead Pipeline
Estimated Fill Area
Proposed 1977, 1984, and 1993 Dredge Areas
Estimated Dredged Area

integral consulting inc.

SOURCES:
Topographic and Bathymetric Elevations, Top of Bank: 2018 DEA Topobathy Survey
Navigation Channel: US Army Corps of Engineers

0 100 200 Feet

N

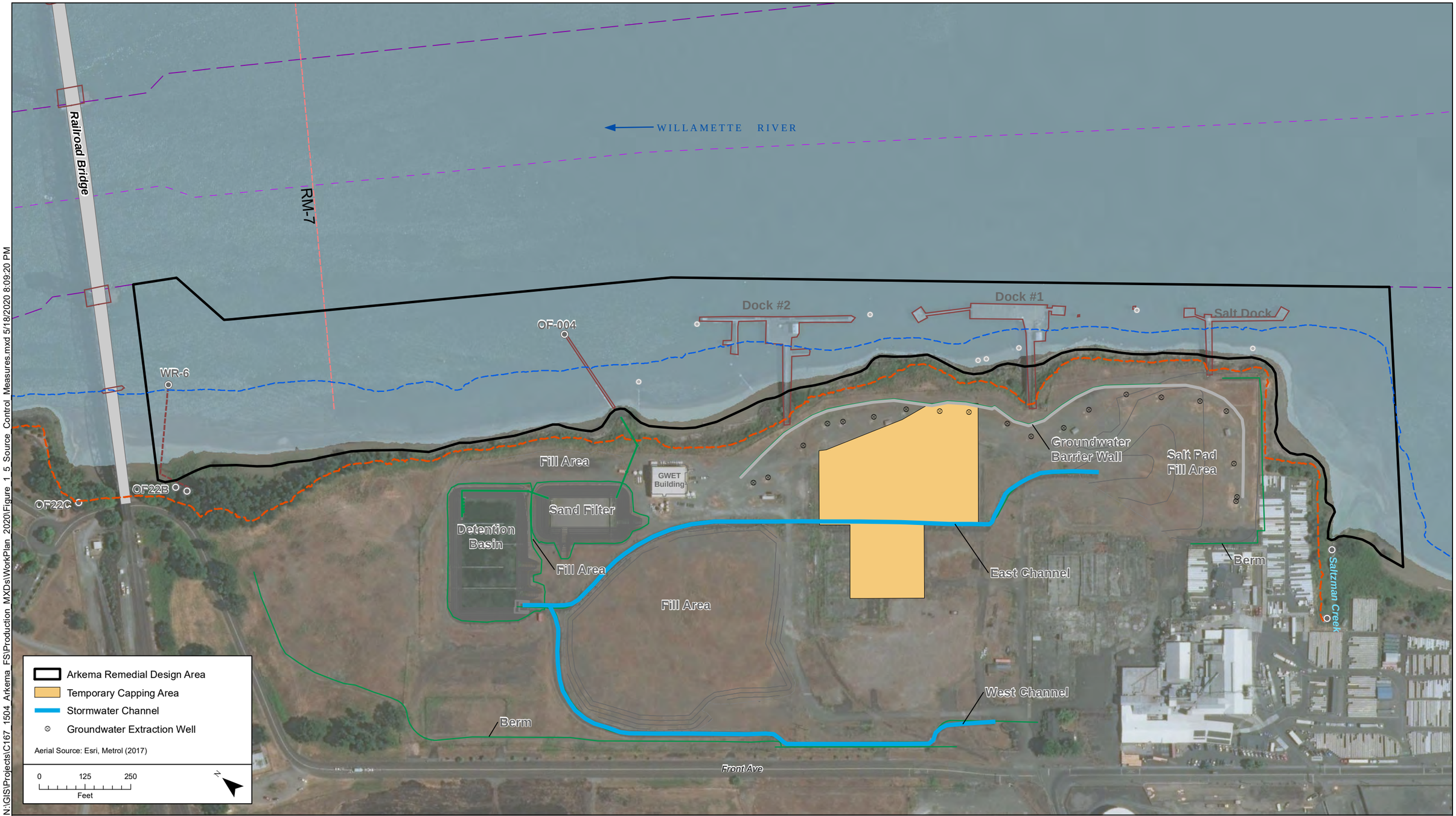
Map Features

- Arkema Project Area
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Outfall
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- Navigation Channel Centerline
- Property and Lot Boundary
- Storm Drain
- Sewer Line
- River Edge

DRAFT

Figure 1-4.
Dredge and Fill and Historical Uses at the Arkema Site
Arkema Project Area Pre-design Investigation Work Plan

P:\Projects\C167_1504_Arkema_FS\Production_MXDs\Workplan_2020\Figure_1_4_Historical_Uses.mxd 6/3/2020 12:02:39 PM



N:\GIS\Projects\C167 1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 1_5 Source Control Measures.mxd 5/18/2020 8:09:20 PM

integral consulting inc.

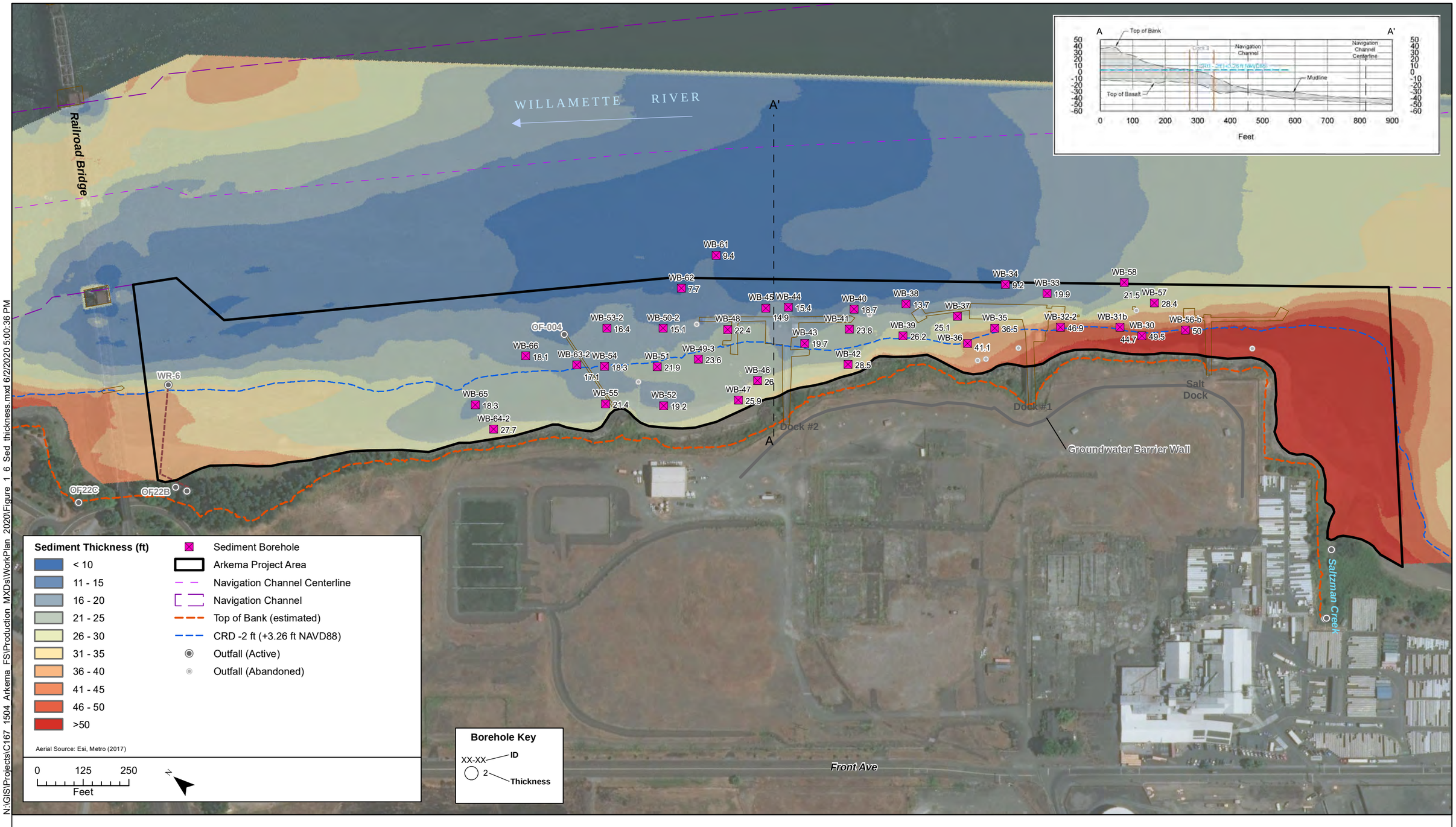
Map Features

- Docks and Structures
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Outfall (Active)
- Outfall (Abandoned)

DRAFT

Figure 1-5.
Upland Source Control Measures for the Arkema Site
Arkema Project Area Pre-design Investigation Work Plan

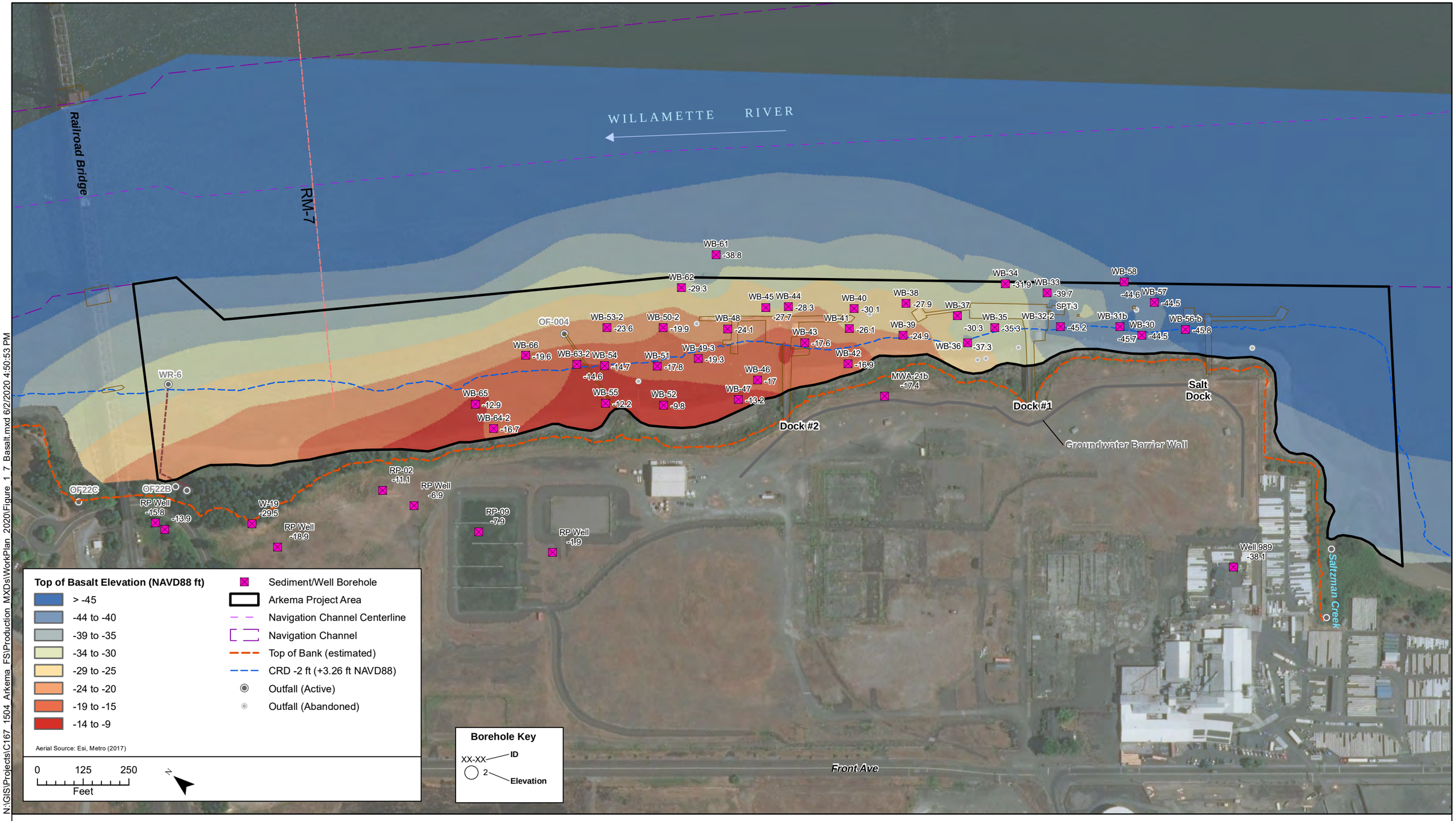
N:\GIS\Projects\C167 1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 1 6 Sed thickness.mxd 6/2/2020 5:00:36 PM



integral consulting inc.

DRAFT

Figure 1-6.
Sediment Thickness Map
Arkema Project Area Pre-design Investigation Work Plan

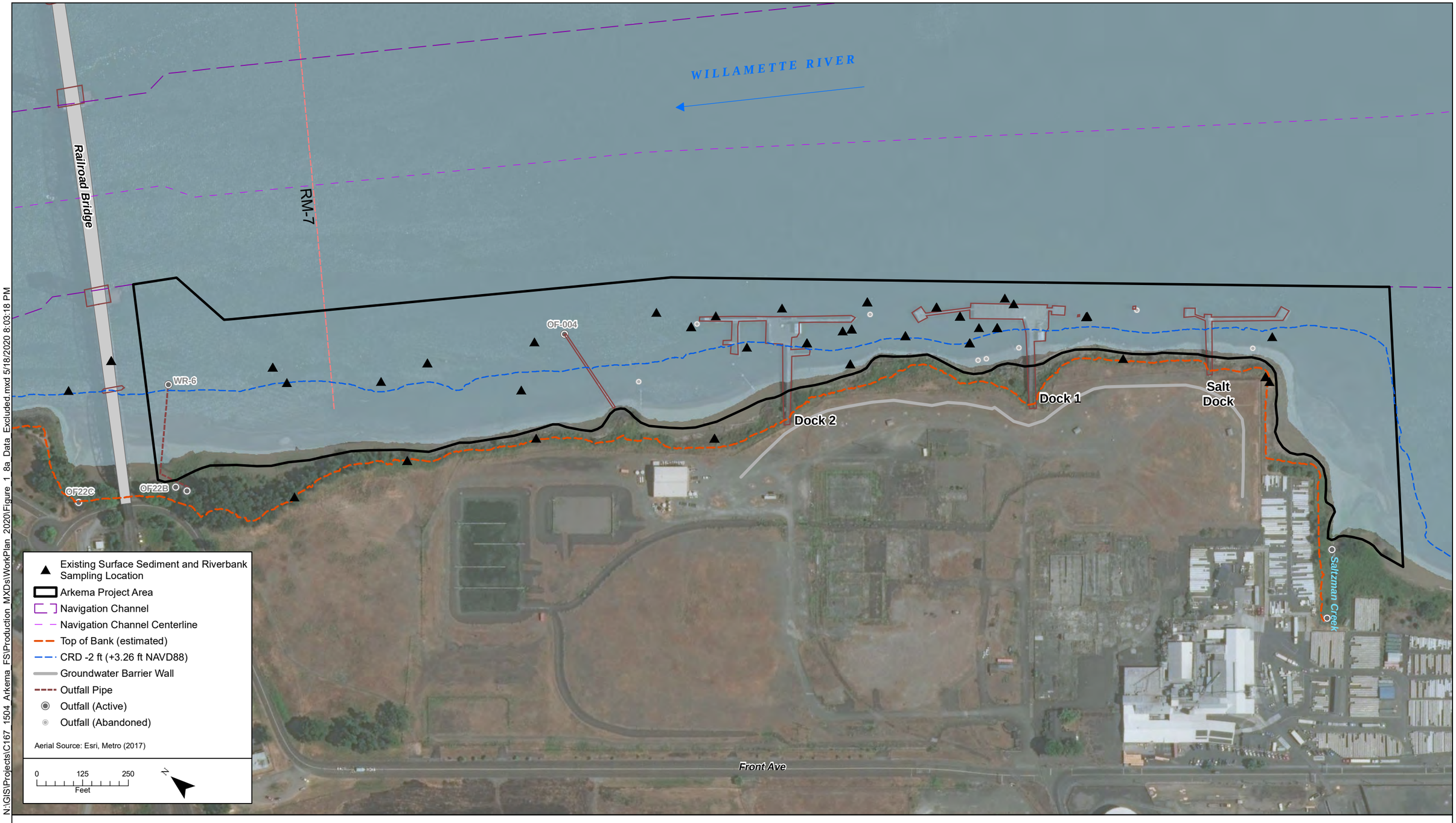


N:\GIS\Projects\C167 1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 1_7 Basalt.mxd 6/2/2020 4:50:53 PM

integral consulting inc.

DRAFT

Figure 1-7.
Top of Basalt Elevation
Arkema Project Area Pre-design Investigation Work Plan



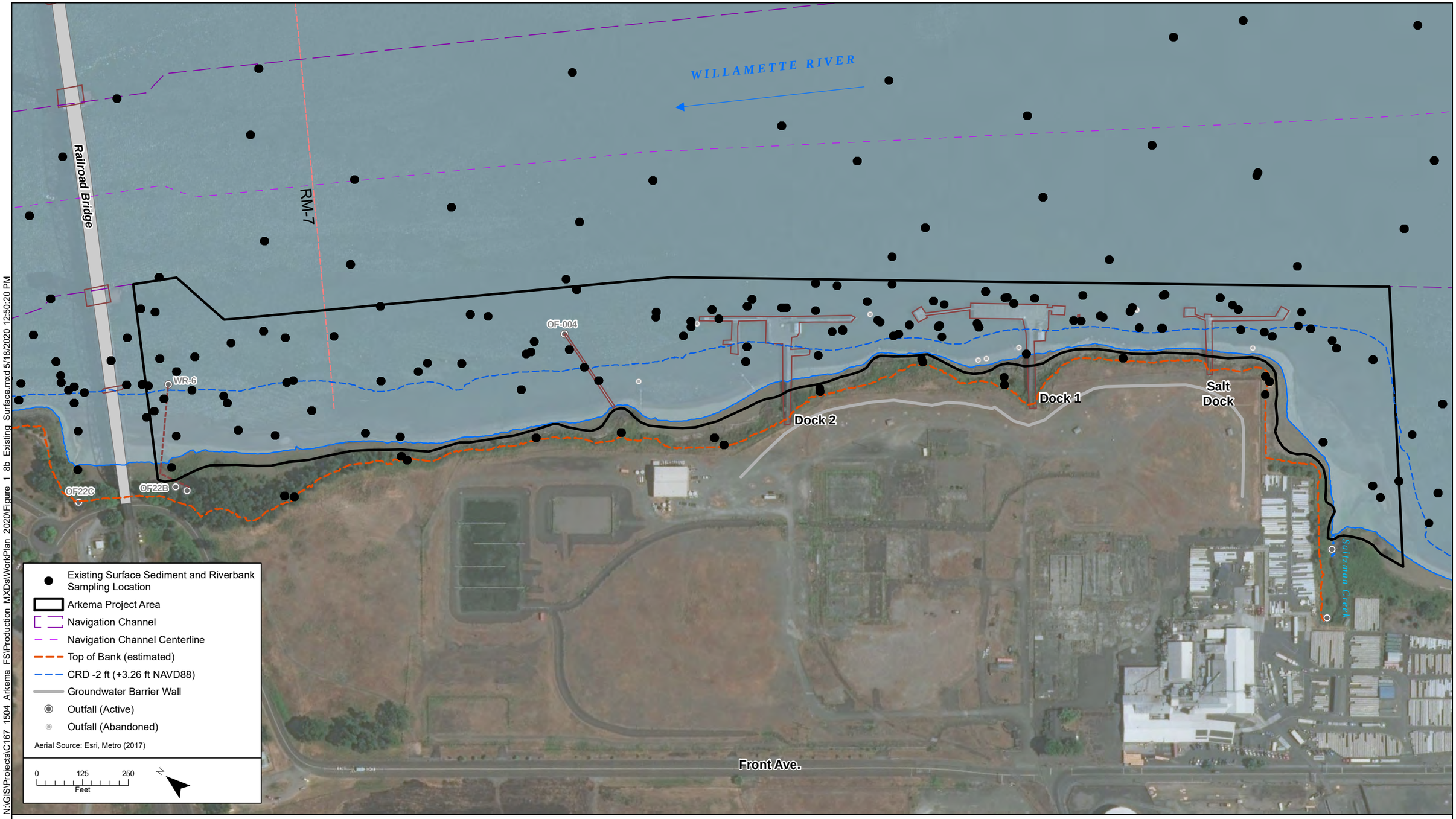
N:\GIS\Projects\C167_1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 1_8a_Data_Excluded.mxd 5/18/2020 8:03:18 PM

integral consulting inc.

DRAFT

Figure 1-8a.
Data Excluded from Consideration Due to Detection Limits Above RALs or PTW Thresholds
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_1_8b_Existing_Surface.mxd 5/18/2020 12:50:20 PM

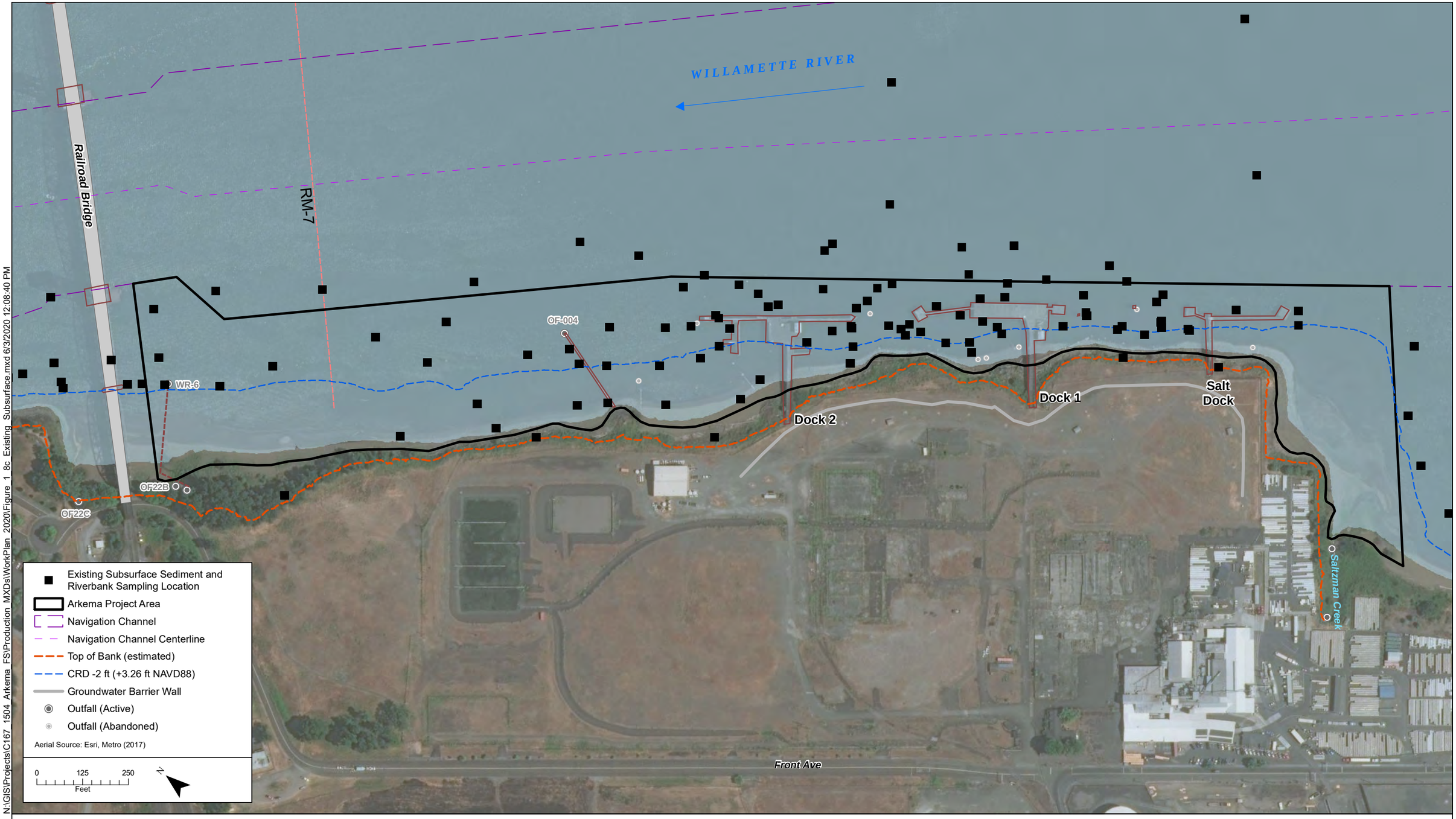


integral consulting inc.

DRAFT

Figure 1-8b.
Existing Surface Sediment and Riverbank Soil Sampling Stations
Arkema Project Area Pre-design Investigation Work Plan

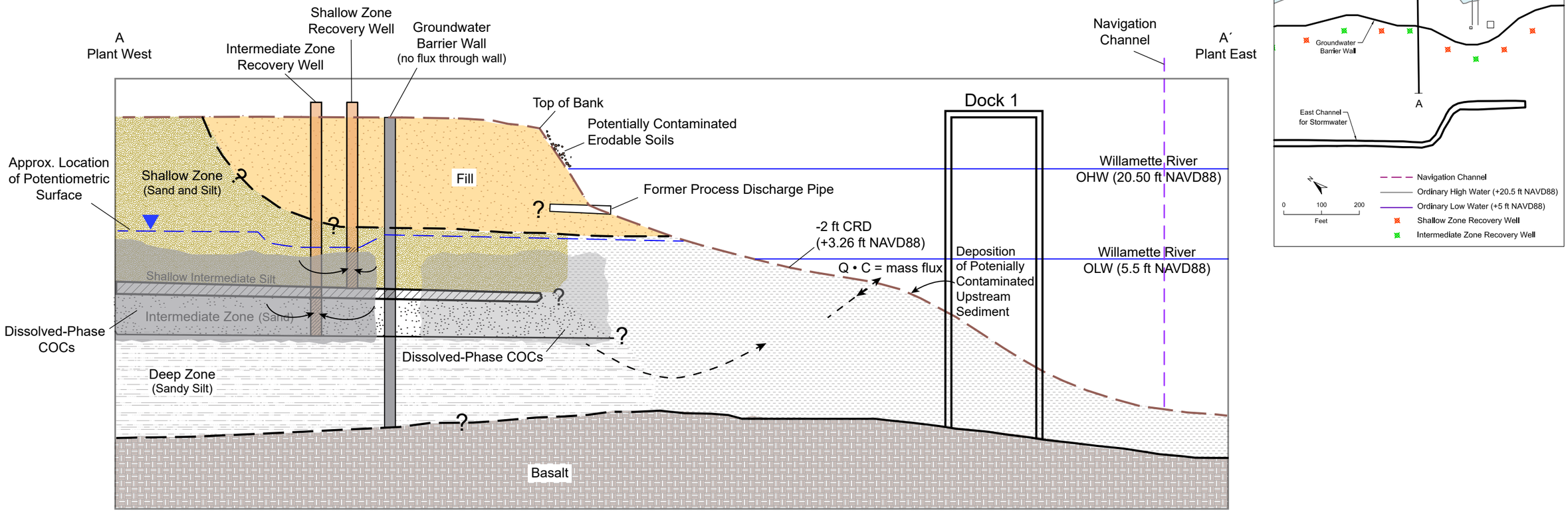
N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_1_8c_Existing_Subsurface.mxd 6/3/2020 12:08:40 PM

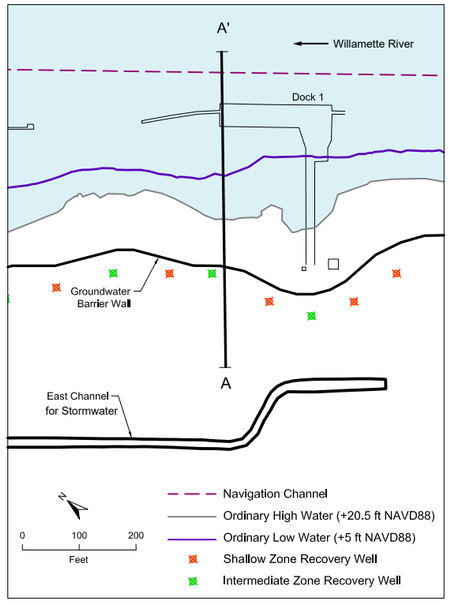


integral consulting inc.

DRAFT

Figure 1-8c.
Existing Subsurface Sediment and Riverbank Soil Sampling Stations
Arkema Project Area Pre-design Investigation Work Plan





Not to scale. Cross section has vertical exaggeration.

integral consulting inc.

DRAFT

Figure 1-9.
Conceptual Site Model Diagram—Dock 1 and 2 Reach
Arkema Pre-design Investigation Work Plan

integral consulting inc.

Aerial Source: Metro, June-July 2009

0 25 50
Feet

N

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel

DRAFT

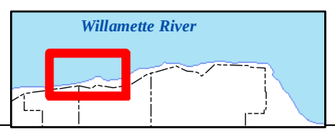


Figure 1-10a
Visual Surface Debris Survey
Outfall 004 Area
Arkema Project Area Pre-design Investigation Work Plan

integral consulting inc.

Aerial Source: Metro, June-July 2009

0 25 50
Feet

N

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel

DRAFT

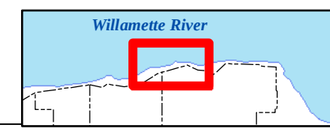
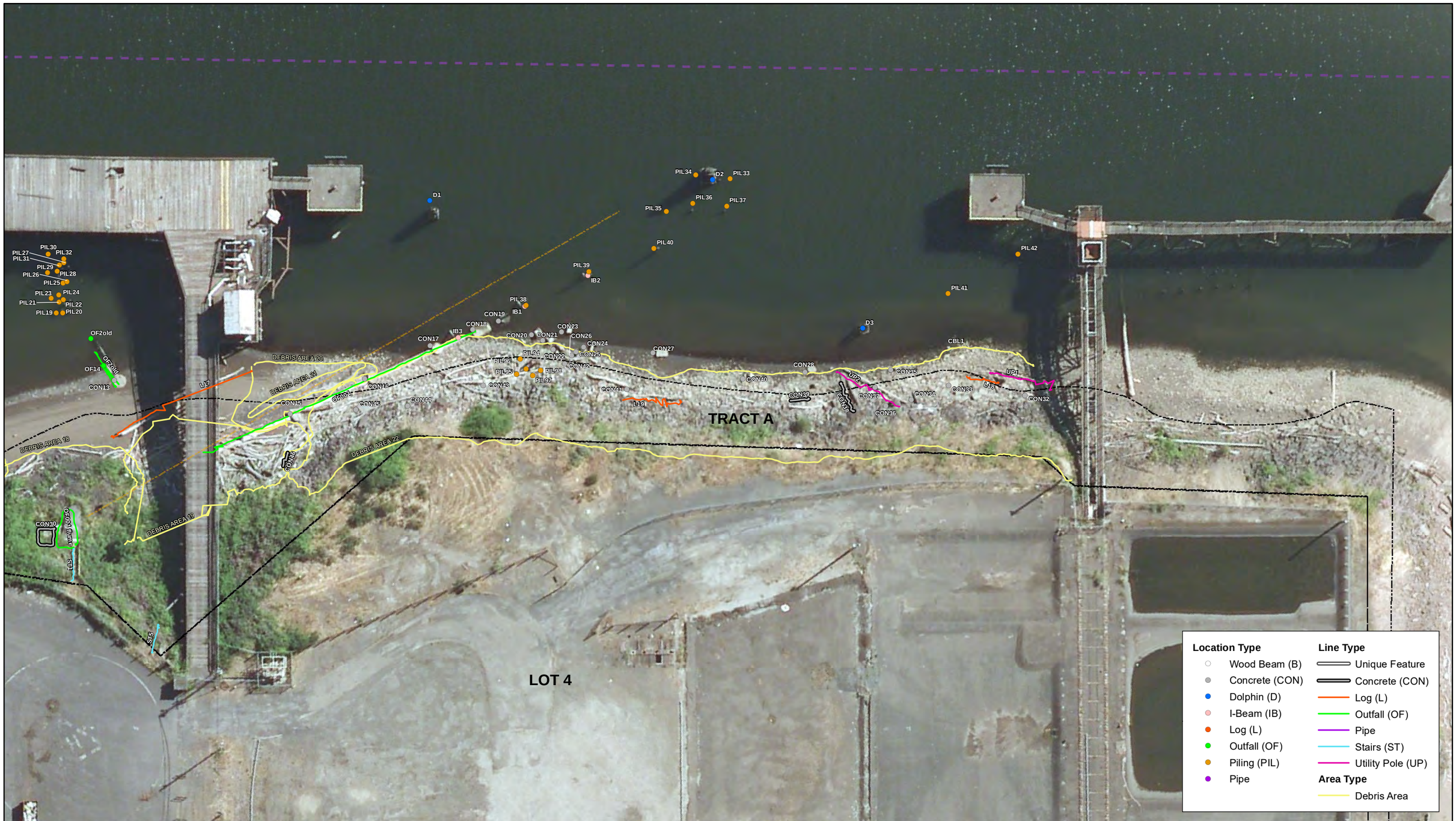


Figure 1-10b
Visual Surface Debris Survey
Between Docks 1 and 2
Arkema Project Area Pre-design Investigation Work Plan



Location Type
- Wood Beam (B)
- Concrete (CON)
- Dolphin (D)
- I-Beam (IB)
- Log (L)
- Outfall (OF)
- Piling (PIL)
- Pipe

Line Type
- Unique Feature
- Concrete (CON)
- Log (L)
- Outfall (OF)
- Pipe
- Stairs (ST)
- Utility Pole (UP)

Area Type
- Debris Area

integral consulting inc.

Aerial Source: Metro, June-July 2009

0 25 50
Feet

N

Map Features
- Property and Lot Boundary
- Storm Drain
- Navigation Channel

DRAFT

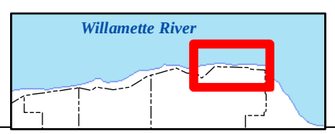
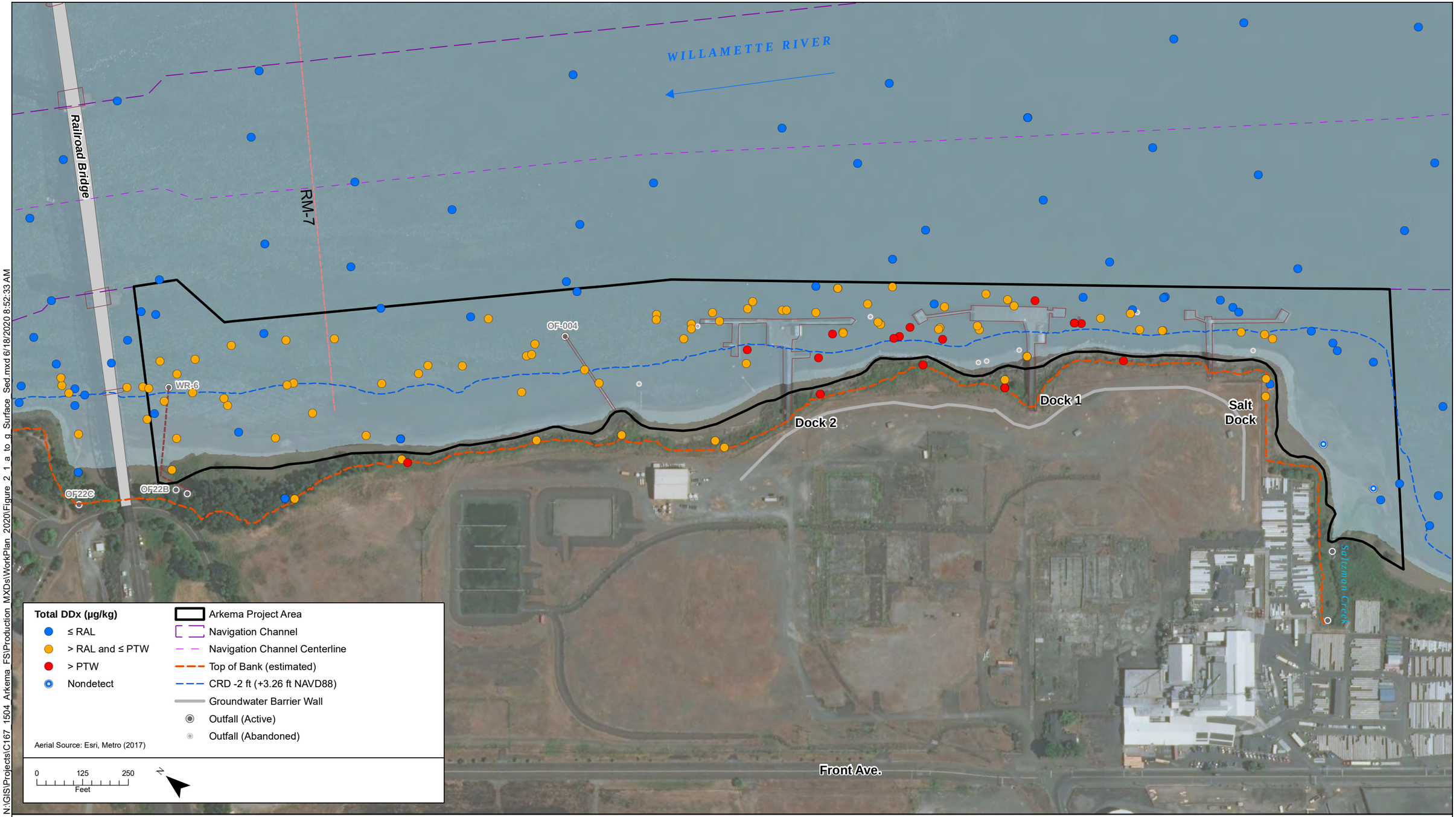


Figure 1-10c
Visual Surface Debris Survey
Between Dock 1 and Salt Dock
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_1_a_to_g_Surface_Sed.mxd 6/18/2020 8:52:33 AM

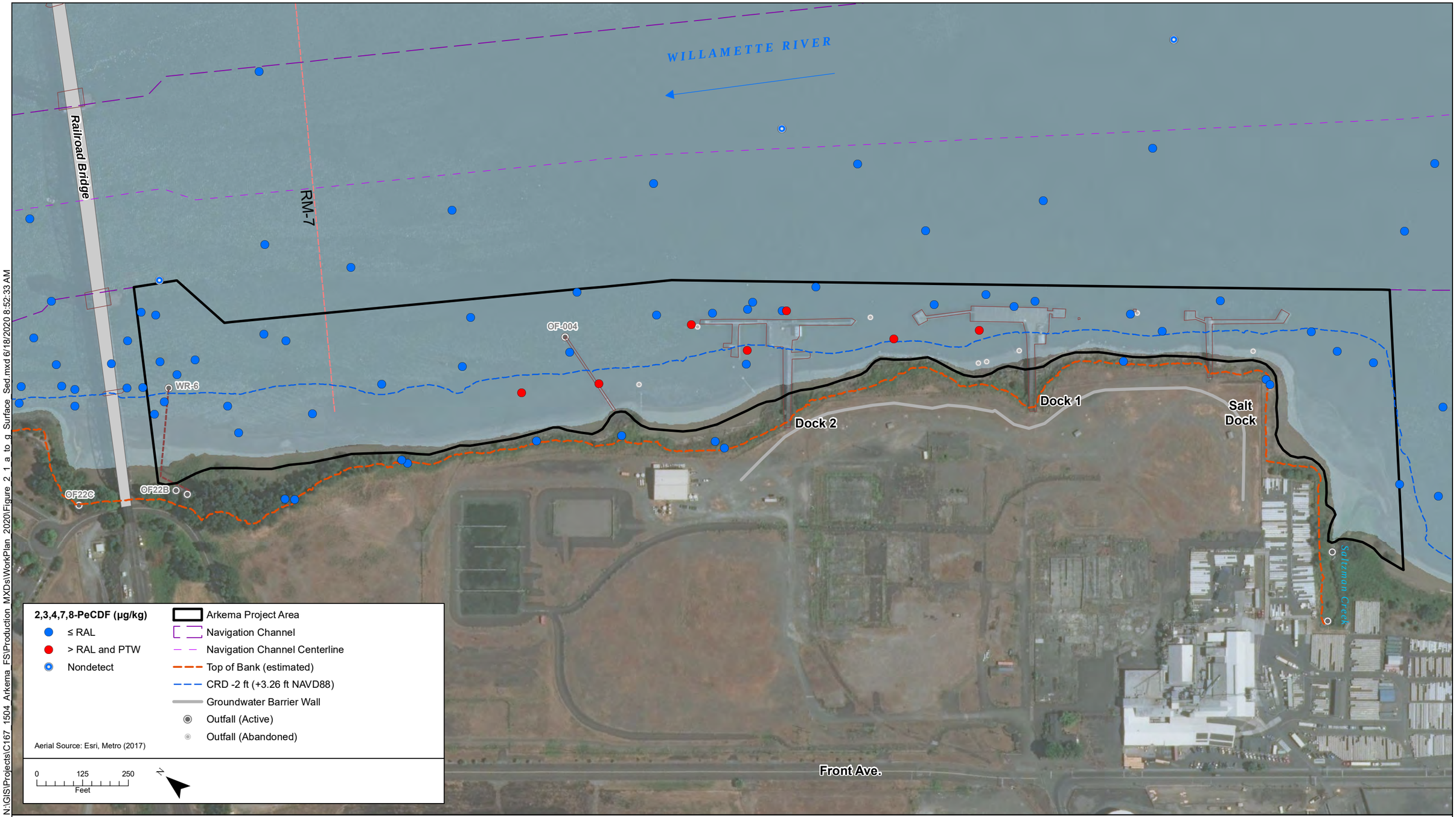
integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 160
Navigation Channel Remedial Action Level = 650
Principal Threat Waste = 7,050

DRAFT

Figure 2-1a.
DDx Surface Sediment and Riverbank Soil Data
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_1_a_to_g_Surface_Sed.mxd 6/18/2020 8:52:33 AM

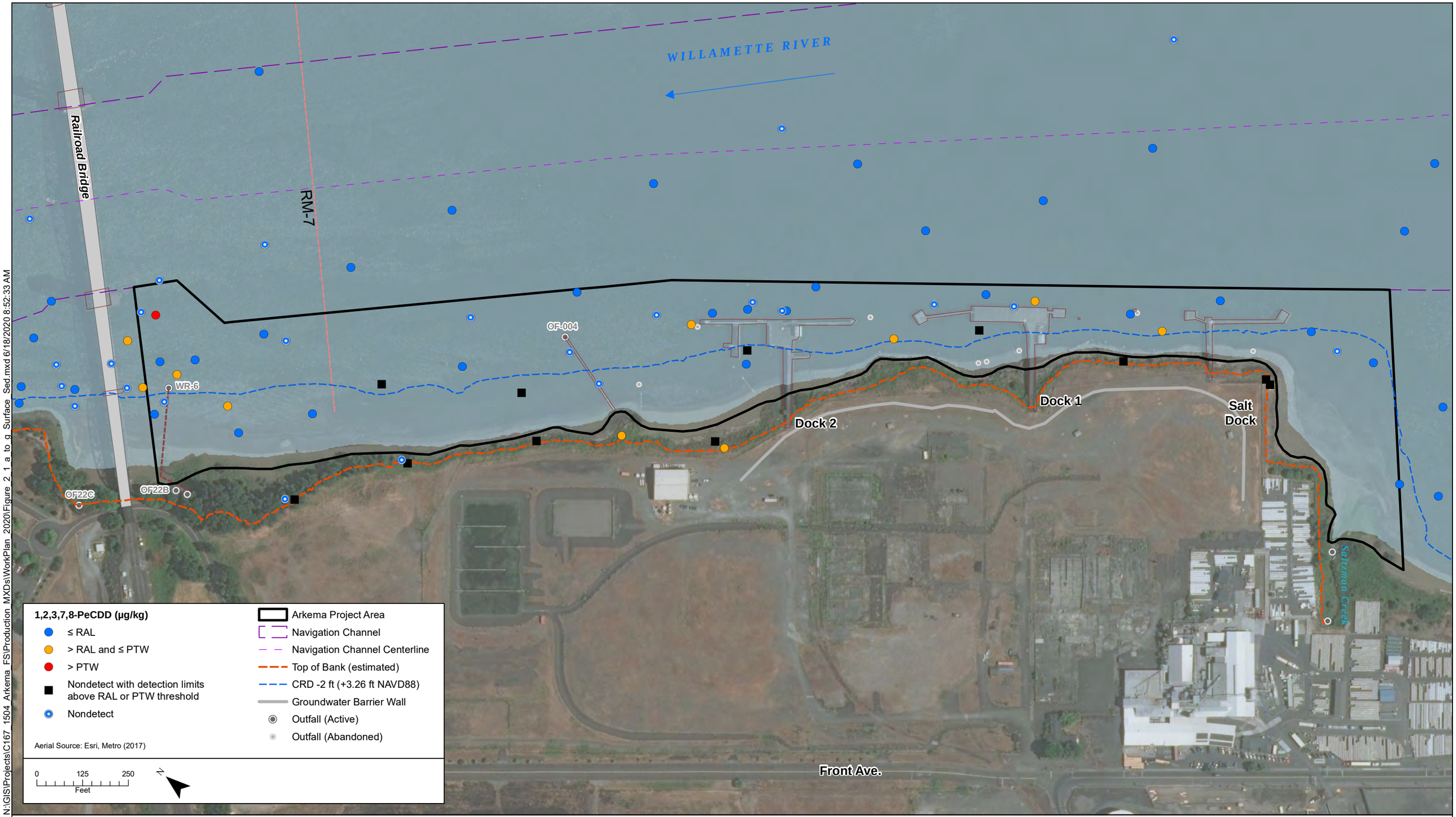


integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 0.2
Navigation Channel Remedial Action Level = 1
Principal Threat Waste = 0.2

DRAFT

Figure 2-1b.
2,3,4,7,8-PeCDF Surface Sediment and Riverbank Soil Data
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_1_a_to_g_Surface_Sed.mxd 6/18/2020 8:52:33 AM

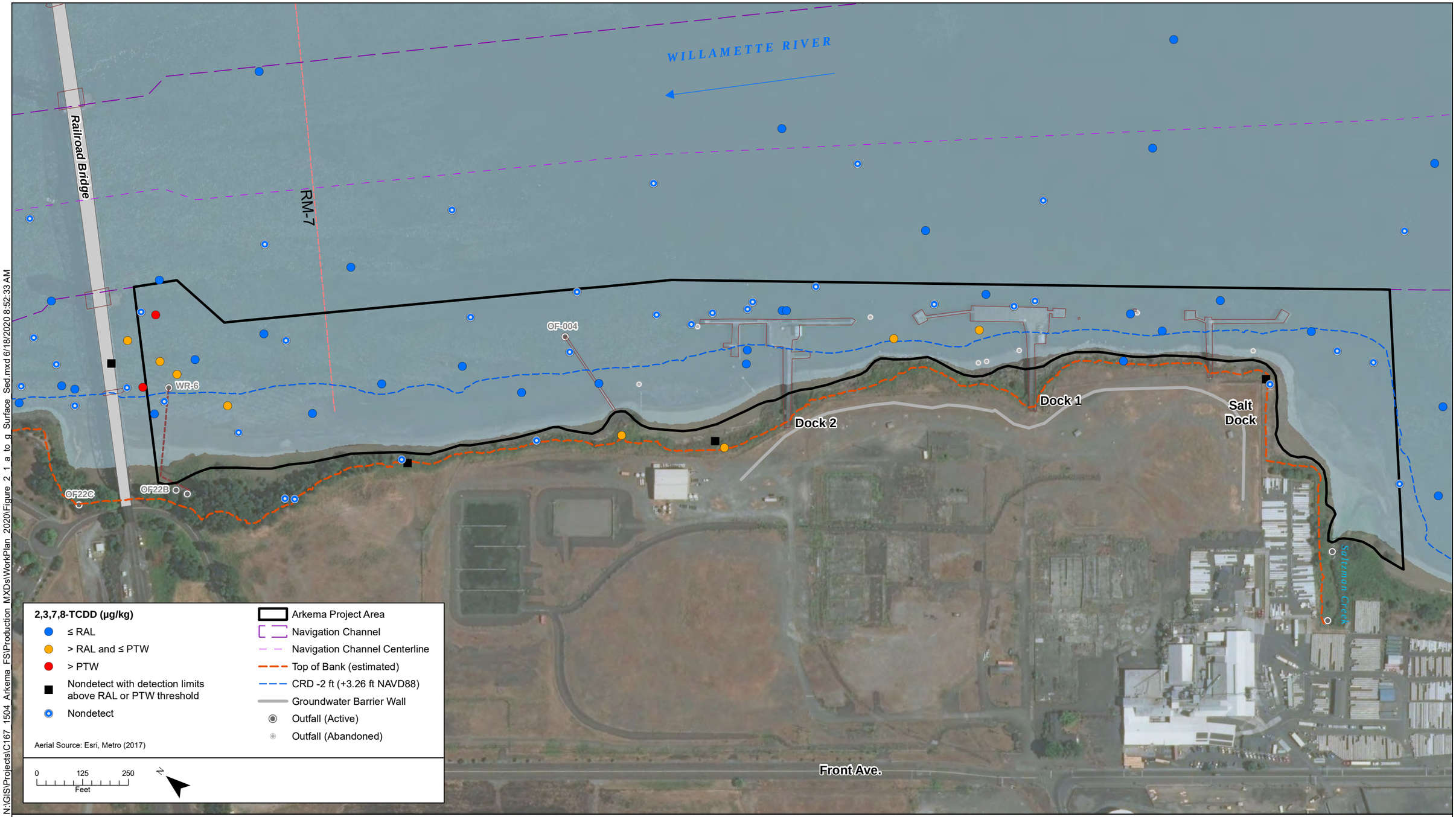
integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 0.0008
Navigation Channel Remedial Action Level = 0.003
Principal Threat Waste = 0.01

DRAFT

Figure 2-1c.
1,2,3,7,8-PeCDD Surface Sediment and Riverbank Soil Data
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_1_a_to_g_Surface_Sed.mxd 6/18/2020 8:52:33 AM



integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 0.0006
Navigation Channel Remedial Action Level = 0.002
Principal Threat Waste = 0.01

DRAFT

Figure 2-1d.
2,3,7,8-TCDD Surface Sediment and Riverbank Soil Data
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_1_a_to_g_Surface_Sed.mxd 6/18/2020 8:52:33 AM

WILLAMETTE RIVER

Railroad Bridge

RM-7

OF-004

WR-6

OF22C

OF22B

Dock 2

Dock 1

Salt Dock

Salzman Creek

Front Ave.

Total PCBs (µg/kg)

- ≤ RAL
- > RAL and ≤ PTW
- > PTW
- Nondetect with detection limits above RAL or PTW threshold
- Nondetect

Aerial Source: Esri, Metro (2017)

- Arkema Project Area
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Groundwater Barrier Wall
- Outfall (Active)
- Outfall (Abandoned)

0 125 250
Feet

integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 75
Navigation Channel Remedial Action Level = 1,000
Principal Threat Waste = 200

DRAFT

Figure 2-1e.
Total PCBs Surface Sediment and Riverbank Soil Data
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_1_a_to_g_Surface_Sed.mxd 6/18/2020 8:52:33 AM

WILLAMETTE RIVER

Railroad Bridge

RM-7

OF-004

WR-6

OF22C

OF22B

Dock 1

Dock 2

Salt Dock

Salzman Creek

Front Ave.

Total PAHs (µg/kg)

- ≤ RAL
- > RAL and ≤ PTW
- > PTW
- Nondetect

- Arkema Project Area
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Groundwater Barrier Wall
- Outfall (Active)
- Outfall (Abandoned)

Aerial Source: Esri, Metro (2017)

0 125 250
Feet

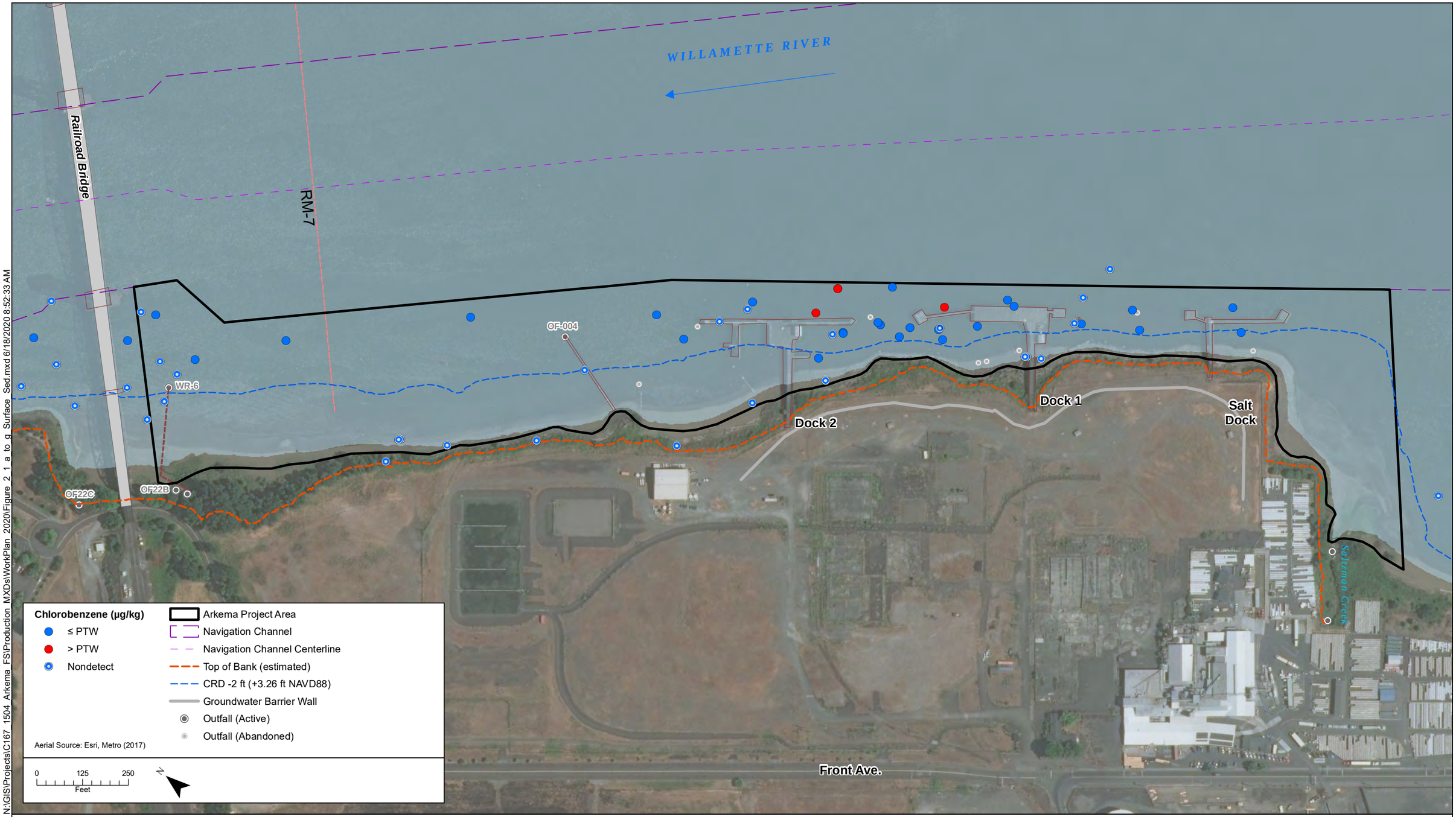
N

integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 30,000
Navigation Channel Remedial Action Level = 170,000
Principal Threat Waste = N/A

DRAFT

Figure 2-1f.
Total PAHs Surface Sediment and Riverbank Soil Data
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_1_a_to_g_Surface_Sed.mxd 6/18/2020 8:52:33 AM

integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = NA
Navigation Channel Remedial Action Level = NA
Principal Threat Waste = 320

DRAFT

Figure 2-1g.
Chlorobenzene Surface Sediment and Riverbank Soil Data
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_2_a_to_g_Sub_Subsurface_Sed.mxd 6/18/2020 9:37:07 AM

WILLAMETTE RIVER

Railroad Bridge

RM-7

OF-004

WR-6

OF22B

OF22C

Saltzman Creek

DDx (µg/kg)

- ≤ RAL
- > RAL and ≤ PTW
- > PTW
- Nondetect

- Arkema Project Area
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Groundwater Barrier Wall
- Outfall (Active)
- Outfall (Abandoned)

Aerial Source: Esri, Metro (2017)

0 125 250 Feet

N

integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 160
Navigation Channel Remedial Action Level = 650
Principal Threat Waste = 7,050

2.3 ← Maximum Depth of RAL Exceedance (ft below mudline)
11 ← Maximum Depth of Core (ft below mudline)

n/a = not applicable because remedial action level was not exceeded

DRAFT

Figure 2-2a.
DDx Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_2_a_to_g_Sub_Subsurface_Sed.mxd 6/18/2020 9:37:07 AM

WILLAMETTE RIVER

Railroad Bridge

RM-7

OF-004

WR-6

OF22B

OF22C

Saltzman Creek

2,3,4,7,8-PeCDF (µg/kg)

- ≤ RAL
- > RAL and PTW
- Nondetect

- Arkema Project Area
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Groundwater Barrier Wall
- Outfall (Active)
- Outfall (Abandoned)

Aerial Source: Esri, Metro (2017)

0 125 250 Feet

N

integral consulting inc.

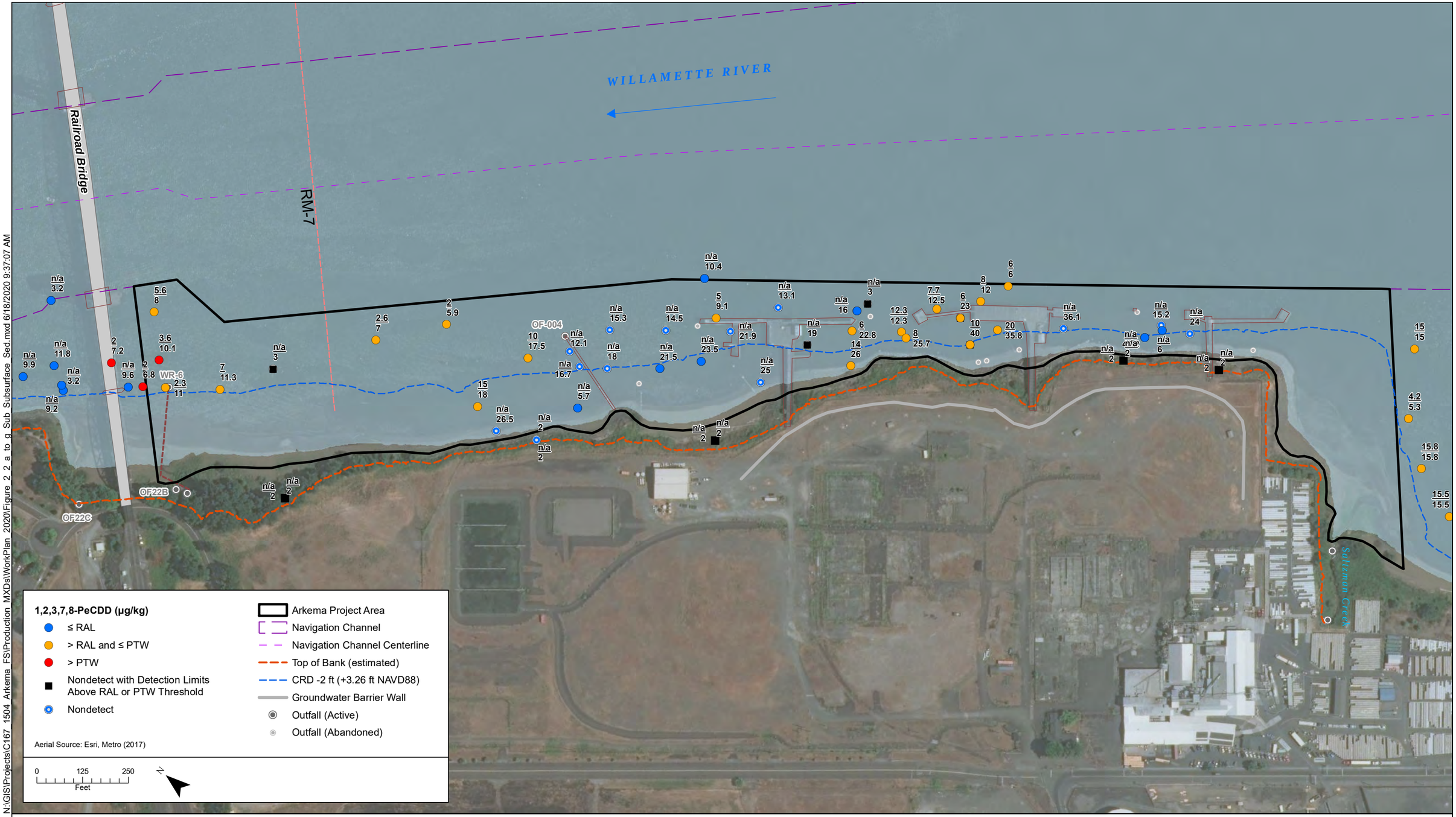
Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 0.2
Navigation Channel Remedial Action Level = 1
Principal Threat Waste = 0.2

2.3 ← Maximum Depth of RAL Exceedance (ft below mudline)
11 ← Maximum Depth of Core (ft below mudline)

n/a = not applicable because remedial action level was not exceeded

DRAFT

Figure 2-2b.
2,3,4,7,8-PeCDF Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167 1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 2_2 a to g_Sub Subsurface Sed.mxd 6/18/2020 9:37:07 AM

integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 0.0008
Navigation Channel Remedial Action Level = 0.003
Principal Threat Waste = 0.01

2.3 ← Maximum Depth of RAL Exceedance (ft below mudline)
11 ← Maximum Depth of Core (ft below mudline)

n/a = not applicable because remedial action level was not exceeded

DRAFT

Figure 2-2c.
1,2,3,7,8-PeCDD Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_2_a_to_g_Sub_Subsurface_Sed.mxd 6/18/2020 9:37:07 AM

WILLAMETTE RIVER

Railroad Bridge

RM-7

OF-004

OF22B

OF22C

WR-6

Salzman Creek

2,3,7,8-TCDD (µg/kg)

- ≤ RAL
- > RAL and ≤ PTW
- > PTW
- Nondetect with Detection Limits Above RAL or PTW Threshold
- Nondetect

Aerial Source: Esri, Metro (2017)

- Arkema Project Area
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Groundwater Barrier Wall
- Outfall (Active)
- Outfall (Abandoned)

0 125 250 Feet

N

integral consulting inc.

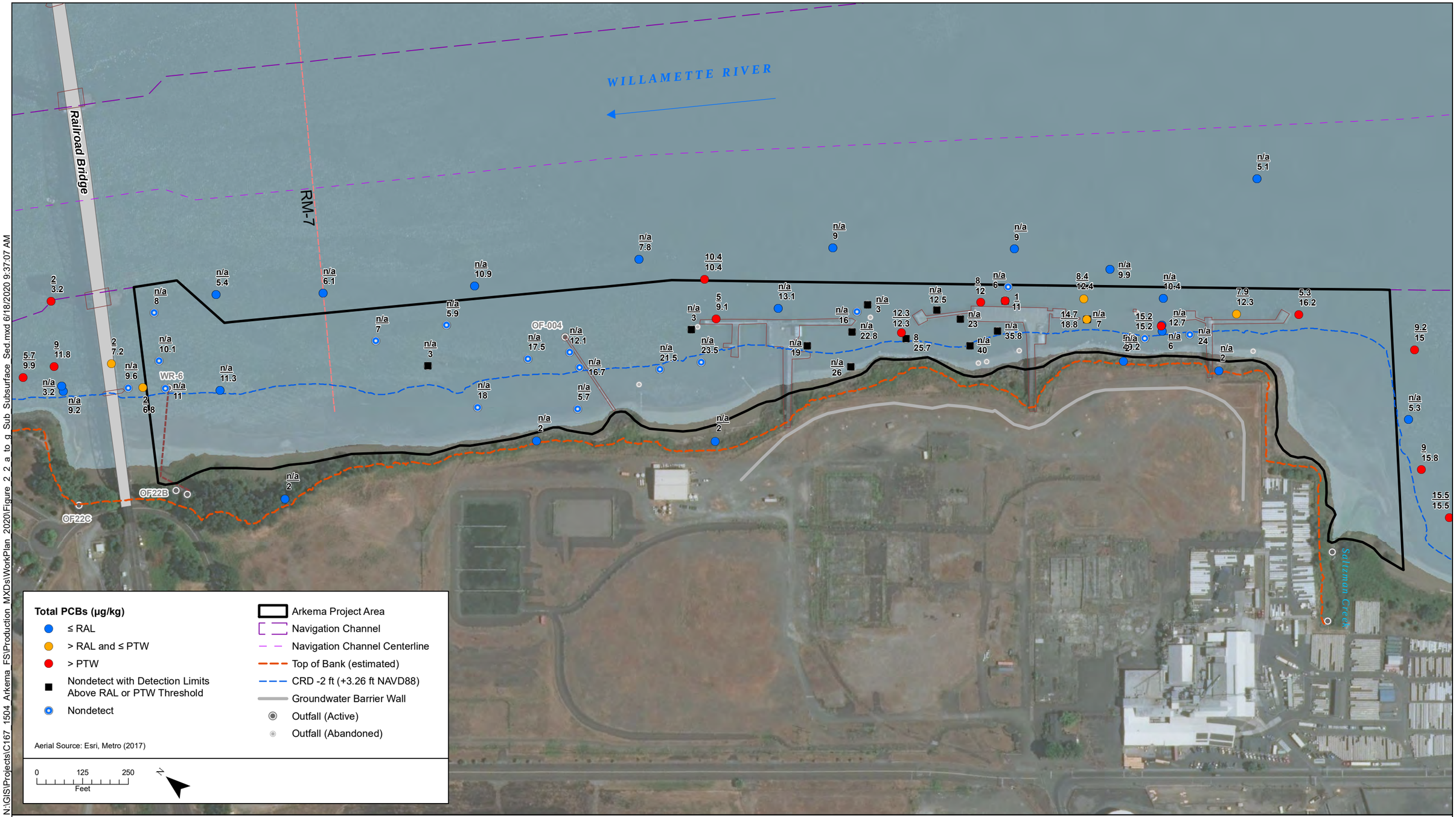
Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 0.0006
Navigation Channel Remedial Action Level = 0.002
Principal Threat Waste = 0.01

2.3 ← Maximum Depth of RAL Exceedance (ft below mudline)
11 ← Maximum Depth of Core (ft below mudline)

n/a = not applicable because remedial action level was not exceeded

DRAFT

Figure 2-2d.
2,3,7,8-TCDD Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_2_a_to_g_Sub_Subsurface_Sed.mxd 6/18/2020 9:37:07 AM

integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 75
Navigation Channel Remedial Action Level = 1,000
Principal Threat Waste = 200

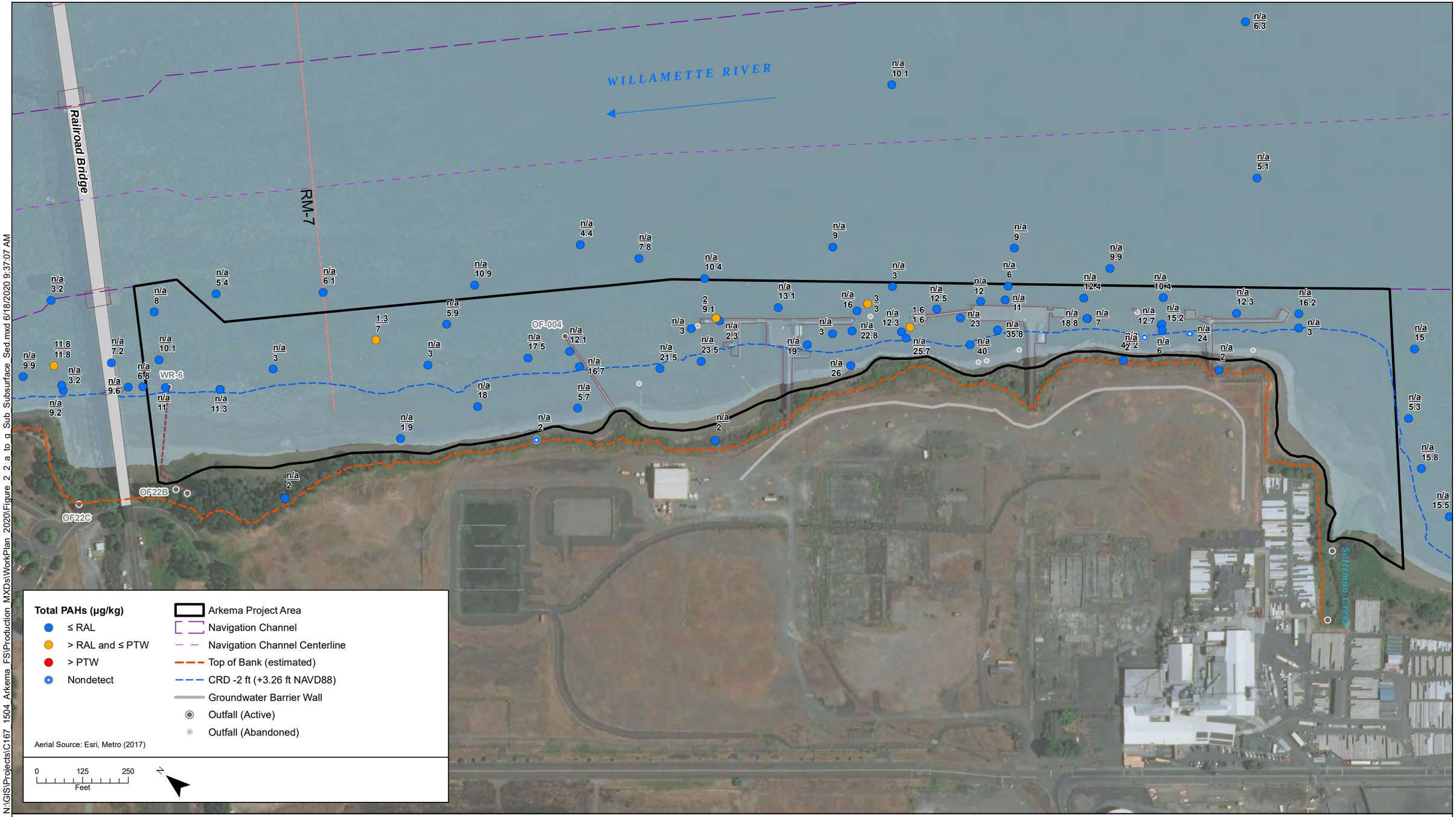
2.3 ← Maximum Depth of RAL Exceedance (ft below mudline)
11 ← Maximum Depth of Core (ft below mudline)

n/a = not applicable because remedial action level was not exceeded

DRAFT

Figure 2-2e.
Total PCBs Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167 1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 2_2 a to g_Sub Subsurface Sed.mxd 6/18/2020 9:37:07 AM



integral consulting inc.

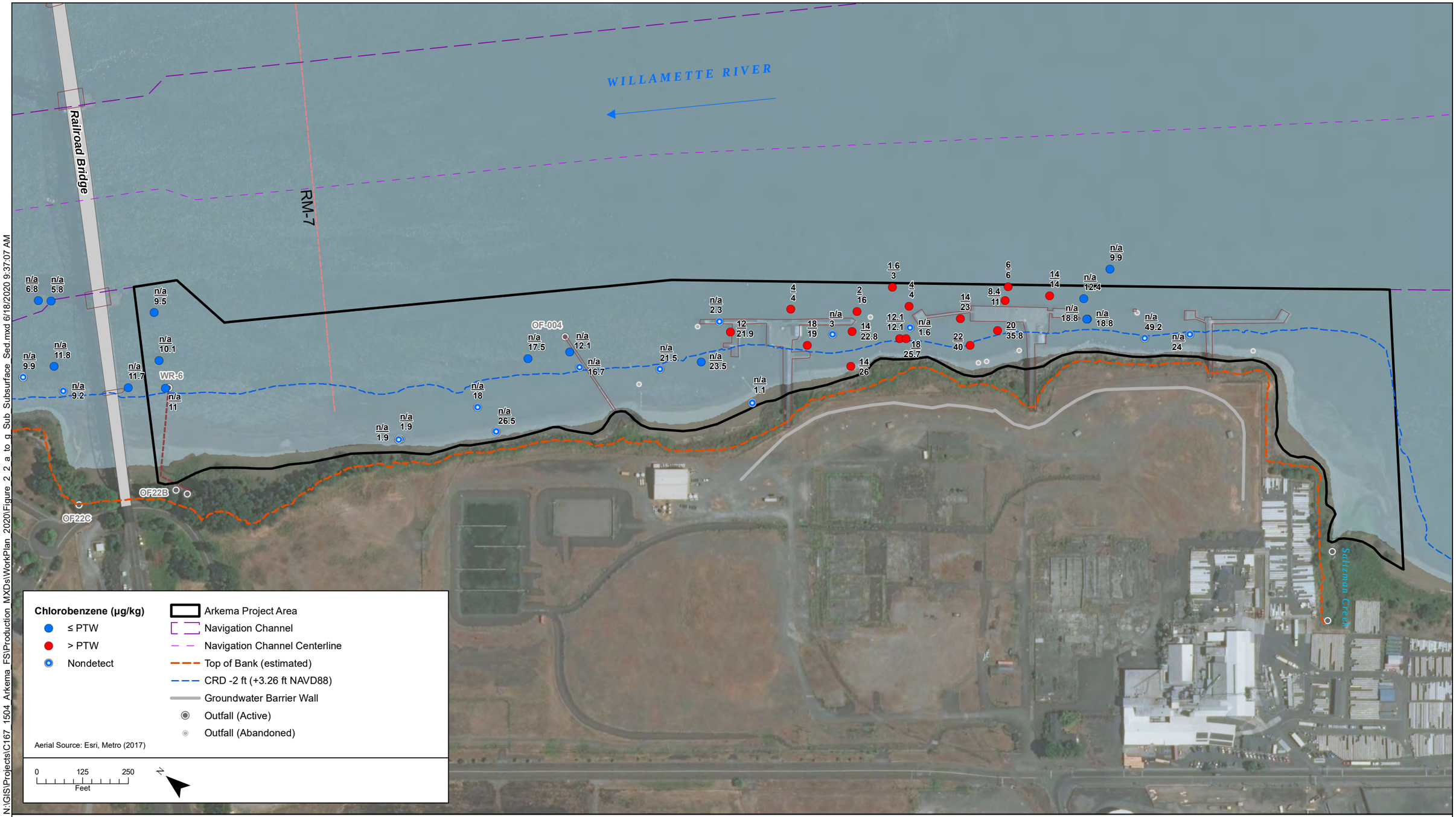
Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 30,000
Navigation Channel Remedial Action Level = 170,000
Principal Threat Waste = N/A

2.3 ← Maximum Depth of RAL Exceedance (ft below mudline)
11 ← Maximum Depth of Core (ft below mudline)

n/a = not applicable because remedial action level was not exceeded

DRAFT

Figure 2-2f.
Total PAHs Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_2_a_to_g_Sub_Subsurface_Sed.mxd 6/18/2020 9:37:07 AM

integral consulting inc.

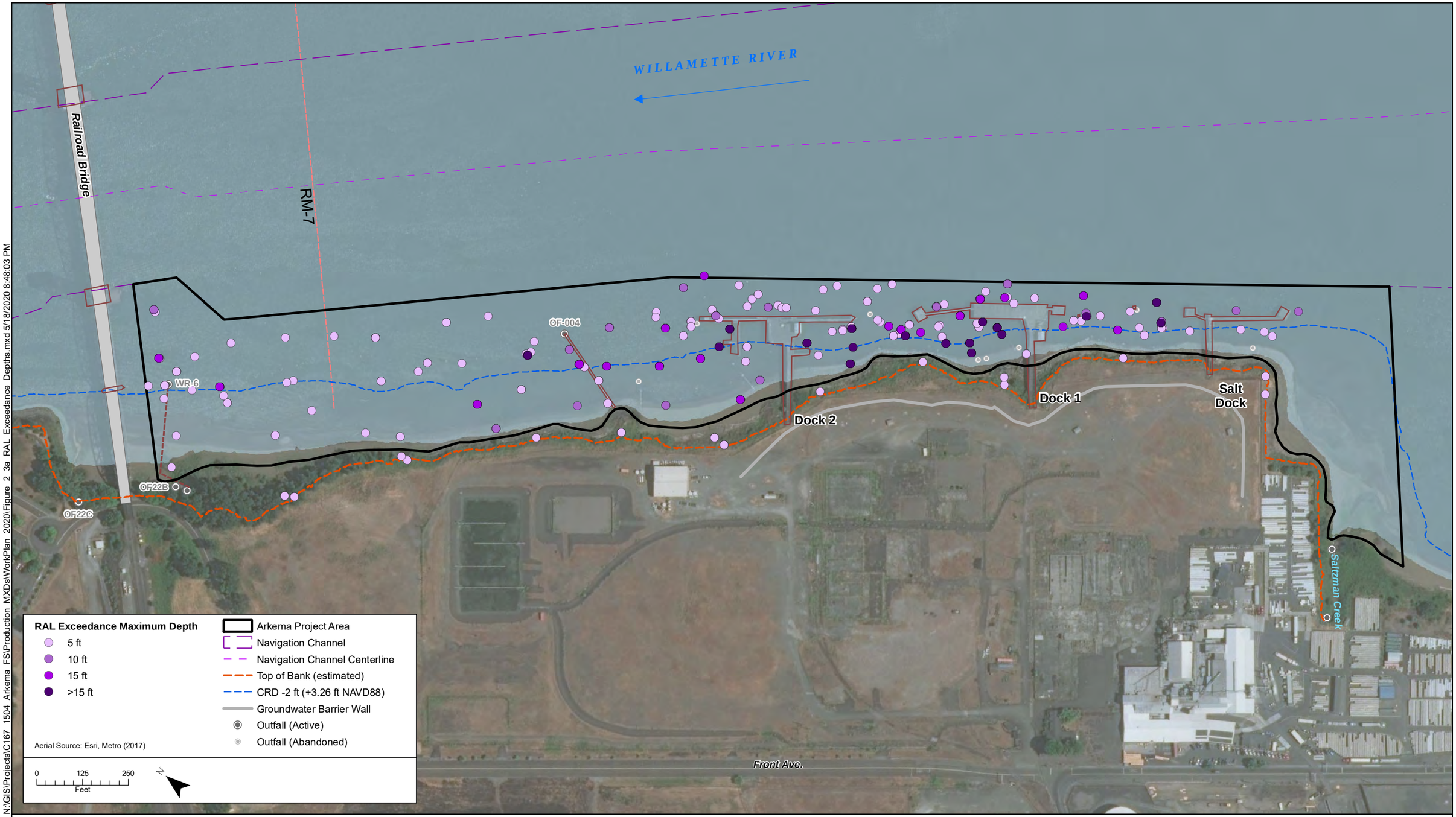
Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = NA
Navigation Channel Remedial Action Level = NA
Principal Threat Waste = 320

2.3 ← Maximum Depth of RAL Exceedance (ft below mudline)
11 ← Maximum Depth of Core (ft below mudline)

n/a = not applicable because remedial action level was not exceeded

DRAFT

Figure 2-2g.
Chlorobenzene Subsurface Sediment and Riverbank Soil Data with Maximum Depth of PTW Exceedance
Arkema Project Area Pre-design Investigation Work Plan

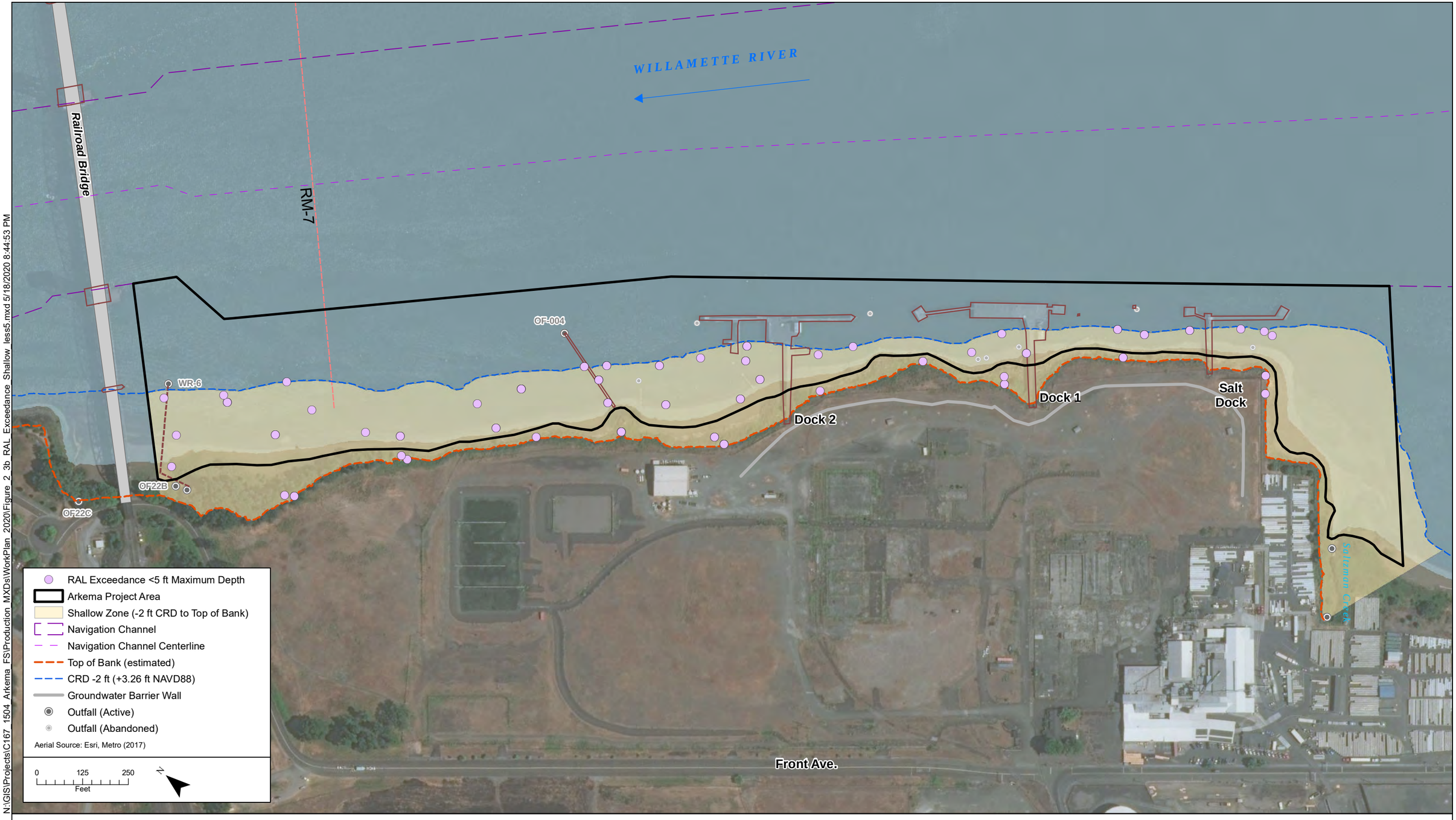


N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_3a_RAL_Exceedance_Depths.mxd 5/18/2020 8:48:03 PM

integral consulting inc.

DRAFT

Figure 2-3a.
Maximum Depth of RAL Exceedances for all Focused COCs - Riverbank Area, Arkema Project Area, and Navigation Channel Area
Arkema Project Area Pre-design Investigation Work Plan

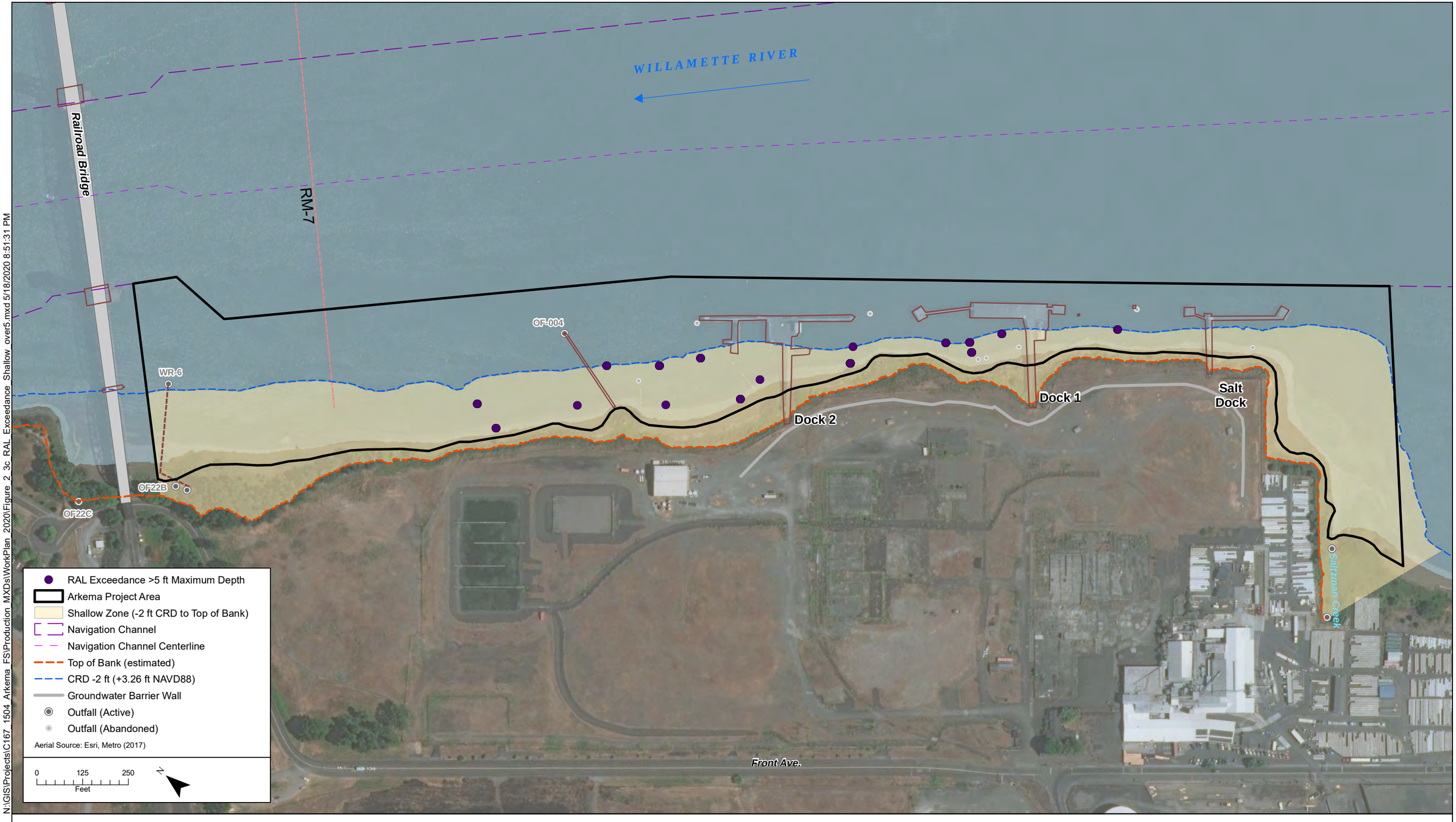


N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_3b_RAL_Exceedance_Shallow_less5.mxd 5/18/2020 8:44:53 PM

integral consulting inc.

DRAFT

Figure 2-3b.
Maximum Depth of RAL Exceedances for all Focused COCs - Shallow Zone (Shoreward of -2 ft CRD), Less than 5 ft Sediment Depth
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167_1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 2_3c_RAL_Exceedance_Shallow_over5.mxd 5/18/2020 8:51:31 PM

integral consulting inc.

DRAFT

Figure 2-3c.
Maximum Depth of RAL Exceedances for all Focused COCs - Shallow Zone (Shoreward of -2 ft CRD), Greater than 5 ft Sediment Depth
Arkema Project Area Pre-design Investigation Work Plan

WILLAMETTE RIVER

Railroad Bridge

RM-7

OF-004

WR-6

OF22B

OF22C

Dock 1

Dock 2

Salt Dock

Saltzman Creek

Front Ave.

PTW Exceedance Maximum Depth

- 5 ft
- 10 ft
- 15 ft
- >15 ft

- Arkema Project Area
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Groundwater Barrier Wall
- Outfall (Active)
- Outfall (Abandoned)

Aerial Source: Esri, Metro (2017)

0 125 250
Feet

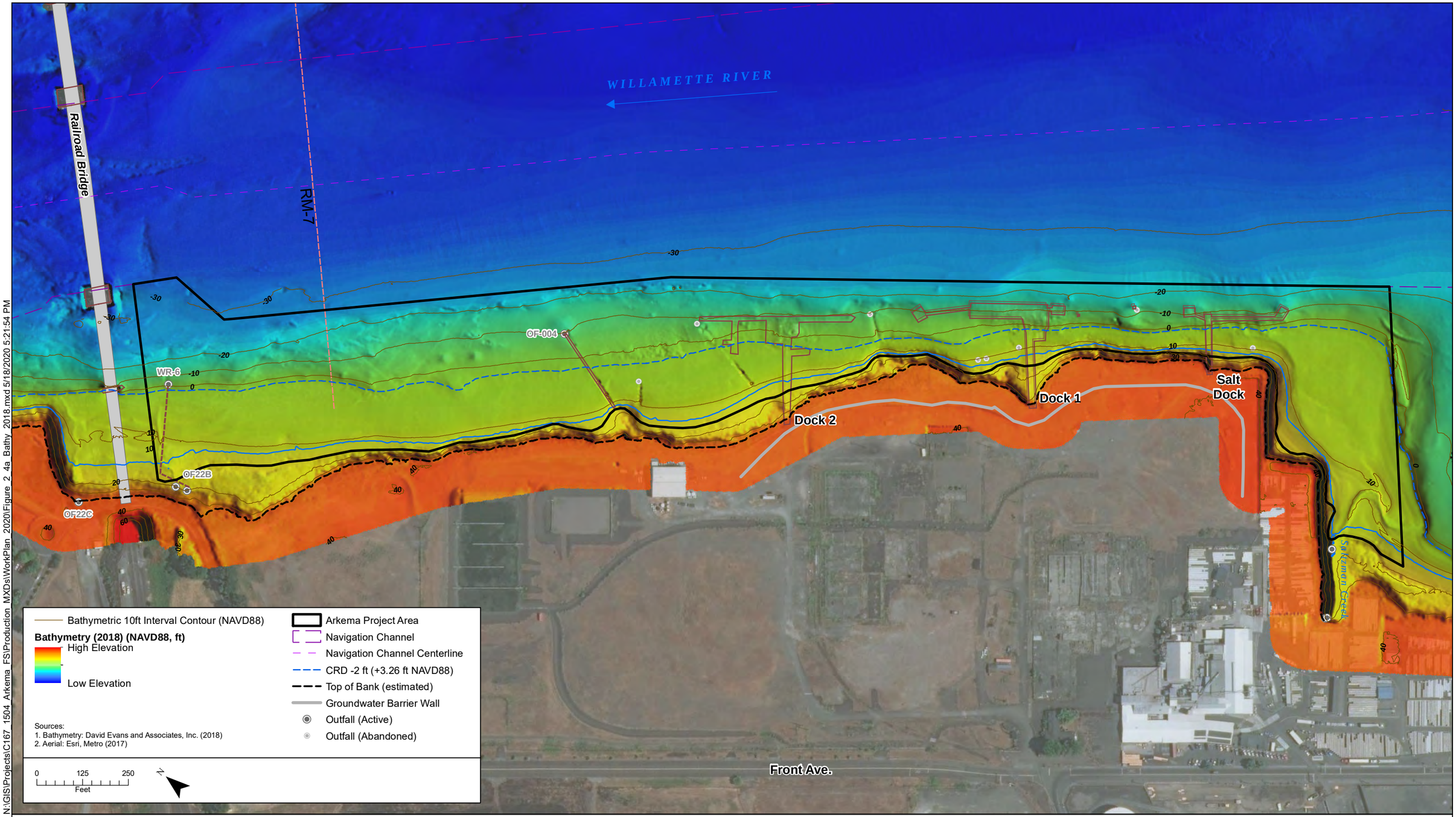
N

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_3d_PTW_Exceedance_Depths.mxd 5/18/2020 8:55:07 PM

integral consulting inc.

DRAFT

Figure 2-3d.
Maximum Depth of PTW Exceedances for all Focused COCs and Additional Contaminants - Riverbank Area, Arkema Project Area, and Navigation Channel Area
Arkema Project Area Pre-design Investigation Work Plan

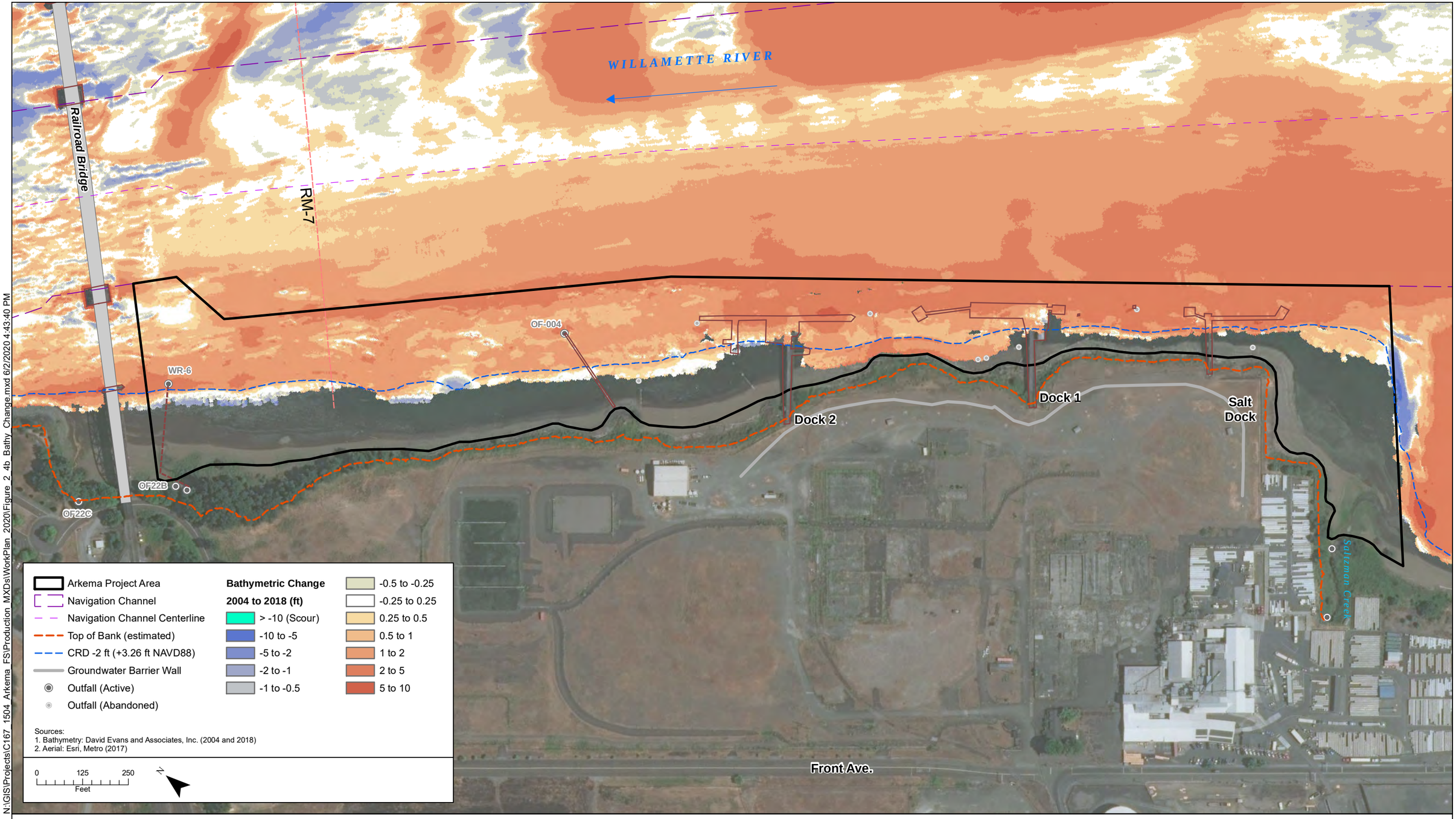


N:\GIS\Projects\C167 1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 2_4a Bathy 2018.mxd 5/18/2020 5:21:54 PM

integral consulting inc.

DRAFT

Figure 2-4a.
Arkema Project Area Bathymetry - 2018
Arkema Project Area Pre-design Investigation Work Plan

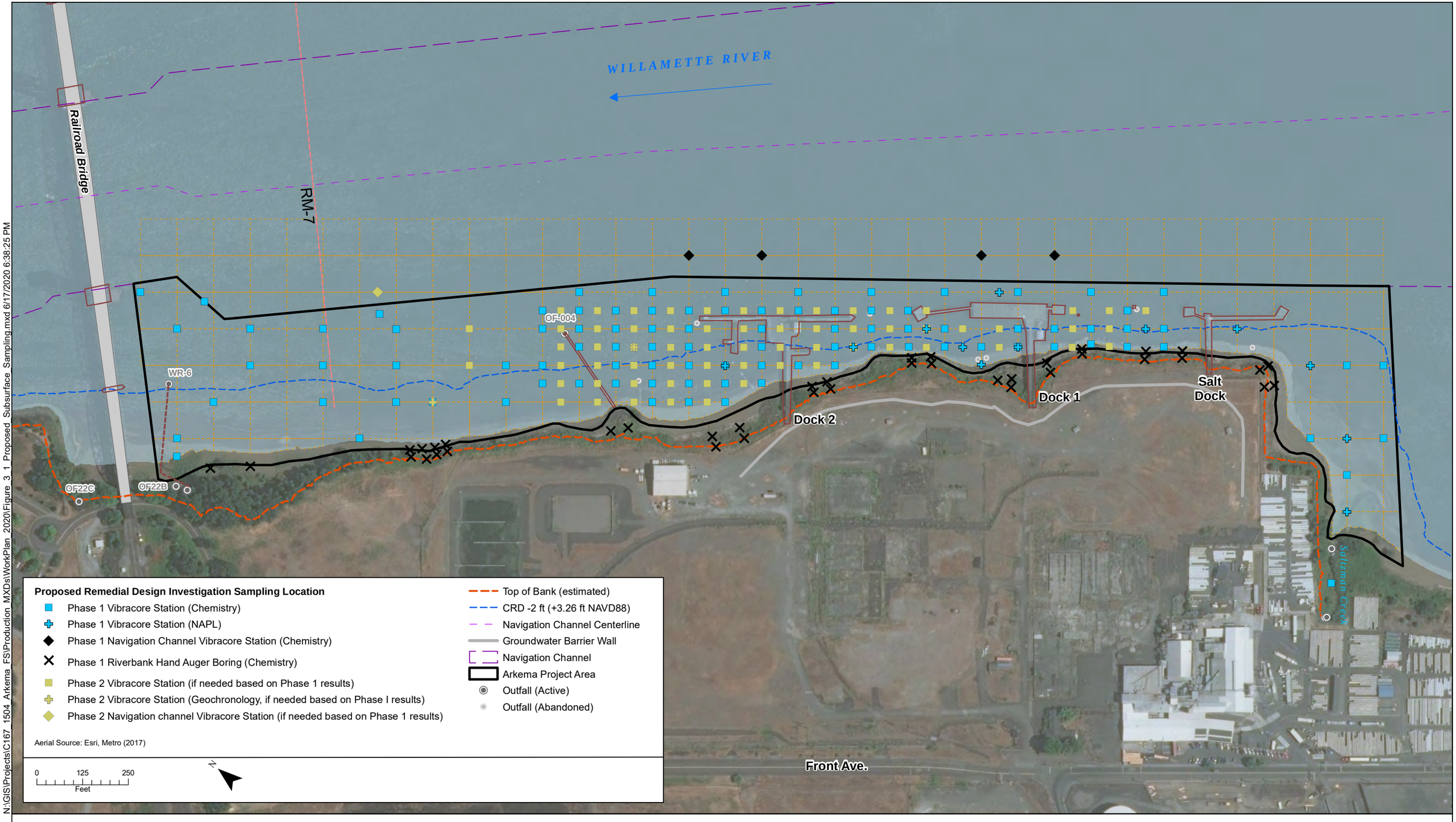


N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_4b_Bathy_Change.mxd 6/2/2020 4:43:40 PM

integral consulting inc.

DRAFT

Figure 2-4b.
Arkema Project Area Bathymetric Change - 2004-2018
Arkema Project Area Pre-design Investigation Work Plan



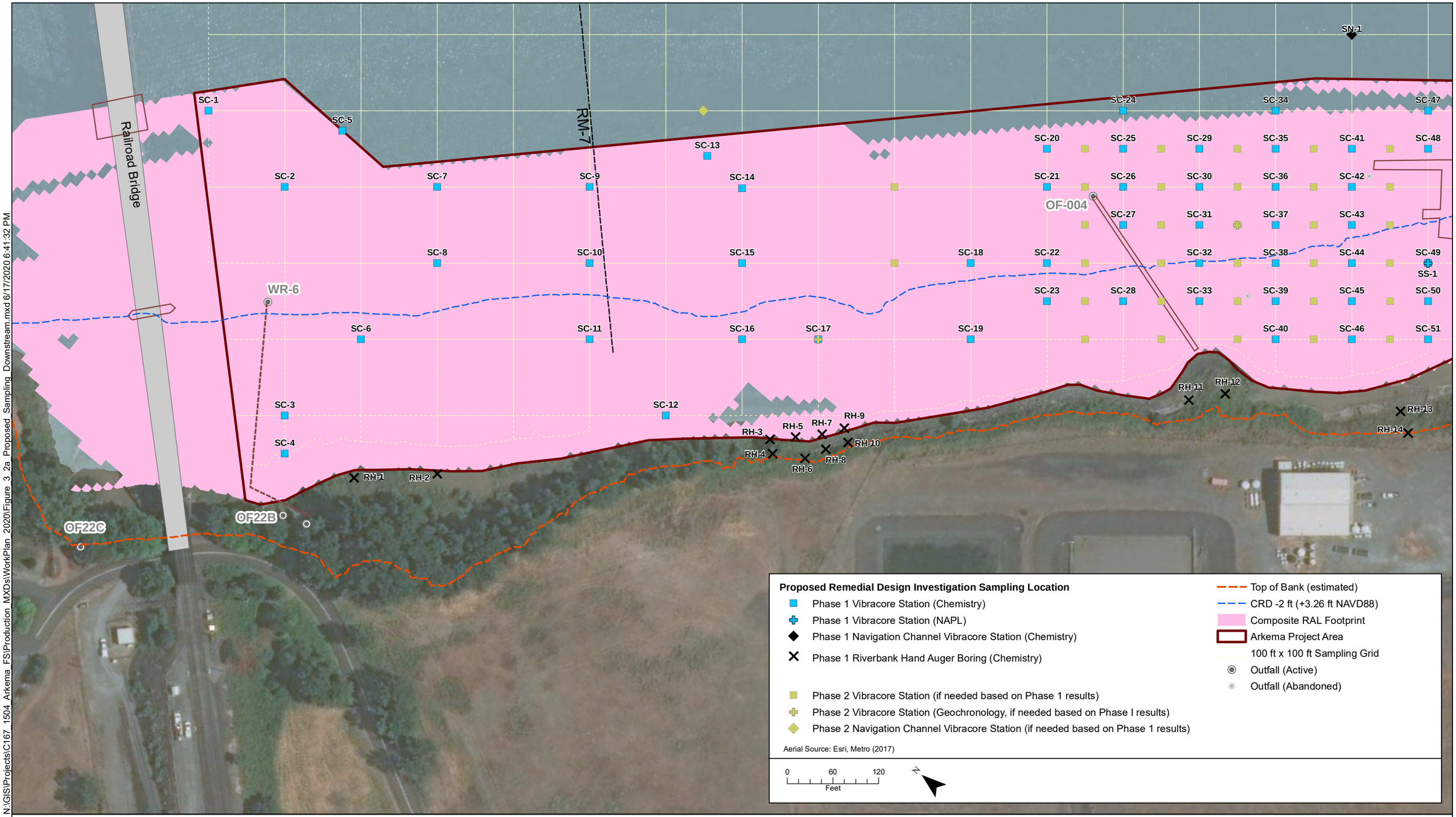
N:\GIS\Projects\C167 1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 3_1 Proposed Subsurface Sampling.mxd 6/17/2020 6:38:25 PM

integral consulting inc.

DRAFT

Figure 3-1.
Summary of Proposed Remedial Design Investigation Subsurface Sediment and Riverbank Soil Chemistry Sampling Stations
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_3_2a_Proposed_Sampling_Downstream.mxd 6/17/2020 6:41:32 PM



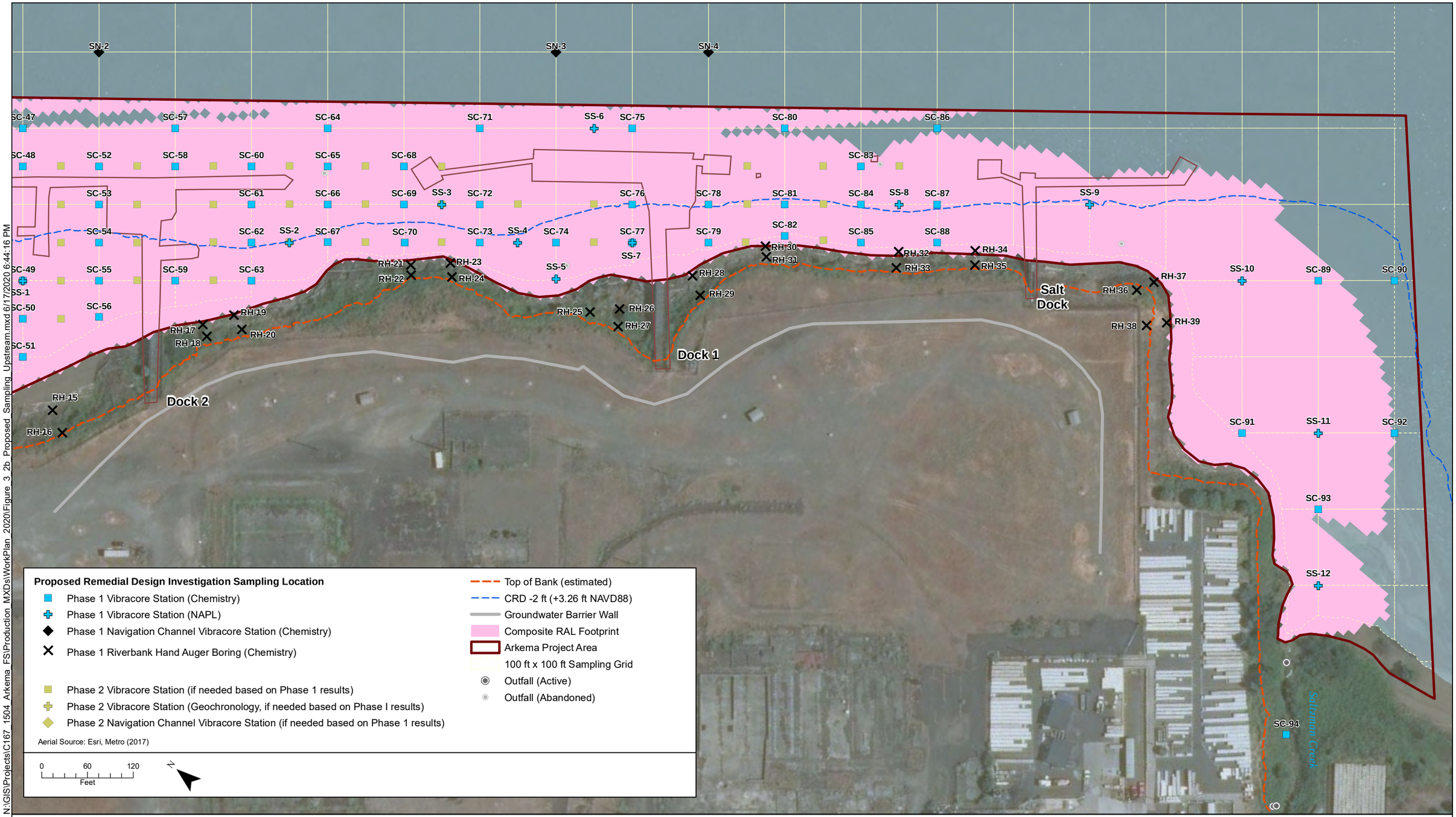
integral consulting inc.

Note:
1. Composite RAL footprint includes the Focused COCs from the ROD

DRAFT

Figure 3-2a.
Detailed Proposed Remedial Design Investigation Sediment and Riverbank Soil Chemistry Sampling Stations Downstream of Dock 2
Arkema Project Area Pre-design Investigation Work Plan

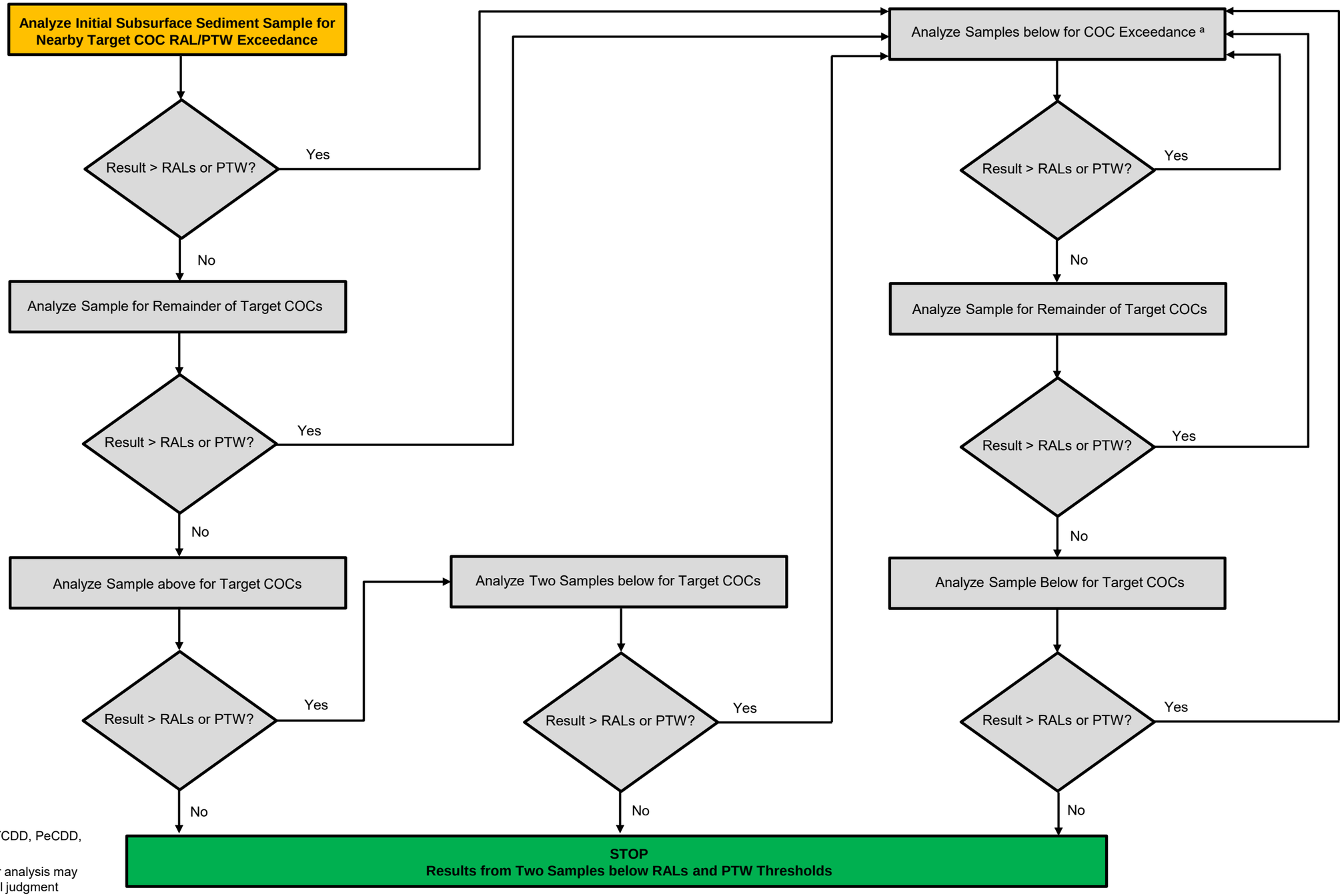
N:\GIS\Projects\C167 1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 3_2b Proposed Sampling_Upstream.mxd 6/17/2020 6:44:16 PM



integral consulting inc.

DRAFT

Figure 3-2b.
Detailed Proposed Remedial Design Investigation Sediment and Riverbank Soil Chemistry Sampling Stations Upstream of Dock 2
Arkema Project Area Pre-design Investigation Work Plan



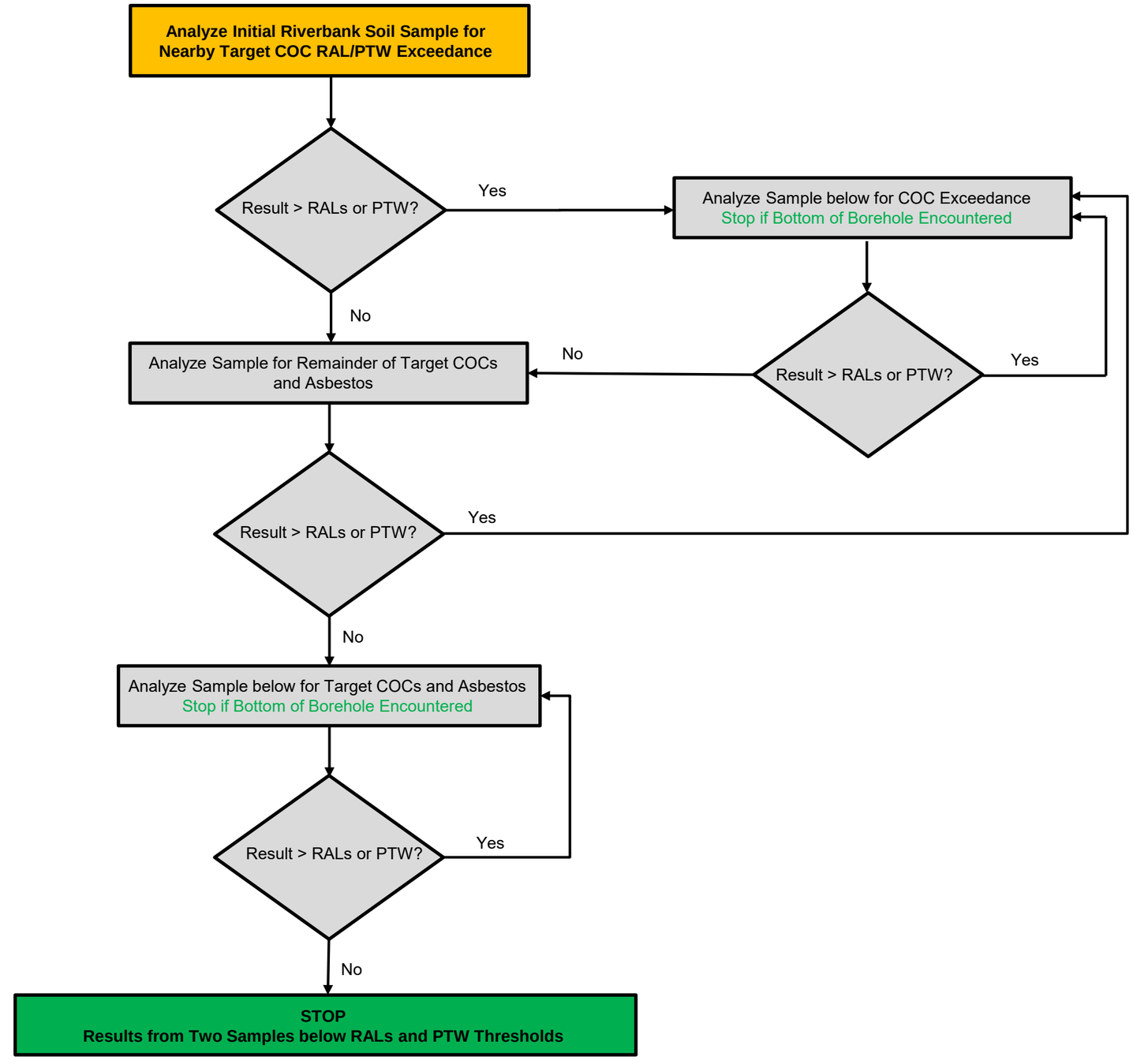
Notes:
Target COCs: DDx, PCBs, TCDD, PeCDD, PeCDF, TCDF, HxCDF

[a]Sample intervals selected for analysis may be based on best professional judgment

integral consulting inc.

DRAFT

Figure 3-2c.
Subsurface Sediment Sample Analysis Decision Tree
Arkema Pre-design Investigation Work Plan

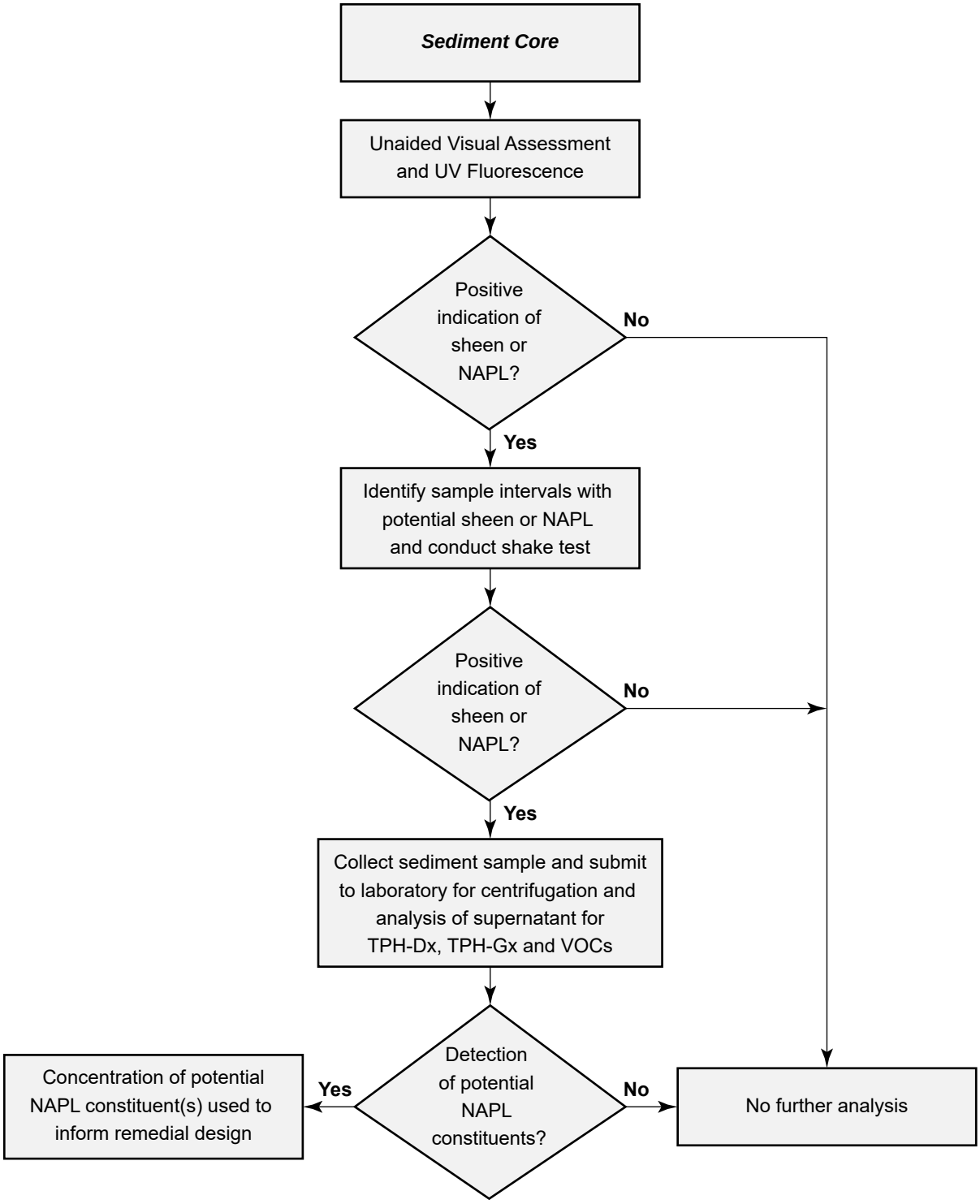


Notes:
Target COCs: DDx, PCBs, TCDD, PeCDD, PeCDF, TCDF, HxCDF

integral consulting inc.

DRAFT

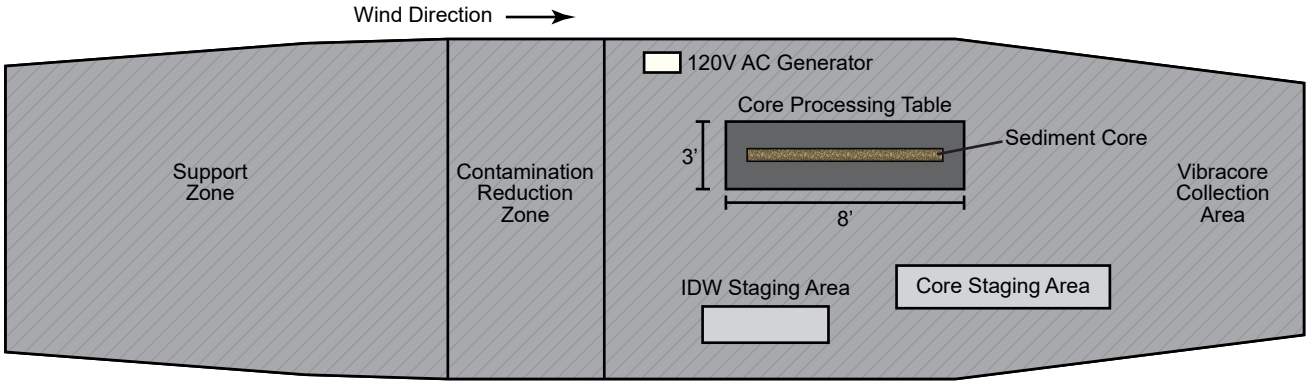
Figure 3-2d.
Riverbank Soil Sample Analysis
Decision Tree
Arkema Pre-design Investigation Work Plan



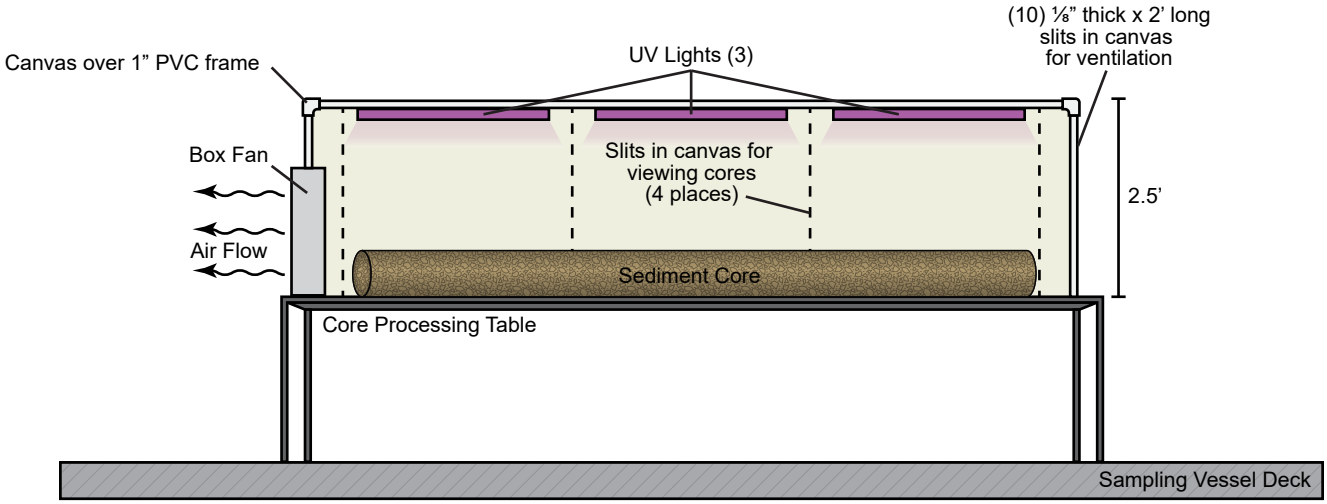
integral consulting inc.

DRAFT

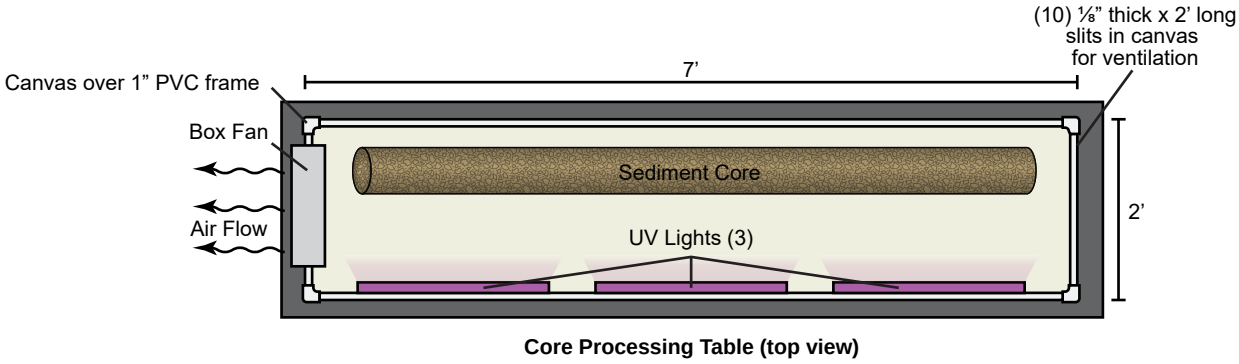
Figure 3-3a.
Evaluation of Potential Subsurface NAPL
Arkema Project Area Pre-design Investigation Work Plan



Conceptual Sampling Vessel Layout (top view)



Core Processing Table (elevation view)



Core Processing Table (top view)

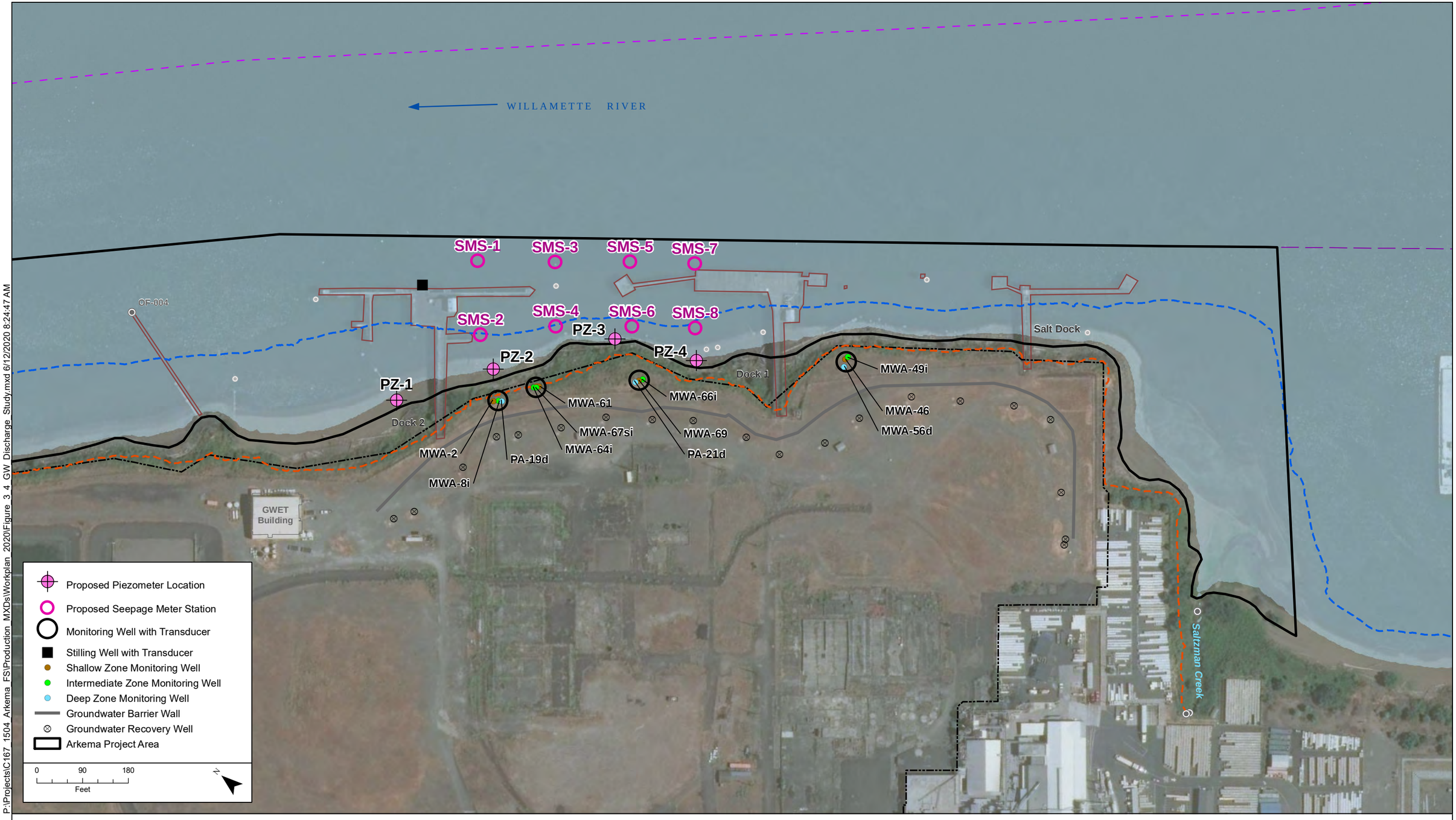
Note: Not to scale

integral consulting inc.

DRAFT

Figure 3-3b.
Conceptual Sampling Vessel Layout and
Core Processing Table
Arkema Project Area Pre-design Investigation Work Plan

P:\Projects\C167 1504 Arkema FS\Production MXDs\Workplan 2020\Figure 3_4 GW Discharge Study.mxd 6/12/2020 8:24:47 AM



integral consulting inc.

Aerial Source: Esri, Metrol (2017)

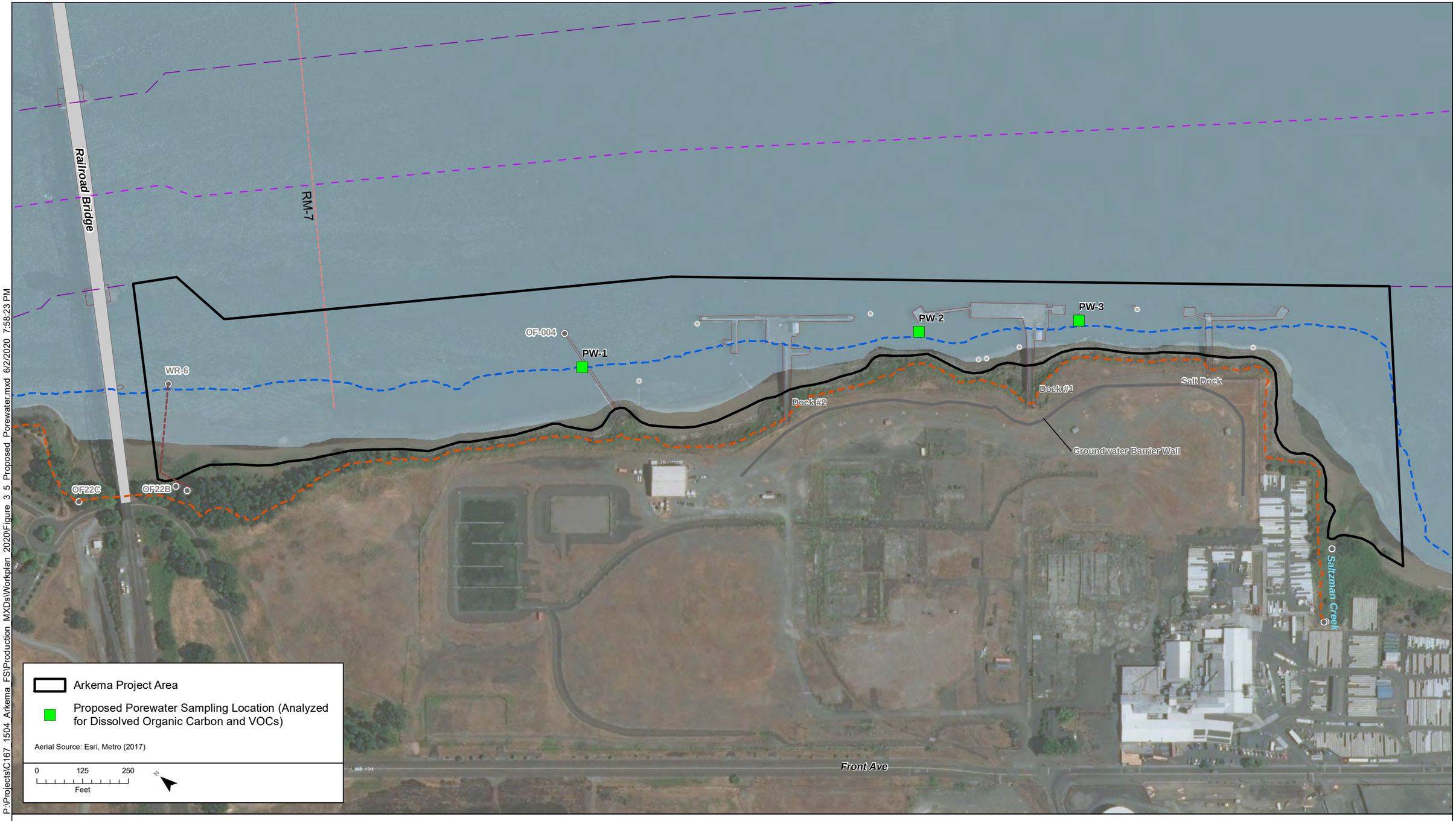
Map Features

- Property Boundary
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Docks and Structures
- Outfall (Active)
- Outfall (Abandoned)

DRAFT

Figure 3-4.
Proposed Groundwater Discharge Study
Arkema Project Area Pre-design Investigation Work Plan

P:\Projects\C167 1504 Arkema FS\Production MXDs\Workplan 2020\Figure 3_5 Proposed Porewater.mxd 6/2/2020 7:58:23 PM



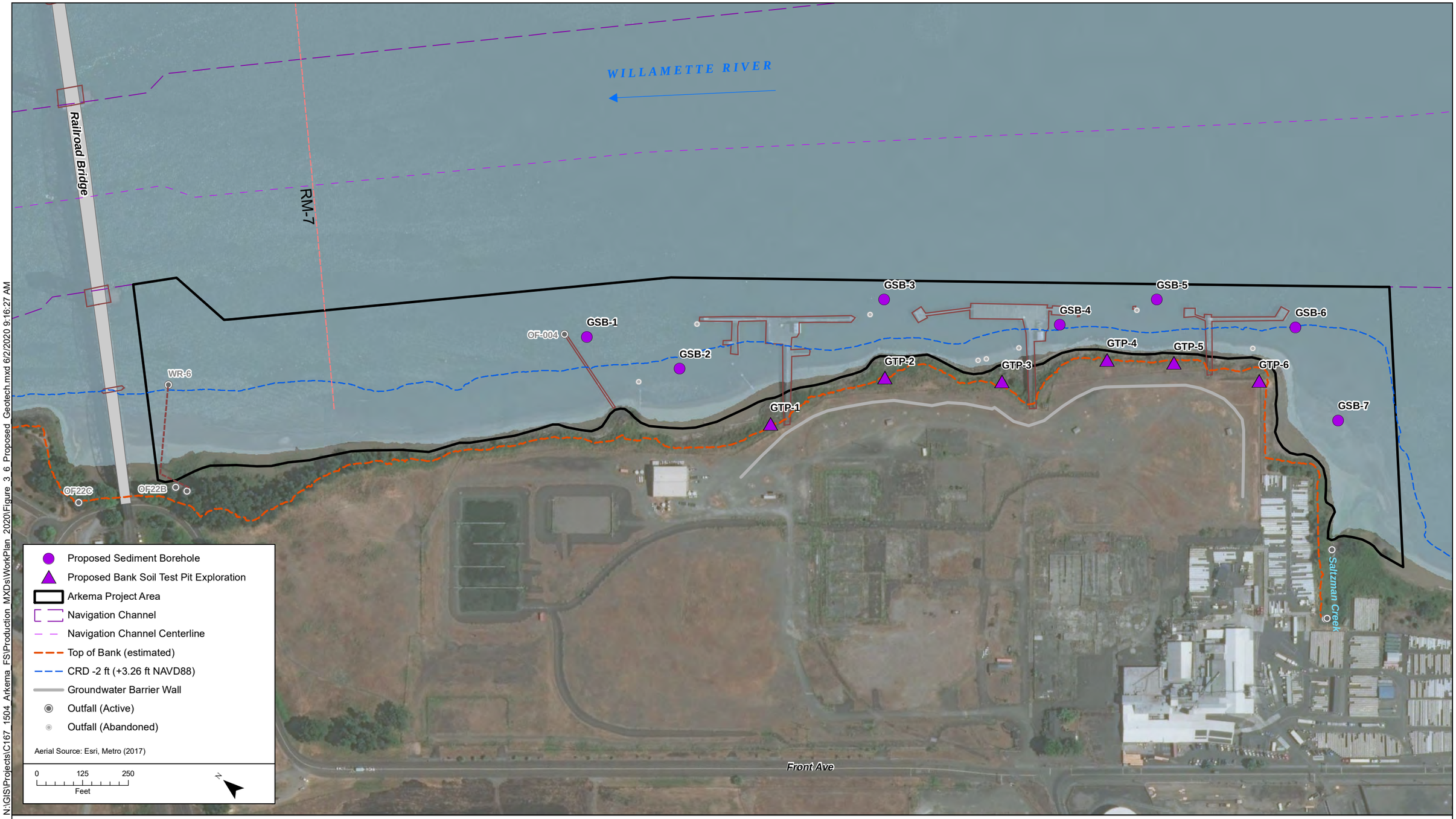
integral consulting inc.

Map Features

- River Miles
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Bridges
- Outfall (Active)
- Outfall (Abandoned)

DRAFT

Figure 3-5.
Proposed Porewater Sampling Locations
Arkema Project Area Pre-design Investigation Work Plan



integral consulting inc.

DRAFT

Figure 3-6.
Proposed Sediment and Riverbank Soil Geotechnical Sample Locations
Arkema Project Area Pre-design Investigation Work Plan

Tables

Table 3-1. Sediment Sampling Groups

Number of Stations	Description	Depth Interval	Analytes	Purpose
6	Sediment cores upstream of the Salt Dock	0-15 ft or refusal	DDx PCBs TCDD, PeCDF, PeCDD, TCDF, HxCDF PAHs (select samples)	Delineate the vertical extent of RAL and PTW exceedances for remedial design upstream of the Salt Dock and near Saltzman Creek. Evaluate sediment contamination related to historical discharges from Saltzman Creek.
11	Sediment cores between Dock 1 and the Salt Dock on an approximate 50- by 100-ft grid	0-15 ft or refusal	DDx PCBs TCDD, PeCDF, PeCDD, TCDF, HxCDF PAHs (select samples)	Delineate the vertical extent of RAL and PTW exceedances for remedial design in the area between Dock 1 and the Salt Dock.
44	Sediment cores in the vicinity of and between Docks 1 and 2 from cells on an approximate 50- by 100-ft grid	0-15 ft or refusal	DDx PCBs TCDD, PeCDF, PeCDD, TCDF, HxCDF Chlorobenzene (select cores) PAHs (select samples)	Delineate the vertical extent of RAL and PTW exceedances for remedial design in the area near the former DDT process discharge pipe.
14	Sediment cores in the vicinity of Outfall 004 from cells on an approximate 50- by 100-ft grid	0-15 ft or refusal	DDx PCBs TCDD, PeCDF, PeCDD, TCDF, HxCDF Chlorobenzene (select cores) PAHs (select samples)	Delineate the vertical extent of DDx RAL and PTW exceedances for remedial design in the vicinity of Outfall 004.
19	Sediment cores between Outfall 004 and the downstream end of the Arkema Project Area	0-15 ft or refusal	DDx PCBs TCDD, PeCDF, PeCDD, TCDF, HxCDF PAHs (select samples)	Delineate the vertical extent of RAL and PTW exceedances for remedial design in the area downstream Outfall 004, which has limited subsurface sediment data.
4	Sediment cores in the western side of the navigation channel	0-15 ft or refusal	DDx PCBs TCDD, PeCDF, PeCDD, TCDF, HxCDF PAHs (select samples)	Delineate the vertical extent of RAL and PTW exceedances for remedial design in the western side of the navigation channel.

Table 3-1. Sediment Sampling Groups

Number of Stations	Description	Depth Interval	Analytes	Purpose
12	Sediment cores for NAPL delineation from the upstream end of the Arkema Project Area to Dock 2	0-15 ft or refusal	NWTPH-Dx NWTPH-Gx VOCs Grain size Total organic carbon NAPL viscosity and density	1) Locate sampling stations in the vicinity of "WB series" boreholes to evaluate the presence or absence of NAPL/sheens (5 stations). 2) Evaluate the presence or absence of NAPL/sheens in the vicinity of Dock 2 (2 stations). 3) Evaluate the presence or absence of NAPL/sheens between Dock 1 and the Salt Dock (1 station) and near the mouth of Saltzman Creek (4 stations)

Notes:
COC = contaminant of concern
DDx = total of 2,4'- and 4,4'-DDD, DDE, DDT
HxCDF = hexachlorodibenzofuran
NAPL = nonaqueous-phase liquid
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PeCDF = pentachlorodibenzofuran
PeCDD = pentachlorodibenzo-p-dioxin
PTW = principal threat waste
RAL = remedial action level
SDU = sediment decision unit
TCDD = tetrachlorodibenzo-*p*-dioxin
TCDF = tetrachlorodibenzofuran
VOC = volatile organic compound

Table 3-2. Subsurface Sediment Data Quality Objectives

DQO Step	Description
1. State the problem	Existing DDx and dioxin/furan data for subsurface sediment are insufficient to define the horizontal and vertical remedial extent for the focused COCs in sufficient detail to prepare a remedial design. Historical data sets include relatively few subsurface measurements within the Arkema Project Area in areas outside of the Arkema docks, and the nature and extent of subsurface focused COCs in those areas is not well characterized. Additional subsurface chemistry data are needed for remedial design to better define the areas of contaminated sediments in the Arkema Project Area.
2. Identify the goals of the study	1) Determine concentrations for focused COCs in the Arkema Project Area with sufficient horizontal and vertical resolution to refine the remedy footprint and support a cost-effective pre-remedial design. The vertical resolution should be sufficient to establish the elevation of contamination (i.e., the elevation of the deepest sediment found to be contaminated above a RAL) with a high degree of accuracy for input into the dredging plan. 2) Provide data to aid in the assessment of upland SCMs effectiveness within the Arkema Project Area. 3) Obtain data with sufficiently low detection limits (i.e., below RALs) for PCBs in sediment in selected locations using EPA Method 1668c.
3. Identify information inputs	Selected sediment samples from each core will be analyzed for DDx by EPA Method 8081B, PCBs by EPA Method 1668C, and dioxins and furans by EPA Method E8290. Sediment samples from some cores between Docks 1 and 2 and in the vicinity of Outfall 004 will be analyzed for chlorobenzene by EPA Method 8260C. Selected sediment samples from cores throughout the Arkema Project Area will be analyzed for PAHs by EPA Method 8270D SIM.
4. Define the boundaries of the study	The study area is located approximately between river miles 6.9 and 7.6 on the west side of the Willamette River in Portland, Oregon. More specifically, the study area is bounded by the navigation channel centerline to the east, the riverbank to the west, approximately river mile 6.9 to the north, and approximately river mile 7.6 to the south. Subsurface sediment samples will be collected by a vibracorer to 15 ft or refusal (whichever comes first).
5. Develop the analytic approach	Subsurface sediment samples will be collected by a vibracorer to 15 ft or refusal (whichever comes first). Sediment core data from immediately downstream of the Salt Dock to just downstream of Outfall 004 will be evaluated to determine the maximum depths of RAL and PTW exceedances for the focused COCs. The results will be used to establish the elevation of contamination and quantity estimates for sediment volume to inform the remedial design and sediment treatment and/or disposal options. Sediment core data from outside of the gridded sampling area will be used to fill data gaps regarding subsurface sediment chemistry to understand the nature and extent of focused COCs, and in particular whether there are exceedances of RALs or PTW in some parts of the Arkema Project Area. Based on the results of these latter sediment sample data, additional surface sampling may be conducted to support remedial decision-making.
6. Specify performance or acceptable criteria	Field criteria: The core will be deemed acceptable if the sediment recovery inside the core tube is at least 80 percent of the penetration depth. Laboratory criteria: The target analytical methods were selected to ensure that detection limits are sufficiently low to meet project analytical concentration goals as shown in QAPP Tables B-5 and B-6 (Appendix B of this work plan). Additional quality control criteria for specific analytes and methods is provided in QAPP Tables B-7 to B-10 (Appendix B of this work plan).
7. Develop the plan for obtaining data	Sediment cores will be collected over water using a vessel-deployed vibracorer equipped with 15-ft core tubes. Sediment samples will be collected at 1-ft intervals for analysis or archive. The core collection, processing, and sample handling methods will follow the FSP (Appendix A of this work plan). Samples will be analyzed in accordance with the decision tree presented in Figure 3-2c of the work plan.

Notes:
COC = contaminant of concern
DDx = total of 2,4'- and 4,4'-DDD, DDE, and DDT
DQO = data quality objective
EPA = U.S. Environmental Protection Agency
FSP = field sampling plan
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PTW = principal threat waste
QAPP = quality assurance project plan
RAL = remedial action level
SCM = source control measure

Table 3-3. Riverbank Soil Data Quality Objectives

DQO Step	Description
1. State the problem	Riverbank soil chemistry data have identified areas with focused COCs exceeding RALs that are potentially erodible sources to the Willamette River. Based on available data, there is uncertainty regarding the nature and extent of selected focused COCs exceeding RALs or PTW in riverbank soil. The remedy design will require surface and subsurface soil data that define the limits of the extent of COCs exceeding RALs in riverbank soil adjacent to the sediment portion of the Arkema Project Area.
2. Identify the goals of the study	The goals of this study are to identify areas of riverbank soil with COCs that exceed RALs and have the potential to mobilize to the sediment portion of the Arkema Project Area through erosion or bank failure. These data will also be used to inform remedy selection and design and to establish pre-remedial baseline conditions adjacent to sediment portion of the Arkema Project Area.
3. Identify information inputs	Surface and subsurface soil samples will be analyzed for DDx by EPA Method 8081B, PCBs by EPA Method 1668C, dioxins and furans by EPA Method E8290, and asbestos by EPA/600R-93/116.
4. Define the boundaries of the study	The study area is located between approximately river miles 6.9 and 7.6 on the west side of the Willamette River in Portland, Oregon. More specifically, the study area is bounded by the -2 ft CRD to the east, the top of bank to the west, approximately river mile 6.9 to the north, and approximately river mile 7.6 to the south. Soil samples will be collected from ground surface to 4 ft below ground surface or refusal (whichever comes first).
5. Develop the analytic approach	The analytical approach will assist in evaluating RAL and PTW threshold exceedances in bank soil and sediment along the Arkema Project Area riverbank, which will be used to assess remedial options and provide information for remedial design bank treatment in the Arkema Project Area.
6. Specify performance or acceptable criteria	The target analytical methods were selected to ensure that detection limits are sufficiently low to meet project analytical concentration goals as shown in QAPP Tables B-5 and B-6 (Appendix B of this work plan). Additional quality control criteria for specific analytes and methods is provided in QAPP Tables B-7 to B-10 (Appendix B of this work plan). The criteria used to determine acceptability of soil samples in the field is 80% recovery from the hand auger bucket for each 1-ft sample interval.
7. Develop the plan for obtaining data	Discrete soil samples will be collected using a hand auger following standard protocols and guidelines and in accordance with guidelines provided in the FSP (Appendix A to this work plan). A total of 37 borings will be advanced to 4 ft below ground surface or refusal. Soil samples will be collected at 1-ft intervals for analysis or archive. Samples will be analyzed in accordance with the decision tree presented in Figure 3-2d of the work plan.

Notes:
COC = contaminant of concern
CRD = Columbia River datum
DDx = total of 2,4'- and 4,4'-DDD, DDE, and DDT
DQO = data quality objective
EPA = U.S. Environmental Protection Agency
FSP = field sampling plan
PCB = polychlorinated biphenyl
PTW = principal threat waste
QAPP = quality assurance project plan
RAL = remedial action level
SCM = source control measure

Table 3-4. NAPL Assessment Data Quality Objectives

DQO Step	Description
1. State the problem	Chlorobenzene NAPL has been identified in a portion of the upland area of the Arkema site in the Acid Plant Area, which is located between Docks 1 and 2 (ERM 2005, 2006). However, site-related chlorobenzene NAPL has not been identified in sediment during previous investigations. The upland groundwater pathway has been isolated from the river as a result of groundwater SCMs; however, as noted in Section 2.6.1 of the work plan text, recent quarterly groundwater monitoring shows elevated levels of chlorobenzene in monitoring wells located on the river side of the groundwater barrier wall between Docks 1 and 2, particularly in the intermediate and deep groundwater zones. For many years, the shoreline adjacent to the Arkema site was used as a staging area for logs. Sheens due to organic material deposited in the sediment from these log rafts have been documented. In addition, the Arkema Project Area is located immediately downstream of a bulk petroleum fuel terminal and along an industrial waterway with many potential hydrocarbon sources. During previous investigations, sheens, blebs, and globules were observed in selected boreholes, which is consistent with a typical navigable river in an industrialized area. Portions of the Arkema Project Area near Outfall 004 and Docks 1 and 2 are designated as "PTW – Source Material (NAPL)" in Figure 8 of the Portland Harbor ROD (USEPA 2017). These areas must and will be appropriately evaluated for NAPL as part of the pre-design investigation. The NAPL evaluation will include visual assessment, UV fluorescence, and shake tests with a hydrophobic dye. Sediment samples with evidence of NAPL, based on the visual assessment, UV fluorescence, and shake tests will be centrifuged in an analytical laboratory and the supernatant then subjected to the UV screening protocols. If NAPL is identified in the supernatant based on the UV screening, the NAPL will be extracted from the supernatant and tested for physical parameters (density and viscosity) and COCs (NWTPH-Dx, NWTPH-Gx, and VOCs). If NAPL is not found in the supernatant, it will not be considered in the design process. If NAPL is found in the supernatant, it will be considered PTW source material and the physical and chemical properties of the NAPL will be considered in the design process for dredging (e.g., mobility based on physical parameters) and capping (e.g., potential breakthrough based on COCs).
2. Identify the goals of the study	The goal of this study is to identify and characterize NAPL, if observed, regardless of source, in subsurface sediment adjacent to the Arkema Project Area. The focus will be to determine whether there is a potential presence of NAPL in site sediment and to evaluate the potential need for additional characterization and consideration during remedial design. Data will be collected to meet the following objectives: • Locate sampling stations in the vicinity of "WB series" boreholes to evaluate the presence or absence of NAPL/sheens (5 stations). • Evaluate the presence or absence of NAPL/sheens at the upstream end of Dock 2 (2 stations). • Evaluate the presence or absence of NAPL/sheens between Dock 1 and the Salt Dock (1 station) and near the mouth of Saltzman Creek (4 stations)
3. Identify information inputs	Field screening will be conducted on the core samples, as described in the analytic approach below. For cores where NAPL is observed, sediment samples will be collected, centrifuged at the analytical laboratory, and the supernatent will be subjected to UV screening protocols. If NAPL is identified in the supernatant, the NAPL will be extracted from the supernatant tested for petroleum hydrocarbons by methods NWTPH-Gx and NWTPH-Dx, and VOCs by EPA Method 8260C. If a sufficient quantity of NAPL is obtained (250 mL), then the NAPL will be tested for density and viscosity. The sediment sample will also be analyzed for TOC by ASTM D4129 and grain size by ASTM D422.
4. Define the boundaries of the study	The study area is located approximately between river miles 6.9 and 7.6 on the west side of the Willamette River in Portland, Oregon. More specifically, the study area is bounded by the navigation channel centerline to the east, the riverbank to the west, approximately river mile 6.9 to the north, and approximately river mile 7.6 to the south. Subsurface sediment samples will be collected by a vibracorer to 15 ft or refusal (whichever comes first).

Table 3-4. NAPL Assessment Data Quality Objectives

DQO Step	Description
5. Develop the analytic approach	The analytic approach will focus on the direct detection of NAPL. An assessment of NAPL will be important for pre-remedial design, particularly for sediment cap engineering. The approach will consist of the following sequence of steps: 1) Unaided visual inspection, logging, and photo-documentation of the entire core 2) Ultraviolet fluorescence examination and photo-documentation of the entire core 3) If potential NAPL is identified in Steps 1 or 2 above, then a sediment-water shake test with hydrophobic dye will be conducted on these portions of the sediment cores. 4) If the sediment-water shake test reveals potential NAPL, then a sediment sample will be collected and centrifuged at the analytical laboratory. Supernatant will be analyzed for petroleum hydrocarbons by methods NWTPH-Gx and NWTPH-Dx, and VOCs by EPA Method 8260C. If a sufficient quantity of NAPL is obtained (250 mL), then the NAPL will be tested for density and viscosity. The sediment sample will be analyzed for TOC by ASTM D4129 and grain size by ASTM D422.
6. Specify performance or acceptable criteria	Field criteria: The core will be deemed acceptable if the sediment recovery inside the core tube is at least 80 percent of the penetration depth. Laboratory criteria: The target analytical methods were selected to ensure that detection limits are sufficiently low to meet project analytical concentration goals as shown in QAPP Tables B-5 and B-6 (Appendix B). Additional quality control criteria for specific analytes and methods is provided in QAPP Tables B-7 to B-10 (Appendix B).
7. Develop the plan for obtaining data	Sediment cores will be collected at 12 locations. Sediment cores will be collected over water using a vessel-deployed vibracorer equipped with 15-ft core tubes. Sediment samples will be collected at 1-ft intervals for analysis or archive. The core collection, processing, and sample handling methods will follow the FSP (Appendix A of this work plan).

Notes:
COC = contaminant of concern
DQO = data quality objective
EPA = U.S. Environmental Protection Agency
FSP = field sampling plan
NAPL = nonaqueous-phase liquid
PTW = principal threat waste
QAPP = quality assurance project plan
ROD = record of decision
TOC = total organic carbon
UV = ultraviolet
VOC = volatile organic compound

Table 3-5. Sediment Stability Data Quality Objectives

DQO Step	Description
1. State the problem	The current assessment of the depositional regime in the Arkema Project Area, which is based on available bathymetric data collected as part of the Portland Harbor RI/FS and 2018 PDI, is inconclusive due to gaps in coverage for the nearshore area in this portion of the Portland Harbor site. However, the following lines of evidence indicate that natural recovery is occurring in the Arkema Project Area, including the area downstream of Dock 2: • The presence of fine-grained surface sediment (e.g., silts and clays) indicative of relatively low-energy (depositional) environments • Higher concentrations of COCs in subsurface than in surface sediment, indicating deposition of relatively cleaner material over sediment impacted by historical discharges • Historical records indicating periodic maintenance dredging adjacent to the site docks, demonstrating that the area in the vicinity of the docks is a net depositional environment. Additional information is needed to support consideration and incorporation of sediment deposition and resulting natural recovery into the remedial design.
2. Identify the goals of the study	The goal of this study is to assess the sediment deposition rate in the area downstream of Dock 2 at the Arkema site. Indication of a depositional regime through use of geochronology can provide an additional line of evidence to confirm and assess natural recovery processes and support consideration of this technology during remedial design. These additional data will support incorporation of remedial technologies, such as monitored or enhanced natural recovery, to address portions of the Arkema Project Area.
3. Identify information inputs	Sediment samples will be collected as described in the analytic approach below. Every third 2-in.-thick sample will be analyzed for DDx by EPA Method 8081B, cesium-137 by TBE-2005 SOP, and lead-210 by TBE-2015 SOP. The remaining samples will be archived at the analytical laboratory for possible future analysis.
4. Define the boundaries of the study	The study area is located approximately between river miles 6.9 and 7.6 on the west side of the Willamette River in Portland, Oregon. More specifically, the study area is bounded by the navigation channel centerline to the east, the riverbank to the west, approximately river mile 6.9 to the north, and approximately river mile 7.6 to the south. Subsurface sediment samples will be collected by a vibracorer to 15 ft or refusal (whichever comes first).
5. Develop the analytic approach	The analytic approach is focused on assessing deposition rates using DDx, cesium-137, and lead-210 data. The sediment deposition rates will be estimated using the depth to the highest DDx concentration (representing the approximate 1947 sediment surface) and absolute age dating: • The highest concentration of DDx in subsurface sediments represents the approximate startup time for DDT manufacturing at the Arkema site, which was 1947. The average annual sediment deposition rate will be estimated by dividing the depth to the approximate 1947 sediment horizon (i.e., highest DDx concentration) in centimeters by the number of years (2020 - 1947 = 73 years). • Absolute age dating can be achieved using cesium-137 and lead-210 data, which have half lives of 30 years and 22 years, respectively. The deposition rate can be estimated based on the sediment depth and year the sediment was deposited using the methodology presented in the previous bullet.
6. Specify performance or acceptable criteria	Field criteria: The core will be deemed acceptable if the sediment recovery inside the core tube is at least 80 percent of the penetration depth. Laboratory criteria: The target analytical methods were selected to ensure that detection limits are sufficiently low to meet project analytical concentration goals as shown in QAPP Tables B-5 and B-6 (Appendix B of this work plan). Additional quality control criteria for specific analytes and methods are provided in QAPP Tables B-7 to B-10 (Appendix B of this work plan).

Table 3-5. Sediment Stability Data Quality Objectives

DQO Step	Description
7. Develop the plan for obtaining data	Two sediment cores will be collected from each of two locations downstream of Dock 2. The sediment cores will be collected over water using a vessel-deployed vibracorer equipped with 15-ft core tubes. Samples from the first core will be collected at 2-in. intervals, homogenized, and submitted to the analytical laboratory for either analysis or archive. Initially every third sediment sample (i.e., 4–6 in., 10–12 in., 16–18 in., 22–24 in., etc.) will be analyzed for the constituents identified in DQO step 3. A second core will be advanced at each location, and the sediment will be submitted to the analytical laboratory to be archived. The core will be cut into manageable lengths (e.g., 2- to 3-ft-long sections) and each end will be securely capped. The core collection, processing, and sample handling methods will follow the FSP (Appendix A of this work plan).

Notes:
COC = contaminant of concern
DDx = total of 2,4'- and 4,4'-DDD, DDE, and DDT
DQO = data quality objective
EPA = U.S. Environmental Protection Agency
FSP = field sampling plan
PDI = pre-design investigation
QAPP = quality assurance project plan
RI/FS = remedial investigation and feasibility study
SOP = standard operating procedure

Table 3-6. Groundwater Discharge Study Data Quality Objectives

DQO Step	Description
1. State the problem	Previous groundwater discharge studies were conducted in 2004 and 2005, prior to implementation of the groundwater SCMs at the Arkema site in 2012. The groundwater SCMs consisted of the installation of a groundwater barrier wall and a GWET system. The groundwater barrier wall extends from the vicinity of Dock 2 to the southern portion of the Salt Dock and former Salt Pads and physically separates upland groundwater from the Willamette River. Therefore, the 2004 and 2005 groundwater discharge data collected by the LWG are not representative of current site conditions. A new groundwater discharge study needs to be conducted to provide data in support of pre-design, specifically for the design of an engineered cap, which would consider the post-SCM flux of groundwater contaminants, if any, through the cap. Discharge of COCs in groundwater upgradient of the groundwater barrier wall has been controlled at the Arkema site for about 8 years; however, recent groundwater concentration measurements indicate that chlorobenzene and other chemicals are still present at elevated concentrations in groundwater downgradient of the groundwater barrier wall. The potential for residual COCs in the area downgradient of the barrier wall to contribute to COC flux during and after sediment remediation is not currently known.
2. Identify the goals of the study	The goal of this study is to assess the current groundwater flux to the Willamette River. The study will consist of the following elements: 1) Direct measurement of groundwater flux to the Willamette River using seepage meters 2) Measurement of the hydraulic gradient between the river side of the groundwater barrier wall and the Willamette River, which will aid in understanding the current relationship between the groundwater hydraulic gradient and groundwater flux 3) Generation of data that can be used to evaluate COC concentrations that could potentially contribute to post-remediation COC flux from the downgradient side of the groundwater barrier wall through the Willamette River sediments.
3. Identify information inputs	The information inputs are groundwater flux measurements, groundwater and river water level measurements, and analysis of focused COCs in groundwater and porewater samples.
4. Define the boundaries of the study	The study area is located between approximately river miles 6.9 and 7.6 on the west side of the Willamette River in Portland, Oregon. More specifically, the study area is bounded by the navigation channel centerline to the east, the riverbank to the west, approximately river mile 6.9 to the north, and approximately river mile 7.6 to the south.

Table 3-6. Groundwater Discharge Study Data Quality Objectives

DQO Step	Description
5. Develop the analytic approach	The analytic approach is focused on the direct measurement of groundwater flux to the Willamette River and estimates of hydraulic gradients between upland groundwater on the river side of the groundwater barrier wall and the Willamette River. This information will be used in support of pre-remedial design. Seepage meters will be deployed in the vicinity of nearshore locations, where the average flux values were positive during the LWG 2005 groundwater pathway assessment, to evaluate the groundwater flux post-groundwater SCM implementation. Concentrations of COCs will also be directly measured by collecting one groundwater/porewater sample from each seepage meter during deployment. Transducer data from 12 wells will be used. The wells are located on the river side of the groundwater barrier wall near the docks and are monitored as part of the GWET system. Piezometers will be installed at four locations on the riverbank to monitor groundwater levels. Transducers will be deployed in each piezometer. The transducers are deployed in four shallow groundwater zone wells, four intermediate groundwater zone wells, one shallow-intermediate well, and three deep groundwater zone wells. In addition, transducer data from a stilling well on Dock 2 will be used to record river levels at the site. Groundwater samples will be collected from each of three well clusters at the top of the riverbank and analyzed for DDx by EPA Method 8081B and VOCs by EPA Method 8260C. Samples will be collected from shallow wells MWA-2, MWA-61, and MWA-69; intermediate or shallow-intermediate wells MWA-8i, MWA-64i, MWA-67si, and MWA-66i; and deep wells PA-19d and PA-21d. The groundwater discharge study will be conducted in summer or fall when river flows and stages are relatively low, which will increase the likelihood that positive groundwater discharges to the river will be present. This is also consistent with the time of year when previous groundwater discharge studies were conducted adjacent to the Arkema site by the LWG. The average hydraulic head at each monitoring well and the stilling well will be calculated using a filtering method to remove tidal fluctuations from 71 consecutive hourly measurements (Serfes 1991). The filtered groundwater elevation data from each monitoring well will be used in conjunction with the filtered river level data to estimated a hydraulic gradient between each well and the Willamette River. Groundwater samples will be collected from selected monitoring wells and analyzed for focused COCs. The average groundwater flux for the duration of the study (approximately 72 hours) will be calculated for each seepage meter. Porewater samples will be collected from the seepage meters and analyzed for focused COCs.
6. Specify performance or acceptable criteria	Field Criteria: The pressure transducer data will be deemed acceptable if the final groundwater level is consistent (within the accuracy of the transducer) with the groundwater level collected using an electronic water level meter at the end of the study. The accuracy of the transducer will be specified by the manufacturer, but is typically within 0.10 ft for vented transducers and 0.20 ft for non-vented transducers. The seepage meters have ultrasonic flow meters that are calibrated at the factory. No additional performance criteria are warranted. Laboratory criteria: The target analytical methods were selected to ensure that detection limits are sufficiently low to meet project analytical concentration goals as shown in QAPP Table B-6 (Appendix B of this work plan). Additional quality control criteria for specific analytes and methods is provided in QAPP Tables B-8 and B-10 (Appendix B of this work plan).

Table 3-6. Groundwater Discharge Study Data Quality Objectives

DQO Step	Description
7. Develop the plan for obtaining data	Groundwater flux will be measured directly at the sediment/water interface using ultrasonic seepage meters at eight locations near Docks 1 and 2 at the Arkema Project Area. Porewater samples will be collected from the seepage meters. Water level measurements will be collected from 12 monitoring wells on the river side of groundwater barrier wall near the docks and 4 piezometers on the riverbank using pressure transducers. Groundwater samples will be collected from monitoring wells using low-flow sampling procedures. River level measurements will be collected from 1 stilling well on Dock 2 using a pressure transducer. Seepage meters will be deployed by divers in accordance with the FSP (Appendix A to this work plan). Flux measurements will be collected at least every 15 minutes. Groundwater samples will be collected in accordance with the FSP (Appendix A to this work plan). Pressure transducers will be deployed in each monitoring well, piezometer, and the stilling well. Pressure readings will be collected every 15 minutes for at least 71 hours, and the measurement times will be synchronized between the monitoring wells and stilling well. Depth to water measurements will be collected at the notch on each well casing during deployment retrieval activities using an electronic water level meter with an accuracy of 0.01 ft. The data will be downloaded from each transducer and corrected for barometric pressure (if non-vented transducers are used).

Notes:
COC = contaminant of concern
DDx = total of 2,4'- and 4,4'-DDD, DDE, DDT
DQO = data quality objective
EPA = U.S. Environmental Protection Agency
FSP = field sampling plan
GWET = groundwater extraction and treatment
LWG = Lower Willamette Group
QAPP = quality assurance project plan
SCM = source control measure

Table 3-7. Geotechnical Data Quality Objectives

DQO Step	Description
1. State the problem	Dredging performed on oversteepened or otherwise unstable slopes can result in slope failures and potential undermining of riverbanks and adjacent offshore and nearshore structures. Dredging in the vicinity of structures and pilings can reduce the amount of available soil to resist lateral loading and can potentially undermine relatively shallow piles. The geotechnical characteristics of the sediment will also be evaluated in conjunction with the structural analysis for assessing implementability limitations regarding dredging setbacks from docks and in-water structures. This evaluation will provide design level data that will identify remedial action implementability concerns associated with sediment and riverbank slope stability. Site-specific data are needed to perform engineering evaluations of static and seismic slope stability, dredge methods and dredged material processing and disposal, and cap design.
2. Identify the goals of the study	Sediment: Establish geotechnical sediment conditions across the site by advancing a limited number of borings. This information will be used as a basis for providing geotechnical design information for the remedial action. Riverbank Soil: Establish geotechnical soil conditions across the site by advancing a limited number of test pits. This information will be used as a basis for providing geotechnical design information for the remedial action.
3. Identify information inputs	Sediment: Select surface and subsurface sediment samples will be analyzed for physical and engineering properties, and elutriate testing will be performed to generate samples that represent dredged sediment solids and dredge return water. Riverbank soil: Select surface and subsurface soil samples will be analyzed for physical properties.
4. Define the boundaries of the study	The study area is located between approximately river miles 6.9 and 7.6 on the west side of the Willamette River in Portland, Oregon. More specifically, the study area is bounded by the navigation channel centerline to the east, the riverbank to the west, approximately river mile 6.9 to the north, and approximately river mile 7.6 to the south. Sediment samples will be collected from mudline to 25 ft below mudline or refusal (whichever comes first). Riverbank soils will be collected to a depth of 6 ft below ground surface or refusal (whichever comes first).
5. Develop the analytic approach	Sediment borings and test pits, field testing and laboratory testing will be performed using ASTM or USACE methods.
6. Specify performance or acceptable criteria	Field and laboratory work performed in accordance with standard ASTM and USACE methods.
7. Develop the plan for obtaining data	Sediment: Sediment boreholes will be advanced using a mud-rotary drill rig mounted on a barge. The boreholes will be advanced through moon holes on the barge. During advancement of the overwater boreholes, the river stage/barge deck elevation will be monitored using a survey-grade differential GPS unit on the barge deck, and the sample intervals will be adjusted based on the river stage changes. Sediment samples will be collected in 2-ft drives using a standard penetration test split spoon sampler. A total of 7 borings will be advanced to very dense soils or bedrock. Sediment samples will be collected at 2- to 5-ft intervals for analysis or archive. Riverbank Soil: Soil samples will be collected from shallow test pits using a backhoe or excavator following standard protocols and guidelines. A total of 6 test pits will be excavated to 6 ft below ground surface or refusal, whichever is shallower. Soil samples will be collected at 2-ft intervals for analysis or archive. The sample collection, processing, and sample handling methods will follow the FSP (Appendix A of this work plan).

Notes:
ASTM = ASTM International
DQO = data quality objective
FSP = field sampling plan
GPS = global positioning system
USACE = U.S. Army Corps of Engineers

Appendix A

Field Sampling Plan

DRAFT
PRE-DESIGN INVESTIGATION WORK PLAN
ARKEMA PROJECT AREA

Appendix A
Field Sampling Plan

Prepared for
Legacy Site Services LLC
665 Stockton Drive
Suite 110
Exton, PA 19341

Prepared by

integral consulting inc.
319 SW Washington St.
Suite 1150
Portland, OR 97204

DOF DALTON OLMSTED FUGLEVAND
1001 SW Klickitat Way
Suite 200B
Seattle, WA 98134

June 18, 2020

CONTENTS

LIST OF FIGURES ..... **iv**

LIST OF TABLES ..... **v**

ACRONYMS AND ABBREVIATIONS ..... **vi**

1 SITE BACKGROUND **1-1**

1.1 SITE DESCRIPTION AND SURROUNDING PROPERTIES 1-1
1.2 CONCEPTUAL SITE MODEL 1-2

2 DATA GAPS AND SAMPLING OBJECTIVES **2-1**

2.1 SEDIMENT CHEMISTRY 2-1
2.2 NAPL AND CHLOROBENZENE PTW 2-1
2.3 SEDIMENT STABILITY 2-1
2.4 BANK AND SHORELINE SOILS 2-2
2.5 GROUNDWATER DISCHARGE AND COC FLUX 2-2
2.6 GEOTECHNICAL EVALUATION 2-2

3 SAMPLING LOCATION AND FREQUENCY **3-1**

4 SAMPLING EQUIPMENT AND PROCEDURES **4-1**

4.1 SUBSURFACE UTILITY CLEARANCE 4-1
4.2 HORIZONTAL AND VERTICAL CONTROL 4-1
4.3 SURFACE SEDIMENT 4-2
4.4 SUBSURFACE SEDIMENT 4-3
4.4.1 Vibracore Boreholes 4-4
4.4.2 Mud-Rotary Boreholes 4-13
4.4.3 Sonic Boreholes 4-16
4.5 RIVERBANK SOIL 4-17
4.5.1 Hand Auger Boreholes 4-17
4.5.2 Test Pit Explorations 4-18
4.6 GROUNDWATER DISCHARGE AND COC FLUX 4-19
4.6.1 Piezometer Installation 4-20
4.6.2 Groundwater Monitoring 4-20
4.6.3 Seepage Meters 4-21
4.7 SEDIMENT POREWATER 4-22

5 SAMPLE DESIGNATION 5-1

6 SAMPLE HANDLING AND ANALYSIS 6-1

6.1 SAMPLING HANDLING PROCEDURES 6-1
6.1.1 Sample Labels 6-1
6.1.2 Custody Seal 6-1
6.1.3 Sample Matrix Table 6-2
6.1.4 Sample Custody/Tracking Procedures 6-2
6.2 FIELD DOCUMENTATION PROCEDURES 6-3
6.2.1 Field Logbooks 6-3
6.2.2 Photo Documentation 6-4
6.2.3 Sample Collection Information Form 6-4
6.2.4 Field Change Request 6-4

7 DECONTAMINATION PROCEDURES 7-1

8 INVESTIGATION-DERIVED WASTE HANDLING 8-1

8.1 SEDIMENT CUTTINGS AND EXCESS/REJECTED SEDIMENT AND SOIL SAMPLES 8-1
8.2 DECONTAMINATION WASTEWATERS 8-1
8.3 PERSONAL PROTECTIVE EQUIPMENT/MISCELLANEOUS DEBRIS 8-1

9 REFERENCES 9-1

Attachment 1. Standard Operating Procedures

Attachment 2. Field Forms

LIST OF FIGURES

Figure A-1 Summary of Proposed Remedial Design Investigation Subsurface Sediment and Riverbank Soil Chemistry Sampling Stations

Figure A-2a. Detailed Proposed Remedial Design Investigation Sediment and Riverbank Soil Chemistry Sampling Stations Downstream of Dock 2

Figure A-2b. Detailed Proposed Remedial Design Investigation Sediment and Riverbank Soil Chemistry Sampling Stations Upstream of Dock 2

Figure A-3. Proposed Groundwater Discharge Study

Figure A-4. Proposed Porewater Sampling Locations

Figure A-5. Proposed Sediment and Riverbank Soil Geotechnical Sample Locations

Figure A-6. Conceptual Sampling Vessel Layout and Core Processing Table

Figure A-7. Evaluation of Potential Subsurface NAPL

LIST OF TABLES

Table A-1. Subsurface Sediment Sample Location Coordinates
Table A-2. Riverbank Soil Sample Location Coordinates
Table A-3. Groundwater Pathway Assessment Sample Location Coordinates
Table A-4. Porewater Sample Location Coordinates
Table A-5. Sediment and Riverbank Geotechnical Sample Location Coordinates
Table A-6. Summary of Samples and Analyses
Table A-7. Sample Containers and Preservation Requirements
Table A-8. Sample Size, Containers, and Holding Times for Geotechnical Sample Analysis

ACRONYMS AND ABBREVIATIONS

ASTM	ASTM International
bgs	below ground surface
bml	below mudline
COC	contaminant of concern
DDD	dichloro-diphenyl-dichloroethane
DDE	dichloro-diphenyl-dichloroethene
DDT	dichloro-diphenyl-trichloroethane
DDx	total of 2,4'- and 4,4'-DDD, DDE, DDT
DGPS	differential global positioning system
DOT	U.S. Department of Transportation
DRET	dredge elutriate test
EET	effluent elutriate test
EPA	U.S. Environmental Protection Agency
FSP	field sampling plan
GNSS	global navigation satellite system
Integral	Integral Consulting Inc.
LSS	Legacy Site Services LLC, agent for Arkema Inc.
NAD	North American Datum
NAPL	nonaqueous-phase liquid
NAVD88	North American Vertical Datum of 1988
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD/F	polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran
PID	photoionization detector
PTW	principal threat waste
QAPP	quality assurance project plan
SOP	standard operating procedure
TOC	total organic carbon

UV	ultraviolet
VOC	volatile organic compound

1 SITE BACKGROUND

This field sampling plan (FSP) describes the field procedures that will be used to support data collection in a portion of the River Mile 7 West Project Area, which is part of the Portland Harbor Superfund Site in Portland, Oregon (Figures 1-1 and 1-2 of the work plan). The River Mile 7 West Project Area includes the Bayer Project Area (approximately river miles 6.5 to 6.9) in the downstream area and the Arkema Project Area (approximately river miles 6.9 to 7.6) in the upstream area. The Willbridge Cove Project Area is immediately upstream of the RM 7 West Project area (approximately river miles 7.6 to 8.1).

The pre-design investigation work plan has been developed for the Arkema Project Area. This FSP is Appendix A to the work plan and has been prepared in accordance with U.S. Environmental Protection Agency (EPA) guidance for the preparation of quality assurance project plans (QAPPs; USEPA 2002).

This FSP, along with the associated QAPP (Appendix B of the work plan), provides specific field methodology and procedures that will be followed by Integral Consulting Inc. (Integral), Dalton, Olmsted & Fuglevand, and their subcontractors during the investigation activities. Additional information about the sampling design and rationale is provided in the work plan.

The following sections present a description of the Arkema Project Area and surrounding properties, and a conceptual site model that includes a discussion of known and suspect contaminant sources and transport pathways. Additional details are provided in the work plan text.

1.1 SITE DESCRIPTION AND SURROUNDING PROPERTIES

As discussed in the work plan, inorganic chemicals were manufactured at the Arkema site from 1941 until 2001, when the facility was closed and chemical manufacturing was discontinued (Figure 1-4 of the work plan). For most of the site's history, the chemical manufacturing activities involved electrolytic decomposition of brine solutions to manufacture inorganic chemicals, including sodium chlorate, chlorine, sodium hydroxide, hydrogen, and hydrochloric acid. Other chemical manufacturing processes during the site's operational history included the production of dichloro-diphenyl-trichloroethane (DDT) from 1947 to 1954, and ammonium perchlorate from 1958 to 1962 (ERM 2005). The upland portion of the Arkema site encompasses approximately 54 acres of land. River access to the Arkema facility historically was provided from three docks, the Salt Dock, Dock 1, and Dock 2, which are still present at the site (Figure 1-4 of the work plan). All historical site buildings have been demolished except for the office building.

The harbor area is heavily industrialized, and land use along this portion of the lower Willamette River includes marine terminals, manufacturing, rail access, and other commercial operations, as well as public facilities, parks, and open spaces. The Siltronic Corporation facility is located downstream of the Arkema site and occupies approximately 85 acres in the Portland Harbor between river miles 6.4 and 6.9. The Willbridge Bulk Fuel Terminal is located near the upstream portion of the Arkema Project Area between approximate river miles 7.6 and 7.8 (Figure 1-2 of the work plan). The Willbridge Terminal has three docks operated by Chevron, ConocoPhillips, and Kinder Morgan.

1.2 CONCEPTUAL SITE MODEL

A conceptual site model is presented in Section 1.3 of the work plan. A conceptual site model diagram showing contaminant sources, transport pathways, and groundwater source control measures relevant to the pre-design investigation is presented in Figure 1-7 of the work plan.

2 DATA GAPS AND SAMPLING OBJECTIVES

The work plan text and tables provide a detailed analysis of data gaps and sampling objectives for the Arkema Project Area. A brief summary is provided in the following sections.

2.1 SEDIMENT CHEMISTRY

Existing DDx[1] and polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran (PCDD/F) data for surface and subsurface sediment are insufficient to define the horizontal and vertical remedial extent for the focused contaminants of concern (COCs) in sufficient detail to prepare a remedial design. Historical data sets include relatively few subsurface measurements within the Arkema Project Area away from the Arkema docks, and the nature and extent of subsurface conditions in those areas is not well characterized. Additional surface and subsurface chemistry data are needed for remedial design to better define the areas of contaminated sediments in the Arkema Project Area.

2.2 NAPL AND CHLOROBENZENE PTW

Chlorobenzene nonaqueous-phase liquid (NAPL) has been observed in the upland portion of the Arkema site in the former Acid Plant area. Based on extensive upland NAPL investigations and remediation activities, it appears that the upland chlorobenzene dense NAPL pinches out and does not make a connection to the river. If chlorobenzene NAPL is present, its identification and characterization in subsurface sediment is necessary for remedial design considerations. Chlorobenzene in groundwater at concentrations that cause sediment to exceed 320 µg/kg is considered not reliably contained PTW in the Record of Decision. Chlorobenzene concentrations in sediment and in groundwater beneath the riverbank area need to be evaluated to inform PTW determination and for other parts of remedial design.

2.3 SEDIMENT STABILITY

The current assessment of the depositional regime in the Arkema Project Area, which is based on available bathymetric data collected as part of the Portland Harbor remedial investigation and feasibility study and 2018 pre-design investigation, is inconclusive due to gaps in coverage for the nearshore area in this portion of the Portland Harbor site. Additional information may be needed based on the Phase 1 results to support consideration and incorporation of natural recovery into the remedial design.

[1] Total of 2,4'- and 4,4'- dichloro-diphenyl-dichloroethane (DDD), dichloro-diphenyl-dichloroethene (DDE), DDT

2.4 BANK AND SHORELINE SOILS

Riverbank soil chemistry data have identified areas that are potential erodible soil sources of focused COCs to the Willamette River. Based on the available data, there is uncertainty regarding the nature and extent of selected focused COCs exceeding remedial action levels or principal threat waste (PTW) thresholds in riverbank soil. The remedy design will require surface and subsurface soil data that define the limits of the extent of COCs exceeding remedial action levels in riverbank soil adjacent to the sediment portion of the Arkema Project Area.

2.5 GROUNDWATER DISCHARGE AND COC FLUX

Arkema groundwater source control measures, consisting of a groundwater barrier wall and a groundwater extraction and treatment system, were installed in 2012–2013. Discharge of COCs in groundwater upgradient of the groundwater barrier wall has been controlled at the Arkema site for about 8 years; however, recent groundwater concentration measurements indicate that chlorobenzene and other chemicals are still present at elevated concentrations in groundwater downgradient of the groundwater barrier wall. Therefore, the potential for residual COCs in the area downgradient of the barrier wall to contribute to COC flux during and after sediment remediation is not currently known.

2.6 GEOTECHNICAL EVALUATION

Dredging performed on oversteepened or otherwise unstable slopes can result in slope failures and potential undermining of riverbanks and adjacent offshore and nearshore structures. Dredging in the vicinity of structures and pilings can reduce the amount of available soil to resist lateral loading and can potentially undermine relatively shallow piles. The geotechnical characteristics of the sediment will also be evaluated in conjunction with the structural analysis for assessing implementability limitations regarding dredging setbacks from remaining in-water structures. This evaluation will provide design level data that will identify remedial action implementability concerns associated with sediment and riverbank slope stability.

3 SAMPLING LOCATION AND FREQUENCY

The following is a summary of the sample locations and frequency for the Arkema Project Area pre-design investigation:

- **Surface sediment.** If needed for Phase 2, surface sediment (0–1 ft below mudline) samples for evaluation of focused COCs and other contaminants will be collected using a vessel-deployed power grab or similar sediment sampler. The number and locations of samples will be determined based on the results of the Phase 1 sampling. The samples will be analyzed for DDx, PCDD/Fs, polychlorinated biphenyl (PCB) congeners, and polycyclic aromatic hydrocarbons (PAHs).
- **Subsurface sediment (chemistry).** A total of 94 sediment cores are proposed in the Arkema Project Area and 4 sediment cores in the navigation channel using a vibracorer (Figures A-1 and A-2a-b). Selected samples will be analyzed for DDx, PCDD/Fs, and PCB congeners. Selected samples from some borings will be analyzed for PAHs and chlorobenzene.
- **Subsurface sediment (NAPL evaluation).** A total of 12 sediment cores are proposed for the evaluation of potential NAPL and sheens in the Arkema Project Area using a vibracorer (Figures A-1 and A-2a-b). Selected samples will be analyzed for volatile organic compounds (VOCs), NWTPH-Dx, NWTPH-Gx, grain size, and NAPL density and viscosity.
- **Subsurface sediment (sediment stability).** If needed for Phase 2, a limited number of sediment cores will be collected for evaluation of sediment stability parameters using a vibracorer. The number and locations of samples will be determined based on the results of the Phase 1 sampling. Selected samples will be analyzed for cesium-137, lead-210, and DDx.
- **Bank and shoreline soils.** A total of 39 soil borings will be advanced in the riverbank adjacent to the Arkema Project area using a hand auger or similar device (Figures A-1 and A-2a-b). Selected samples will be analyzed for DDx, PCDD/Fs, PCB congeners, and asbestos.
- **Groundwater discharge and COC flux.** A total of nine groundwater samples will be collected from monitoring wells, four groundwater samples collected from piezometers, and eight transition zone water samples collected from UltraSeep meters (or similar devices) along the groundwater flow path from the top of the riverbank to the nearshore area of the Arkema site (Figure A-3). The samples will be collected during a single event and analyzed for DDx and VOCs.
- **Porewater.** Porewater sampling will be conducted at three locations in support of sediment cap design using a Trident Probe or similar device (Figure A-4). The

porewater samples will be collected from three depths and analyzed for dissolved organic carbon and VOCs.

- **Geotechnical.** Sediment borings will be advanced at seven locations to assess geotechnical parameters using a mud-rotary drill rig (or similar rig). Selected sediment samples will be analyzed for water content, grain size, total organic carbon (TOC), plasticity, sediment strength, and bulk density. In addition, six test pits will be excavated for the evaluation of geotechnical parameters in riverbank soils. Selected soil samples will be analyzed for moisture content, grain size, Atterberg Limits, and organic content. The sample locations are presented on Figure A-5.

Field duplicates will be collected at a frequency of 1 per 20 natural samples. One equipment rinsate blank will be collected for each sampling type. Additional details on analytes, analytical concentration goals, method detection limits, and method reporting limits are presented in the QAPP (Appendix B of the work plan). A sample matrix is presented in Attachment 2.

4 SAMPLING EQUIPMENT AND PROCEDURES

This section presents the field sampling equipment and procedures to be used by Integral and its subcontractors for the pre-design investigation. In general, field sampling methods will follow standard protocols and guidelines (PSEP 1997) and the standard operating procedures (SOPs) provided in Attachment 1, where applicable. Attachment 2 contains field forms and examples of chain-of-custody forms, sample labels, custody seals, and logbooks. All sampling will be conducted in accordance with the quality assurance procedures outlined in the QAPP (Appendix B to the work plan). Safety guidelines presented in the site health and safety plan will be followed for all field activities (Appendix C to the work plan). General guidelines for conducting the fieldwork are described in the following sections.

4.1 SUBSURFACE UTILITY CLEARANCE

Prior to commencing field activities, a utility survey will be conducted to identify all known in-water utilities within the Arkema Project Area and adjacent areas. If knowledgeable personnel are available, Arkema representatives will be contacted regarding the locations of the private utilities on the Arkema property, including stormwater outfalls and other utilities associated with former plant operations. The Oregon Utility Notification Center (811) will be contacted to locate public utilities in the study area. If proposed sample locations interfere with utilities, alternate locations will be determined in consultation with the Legacy Site Services LLC, agent for Arkema Inc. (LSS) Project Team, as designated in the work plan.

4.2 HORIZONTAL AND VERTICAL CONTROL

The horizontal coordinates for each proposed sample station are specified in Tables A-1 through A-5. A differential global positioning system (DGPS) unit with an accuracy of approximately $\pm$1 m will be used to navigate to each sample station. The DGPS beacon will be positioned where the sampling or drilling will occur (e.g., A-frame, moon pool, or hand auger). The horizontal location of the station will be recorded in latitude and longitude (North American Datum [NAD] 1983) in the field and converted to state plane coordinates (Oregon North, International Feet). Navigation and positioning will follow guidelines in SOP AP-06. Elevation data will be collected using a high accuracy global navigation satellite system (GNSS) receiver on the DGPS unit. The elevation data will be logged on the DGPS unit and converted to the North American Vertical Datum of 1988 (NAVD88).

The mudline elevation at each station will be calculated using the elevation of the barge deck (measured using GNSS receiver) and the depth to mudline measurements. The elevation of the barge deck will be determined using the survey grade GNSS receiver. The mudline depth from the top of the barge deck and the water surface will be measured with a sounding device (e.g.,

fathometer or weight tied to the end of a fiberglass tape measure) to the nearest 0.1 ft. The water surface elevation will be calculated as the barge deck elevation minus distance from the barge deck to the water surface. The mudline elevation will be calculated as the elevation of the river minus the depth to mudline in feet.

The following parameters will be documented in the field logbook at every sample location:

- Horizontal location and elevation data using a DGPS unit (elevation data will use a high accuracy GNSS receiver)
- Depth to mudline from river level
- Depth from vessel or barge deck to the river level
- Time and date.

4.3 SURFACE SEDIMENT

If needed for Phase 2, surface sediment (0–1 ft below mudline [bml]) samples for chemistry analyses will be collected using a vessel-deployed hydraulically-powered 0.1 m^2 grab sampler or equivalent sediment sampler in accordance with guidelines provided in SOP SD-04 (Attachment 1). The maximum penetration of this grab sampler is 1 ft. A total of three subsamples will be collected within an approximate 5-ft radius from each station and homogenized into a composite sample. The number and locations of samples will be determined based on the results of the Phase 1 sampling.

Prior to sample collection at each station, the grab sampler will be decontaminated with a non-surfactant detergent solution (e.g., Alconox® or Liquinox®) followed by a site water rinse. Sample collection equipment (stainless steel spoons and bowls) will be decontaminated following the procedures provided in Section 7. The grab sampler will be raised and lowered through the water column by the vessel's winch at a rate no greater than 1 ft per second. This will ensure that the sampler doesn't flip over on descent and will prevent disturbance of the sediment surface upon retrieval. Once the sampler is brought on board, it will be placed on a stand or table. Access doors in the cover on the top of the sampler will allow visual characterization of the sediment surface in order to assess sample acceptability. Before characterization, the overlying water in the sampler will be removed by siphoning and the depth of sediment collected will be measured using a stainless steel ruler. Criteria to determine acceptability include the following:

- The sampler is not overfilled, which could be indicative of sample loss over the top of the sampler
- Overlying water is present, indicating sample integrity
- The sediment surface appears to be intact with minimal disturbance

- The desired sample depth has been achieved (80% recovery).

If the sample meets acceptability criteria, the sample collection location will be recorded using a DGPS unit and observations entered into a surface sample log or the field logbook.

The following physical characteristics of the surface sediment grab samples will be described and recorded on the surface sediment sample log (see Attachment 2): sediment texture; sediment color; presence, type, and strength of odors; grab penetration depth (nearest tenth of a foot); sediment surface disturbance; and presence of debris, wood/shell fragments, or large organisms. Photographs will be taken of the sediment in the grab sampler, and a white board with sample information will be included within the frame of the photograph (sample ID, time, and date).

Because an undisturbed sediment surface is necessary for chemical sampling, the physical characterization of the sediment in the grab sample will be delayed until after the chemical samples have been taken. Sediment for chemical analyses will be collected using a stainless steel spoon or spatula. Sediment that is in contact with the sides of the sampler will not be sampled. Large organisms and pieces of debris will be removed and noted in the sample log sheet. The sediment sample will then be placed into a stainless steel mixing bowl for homogenization. The sediment will be mixed using a decontaminated stainless steel spoon until it is of uniform color and texture throughout. The homogenized sample will then be dispensed into labeled laboratory-supplied sample containers and analyzed for the following constituents (Table A-6):

- DDx
- PCDD/Fs
- PCB congeners
- PAHs.

After processing, samples will be placed in the appropriate containers listed in Table A-7 and labeled in accordance with Section 6.1 and SOP-5. The samples will be immediately placed in a cooler with ice for preservation. Additional quality assurance guidelines, including sample handling and the collection of duplicate and rinsate blank samples, are presented in the QAPP (Appendix B to the work plan).

4.4 SUBSURFACE SEDIMENT

The following sections describe the borehole advancement technologies, and sample collection and processing methods that will be used to collect subsurface sediment from locations shown in Figures A-1 and A-2a-b. Subsurface sediment cores will be collected over water using either a vessel-deployed coring device or a barge-mounted drill rig.

4.4.1 Vibracore Boreholes

The following sections present general procedures for vibracores and specific procedures for processing cores for chemistry, potential NAPL, and sediment stability.

4.4.1.1 General Procedures

A vessel-deployed vibracorer equipped with 15-ft core tubes will be used to collect subsurface sediment cores. Vibracore collection methods will follow standard protocols and guidelines for subsurface sediment sampling provided in SOP SD-08 (Attachment 1). Prior to core advancement and sample collection, all coring and non-disposable sampling equipment will be decontaminated following the procedures provided in Section 7. The vibracorer uses a hydraulic system that vibrates and drives a 4-in.-outside-diameter aluminum core tube into the sediment. A continuous sediment sample is retained within the aluminum core tube with the aid of a core cutter/catcher attached to the bottom of each tube. The core tube will be driven to the target depth of 15 ft bml or refusal, whichever comes first, and retrieved. Before removing the aluminum core tube from the vibracorer, the core cutter/catcher will be visually inspected to ensure that proper penetration was attained and that there was no obvious loss of sediment from the tube. Any presence of noticeable odors or sheen at the end of the tube or in the water will be noted on the core collection log form (Attachment 2).

The core will be deemed acceptable if the sediment recovery inside the core tube is at least 80 percent of the penetration depth. If the core is deemed acceptable, it will be cut into two equal lengths (i.e., approximately 7–8 ft long) using a decontaminated pipe cutter or similar device. Prior to cutting the core tube, the depth bml will be indicated on the core tube, and a label that includes the station ID, core section, time, and date will be securely attached to the top of each section. The cores will be capped and stored in a vertical position prior to field screening and processing. Details on core collection (such as core penetration depth and physical characteristics of the sediment sample observed at the end of the tube) will be recorded on the core collection log form (Attachment 2).

The field screening and processing will occur on a support vessel, such as a small barge, or at an upland location. Cores will be processed concurrently with core collection. Every effort will be made to process the cores within 24 hours of collection. Cores awaiting processing will be sealed tightly at both ends and stored upright in a refrigerator. If core collection outpaces processing such that significant delays in core processing appear likely, core collection will be suspended to allow the core processing to catch up. Each 7-8-ft core section will be placed on a sample processing table with new visqueen or aluminum foil. The core will be cut open length-wise in two locations at approximately 180 degrees using electric sheers or equivalent cutting device and the core will be opened for examination. If samples for volatile analyses or headspace screening are required, aliquots of sediment will be collected from each sample interval immediately after opening the core tube as described in SOP SD-08 (Attachment 1).

Headspace screening will be conducted on all intervals using a photoionization detector (PID) and recorded on the boring log.

Sediments from each borehole will be continuously collected and logged by or under the supervision of an Oregon-licensed geologist or professional engineer using ASTM International (ASTM) D2488 (2017) guidelines, as described in SOP SL-04. A boring log (Attachment 2) will be completed for each borehole following guidance provided in SOP SL-06. Sediment cores will be processed for chemical analysis and/or geochronology following the procedures described above and in Section 4.4.1.2. In addition, each sample will be screened for VOCs using a PID in accordance with SOP-12 (Attachment 1).

Excess sediment generated during coring will be temporarily stored in 5-gallon buckets on the vessel. As needed, these buckets will be transferred to properly labeled U.S. Department of Transportation (DOT)-approved, 55-gallon drums located on the upland portion of the Arkema facility where sediment generated during processing will be stored. The drums will be managed in accordance with SOP-11 (Attachment 1). The vibracore boreholes will not be backfilled with grout.

4.4.1.2 Chemistry Stations

Sediment cores for chemical analyses will be advanced at 94 locations in the Arkema Project Area and 4 locations in the navigation channel to evaluate focused COCs and other contaminants in support of remedial design (Figures A-1 and A-2a-b). Sediment samples will be collected from 0–1 ft and every subsequent 1 ft to the total depth of the borehole and submitted to the analytical laboratory for analysis, or to be archived.

Discrete samples slated for volatile analyses (e.g., chlorobenzene or VOCs) will be collected using a Terracore sampling kit immediately after the core is opened to minimize loss of volatiles. The Terracore sampler containers will be labeled and placed in a cooler with ice for preservation immediately after collection.

Except for sample volumes collected for volatile analytes noted above, sediment from each subsample sample interval will be individually mixed in a decontaminated, stainless steel bowl to a uniform color and texture using a decontaminated, stainless steel spoon following procedures provided in SOP SD-08 (Attachment 1). Care will be taken to not include sediment that is in direct contact with the aluminum tube. In addition, the cutting of the aluminum tube can introduce metal shavings to the core sediment; care will be taken to avoid mixing these shavings into the homogenate. The homogenized sample will then be dispensed into labeled laboratory-supplied sample containers.

Sediment samples will be analyzed in accordance with the Subsurface Sediment Sample Analysis Decision Tree (Figure 3-2c of the work plan). Select samples will be analyzed for one or more of the following constituents (Table A-6):

- DDx
- PCB congeners
- PCDD/Fs
- PAHs.

After processing, samples will be placed in the appropriate containers listed in Table A-7 and labeled in accordance with the directions in Section 6.1 and SOP-5. The samples will be immediately placed in a cooler with ice for preservation. Additional quality assurance guidelines, including sample handling and the collection of duplicate and rinsate blank samples, are presented in the QAPP (Appendix B to the work plan).

4.4.1.3 NAPL Stations

Based on previous investigations conducted in the Arkema Project Area, NAPL is not expected in sediments. However, portions of the Arkema project area near Outfall 004 and Docks 1 and 2 are designated as "PTW – Source Material (NAPL)" in Figure 8 of the Portland Harbor ROD (USEPA 2017). These areas will be appropriately evaluated for NAPL as part of the pre-design investigation. The evaluation will include visual assessment, ultraviolet (UV) fluorescence, and shake tests with a hydrophobic dye. Sediment samples with evidence of NAPL will be centrifuged in an analytical laboratory and the supernatant will be subjected to the UV screening protocols. If NAPL is identified in the supernatant based on the UV screening, the NAPL will be extracted from the supernatant and tested for physical parameters (density and viscosity) and COCs (NWTPH-Dx, NWTPH-Gx, and VOCs). If NAPL is not found in the supernatant, it will not be considered in the design process. If NAPL is found in the supernatant, it will be considered PTW source material, and the physical and chemical properties of the NAPL will be considered in the design process for dredging (e.g., mobility based on physical parameters) and capping (e.g., potential breakthrough based on COCs).

This section presents the protocols that will be used to evaluate potential NAPL in subsurface sediment. The following terms will be used to describe the range of conditions that could exist in sediments:

- Discontinuous sheen—A sheen that is discontinuous (i.e., spotty) within a section of sediment core and does not fill the sediment pore spaces.
- Continuous sheen—A sheen that is continuous (i.e., covering an area greater than 1 $in.^2$) within a section of sediment core and does not fill the sediment pore spaces.
- Globules—Globules that are present in distinct small spheres, typically ranging in size from 0.01 to 0.05 in. in diameter.

- Residual NAPL—NAPL that is hydraulically discontinuous and immobile under prevailing condition. Residual NAPL fills a portion of the sediment void spaces. The estimated thickness of the residual NAPL will be recorded on the boring log.
- Mobile NAPL—NAPL that is hydraulically connected in the pore space and has the potential to move in the environment. Free NAPL fills all the sediment void spaces and will seep out of the sediment core. The estimated thickness of the mobile NAPL will be recorded on the boring log.

The characterization of any sheen, globule, and NAPL will consist of the following sequence of steps to be conducted under the supervision of an Oregon-registered geologist or Oregon-registered professional engineer with experience logging sediments:

1. Conduct unaided visual inspection, logging, and photo-documentation of the entire core.
2. Conduct UV fluorescence examination and photo-documentation of the entire core.
3. If potential NAPL[2] was identified in Steps 1 or 2 above, conduct a sediment-water shake test with hydrophobic dye on these portions of the sediment cores.
4. If the sediment-water shake test reveals potential NAPL, or other lines of observational evidence indicate potential NAPL presence (e.g., sheen, odor, PID reading), collect a sediment sample that contains the potential NAPL for laboratory analysis.

The following sections provide a detailed description of each step. Figure A-6 presents the conceptual sampling vessel layout and core processing table and Figure A-7 illustrates the corresponding decision process that will be used to guide the evaluation.

Unaided Visual Assessment

Each core will be visually assessed and logged following ASTM D2488 (ASTM 2017) and SOP SL-04 (Attachment 1). A boring log (Attachment 2) will be completed for each borehole following guidance provided in SOP SL-06 (Attachment 1). High-resolution photographs will be taken of each 2-ft section of core. The outside of the core will be removed by using a decontaminated stainless steel spoon or spatula to scrape off sediment that may be smeared on the outer core surface from a shallower depth. The visual assessment will include a physical description (e.g., color and consistency) of any sheens, globules, and the thickness of residual or mobile NAPL, if present. If sheen is present, the following specific questions will be addressed:

- Is NAPL present?

[2] The term "potential NAPL" is used because the presence of NAPL has not been positively identified through laboratory tests.

- Is the sheen continuous or is it isolated in certain portions of the sample?
- Is sheen limited to specific geologic type materials in the sample?
- What is the interval that sheen impacts are visible?

Similarly, if NAPL is present, the following questions will be addressed:

- Are there distinct globules in the sample?
- Is visible NAPL limited to specific portions of the sample?
- Is NAPL associated with gas bubbles or voids?
- Does NAPL flow out of core samples in the field (obtain photo-documentation of this occurrence if present)?
- What is the NAPL color?
- Does NAPL appear to be more or less viscous than water?
- Do there appear to be distinct portions of the sample that are water saturated or NAPL saturated?
- What portion of the sample appears to be NAPL saturated?

The location of the sheens and potential NAPL will be noted on the visqueen adjacent to the core with a black felt-tipped pen for reference prior to taking the photographs. The type of material containing the potential NAPL (e.g., sand lamination) and the material immediately above and below the potential NAPL (e.g., clay or silt) will be carefully logged and photo-documented.

Ultraviolet Fluorescence

Once the sediment core has been visually examined, logged, and photographed, the core will be exposed to UV light to provide an additional assessment of the potential presence of NAPL. The following sections discuss construction of a UV light tent and protocols for conducting the UV fluorescence screening. Figure A-6 presents a conceptual sampling vessel layout and core processing table for the UV fluorescence screening.

Ultraviolet Fluorescence Tent Construction

A UV light canvas (or similar light-shielding material) tent will be constructed for placement on the coring table to reduce the amount of sunlight on the core (Figure A-6). The tent will be constructed to fit on top of the sample processing table and will be approximately 7 ft long, 2 ft wide, and 2.5 ft tall. The canvas will be attached to a frame of 1-in.-diameter polyvinyl chloride pipe or similar material. The tent will have a fan on one end and a series of 1/8-in.-wide by 2-ft-

long vertical slits cut on the other end to provide ventilation to protect field staff from exposure to vapors, if any, from the sediment cores. The front of the tent will have four flaps that can be opened to view the core. The top front interior portion of the tent will have three 1.5-ft-long shortwave UV (254 nanometers) and longwave UV (365 nanometers) fluorescent lights.

Ultraviolet Fluorescence Screening Protocols

The tent will be placed over the processing table with the sediment core and tape measure. The ventilation fan will be turned on for 1 to 2 minutes and continuous air monitoring will be conducted inside the tent with a PID to ensure that any vapors from the core are being removed by the ventilation system. The UV fluorescent light will be turned on and the core will be examined. Each area that fluoresces will be identified on the visqueen adjacent to the core with a black felt-tipped pen for reference and noted on the boring log. Photographs will then be taken of each 2-ft section of core without a flash. The camera will be mounted on a tripod if necessary to accommodate the extended exposure time required for taking photographs with limited light. Samples of sediments that fluoresce will be collected for a shake test with hydrophobic dye.

Shake Test with Hydrophobic Dye

A shake test with Sudan IV hydrophobic dye will be conducted on all sediment samples with potential NAPL identified by unaided visual inspection or examination with UV fluorescence. The following sections discuss preparation of shake test standards and protocols for conducting the shake tests.

Preparation of Shake Test Standards

Prior to initiating the coring activities, standards will be created with known volumes of natural (not synthetic) 30 weight motor oil that can be used to estimate the amount of any NAPL present in the field shake test samples. The standards will be prepared in new 50 mL plastic tubes with approximately 20 mL of clayey silt soil, 20 mL of deionized water, 2 mg of Sudan IV hydrophobic dye, and various quantities of 30 weight motor oil—0.25 mL (0.5 percent), 0.5 mL (1 percent), 2.5 mL (5 percent), and 5.0 mL (10 percent). The standards will be shaken for 25 to 30 seconds prior to use for comparison purposes.

Shake Test Protocols

The shake test protocols will generally follow those used by Cohen et al. (1992). Approximately 20 mL of sediment, 20 mL of deionized water, and 2 mg of Sudan IV hydrophobic dye will be placed in a new 50-mL plastic tube. The contents of the tube will be mixed by shaking by hand for 25 to 30 seconds and examined for the presence of NAPL. The tube will also be exposed to UV light to enhance the identification of NAPL. If NAPL is observed, the percentage of NAPL

will be estimated using the shake test standards under UV light. The results will be documented in the field logbook. A close-up photograph will be taken of the tube under natural and UV light.

A sediment sample from each interval that tested positive for NAPL by the shake test will be collected from the core and submitted to the analytical laboratory under chain-of-custody protocols for the testing outlined in the next section.

Laboratory Assessment

The following sections briefly describe the laboratory analyses that will be conducted on sediment samples with potential NAPL. Sample volume may be limited, so priority will be given to the analysis of COCs.

Sediment Physical Parameters

Bulk sediment samples with potential NAPL will be analyzed for the following:

- Grain size
- TOC.

NAPL Physical Parameters and Chemicals of Concern

Sediment samples with evidence of NAPL will be centrifuged in an analytical laboratory and the supernatant will be subjected to the UV screening protocols described above. If NAPL is identified in the supernatant based on the UV screening, the NAPL will be extracted from the supernatant and analyzed for the following (Table A-6):

- Total petroleum hydrocarbons—diesel range organics/motor oil range organics
- Total petroleum hydrocarbons—gasoline range organics
- VOCs
- Viscosity
- Density.

The samples will be immediately placed in a cooler with ice for preservation. Additional quality assurance guidelines, including sample handling and the collection of duplicate and rinsate blank samples, are presented in the QAPP (Appendix B to the work plan).

4.4.1.4 Sediment Stability Stations

If needed for Phase 2, a limited number of sediment cores will be collected for evaluation of sediment stability parameters (cesium-137, lead-210, DDx). The number and locations of samples will be determined based on the results of the Phase 1 sampling.

Samples will be collected from 2-in. intervals homogenized, and submitted to the analytical laboratory for either analysis or archive. Initially, every third sediment sample (i.e., 4–6 in., 10–12 in., 16–18 in., 22–24 in., etc.) will be analyzed for the following constituents (Table A-6):

- Organochlorine pesticides (DDx)
- Cesium-137
- Lead-210.

The other sample intervals from this core will be archived. A second core will be advanced at each location and the sediment will be submitted to the analytical laboratory to be archived. The core will be cut into manageable lengths (e.g., 2- to 3-ft-long sections), and each end will be securely capped. The cores will be placed in a cooler with ice and shipped to the analytical laboratory under chain-of-custody protocols (see Section 6.1.4).

The core collection, core processing, and sample handling methods will follow the procedures described above in Sections 4.4.1.1 and 4.4.1.2.

4.4.1.5 Elutriate Testing

After collection of the initial sediment cores at designated stations, additional sediment and surface water samples will be collected to obtain the necessary sample volume for elutriate testing. The samples will be containerized in polycarboys for use in the elutriate testing. The following sample volumes will be collected using composited sediment and surface water samples:

1. Dredge elutriate test (DRET) bulk samples
   - 4 L sediment
   - 12 L surface water
2. Effluent elutriate test (EET) bulk samples
   - 4 L sediment
   - 12 L surface water.

Elutriate tests will be performed to generate representative samples of dredged sediment and supernatant water that separates from sediment. The tests proposed were developed by the

U.S. Army Corp of Engineers specifically to represent water quality impacts during dredging and to represent slurries generated during dredging. The DRET (USACE 1995) and EET (USACE 2003) tests are similar and include the following steps:

1. Mix sediment with site water to generate a slurry. The DRET starts with a slurry solids concentration of 10 g/L and the EET starts with 150 g/L.
2. The slurries are aerated for 1 hour to represent the aeration that occurs during dredging and slurry pumping.
3. The slurries are allowed to settle. The settling time for the DRET is 1 hour, and the time for the EET can vary from 1 hour to 24 hours. For this project, a settling time of 1 hour will be used for both tests. This will provide a basis to compare the impact of slurry solids concentration.
4. After settling, an interface usually develops between sediment particles in the bottom of the test vessel and supernatant water in the top part of the vessel.
5. Supernatant water is extracted for chemical testing and can also be used for testing water treatment methods.
6. The sediment particles can be used for testing solidification methods.

The supernatant water collected at the end of the elutriate tests will be tested for the constituents listed below, and the testing will be done without any treatment of the water generated during the bench-scale tests in order to represent the conditions in water that is separated from sediment particles after dredging:

- Total suspended solids
- Turbidity
- Visual NAPL
- Hardness (as $CaCO_3$)
- Biological oxygen demand
- VOCs SW-846 8260B
- Total Metals by SW-846/8020
- Filtered Metals by SW-846/8020
- DDx
- PCB congeners
- PCDD/Fs
- PAHs.

4.4.2 Mud-Rotary Boreholes

Sediment boreholes for geotechnical analysis will be advanced to dense soil or bedrock at seven locations using barge-mounted mud-rotary drill equipment (Figure A-5). During advancement of all overwater boreholes, the river stage/barge deck elevation will be monitored using a survey-grade GNSS receiver on the DGPS unit, and the sample intervals will be adjusted based on the river stage changes. The river stage and sample interval calculations will be displayed on a white board near the drill rig so the drilling crew can refer to them prior to collecting each sediment sample. Geotechnical data collection will include the following:

- Standard penetration tests/split-spoon sampling will be performed to obtain estimates of material density/consistency and to recover disturbed samples.
- Shelby tube samples will be collected from selected boreholes to obtain relatively undisturbed samples to determine compressibility and strength properties of silt and clay sediment/soils.

Prior to core advancement and sample collection, all coring and non-disposable sampling equipment will be decontaminated following the procedures provided in Section 7 and SOP-9 (Attachment 1).

4.4.2.1 General Drilling Procedures

Mud-rotary boreholes are advanced by grinding the subsurface material (in this case sediments) using a drill bit attached to a rapidly rotating drill string of hollow steel rods. During borehole advancement, drilling mud is forced downward through the hollow drill string to keep the hole open and prevent caving and heaving. The mud exits the drill string through the drill bit and pushes the sediment cuttings to the annular space surrounding the drill bit. Mud along with the sediment cuttings is then transported upward through the annulus surrounding the drill string out of the boring and into a settling tank at the surface equipped with screens that remove some of the cuttings prior to the mud being recirculated. To maintain separation of drilling fluid from the surrounding water column, temporary casing will be used within the drilling string. A bentonite based drilling fluid may be used during drilling to keep the borehole open and to remove cuttings.

Steel conductor casing will be employed at all mud-rotary borehole locations. The conductor casing will be pushed approximately 2 ft into the sediment and will be securely attached to the barge deck using a clamping mechanism so it does not drop when drilling commences. To contain the sediment cuttings as they surface during drilling activities, the top of the conductor casing will protrude through a 4- by 8-ft sheet of ¾-in. plywood that has a 2- by 6-in. frame attached. The sediment cuttings will be shoveled into properly labeled, DOT-approved, 55-gallon steel drums. Care will be taken to minimize any spilling of the sediment.

Soil samples will be collected from the soil boreholes for lithological identification and geotechnical tests. As the drill is advanced, split-spoon samples will be collected at an interval of one every 5 ft and lithology changes from a depth of 5 ft bgs to the total depth of the boring. Standard penetration test (ASTM Method D1586-11) hammer blow counts will be recorded. Split-spoon soil samples will be collected for lithological description and laboratory analysis. Three-foot-long undisturbed Shelby tube samples (ASTM Method D1587/D1587M) will be collected from the silts and clays.

4.4.2.2 Standard Penetration Tests and Split Spoon Sampling

Standard penetration tests will be performed in accordance with ASTM D1586 methodology guidance using a 2-in.-outer-diameter split-spoon sampler. The split-spoon sampler is attached to steel rods and then lowered to the bottom of the borehole. The sampler is driven for 18 in. using a 140-lb hammer with a drop height of 30 in. For each 6-in. interval of driving, the number of blows is noted. The standard penetration resistance, the N-value, is recorded as the number of blows required to drive the sampler the final 12 in. The N-value can then be correlated to the density of granular material and the consistency of cohesive material. If hard driving prevents the sampler from being advanced the full 18 in. due to the presence of very dense material or obstructions, the penetration resistance is recorded as follows:

- For less than 6 in of penetration, the N-value is recorded as the total number of blows over the distance of penetration, in inches.
- For more than 6 in. of penetration, the N-value is taken as the sum of the total number of blows after the initial 6 in. of penetration. The sum is expressed over the number of inches driven that exceed the first 6 in. The blow count over the first 6 in. is not used to calculate the N-value due to drilling effects that create disturbance.

Split-spoon samples will be recovered from borings at select intervals in accordance with ASTM D1586 (2018) and SOP-5 (Attachment 1). Sediments will be collected and logged by an Oregon registered geologist or professional engineer using ASTM D2488 (2017) guidelines, as described in SOP SL-04. A boring log (Attachment 2) will be completed for each borehole following guidance provided in SOP SL-06. Sediment cores will be processed as described in SOP-3 (Attachment 1). Samples will be placed into the containers listed in Table A-8 and shipped to a geotechnical testing laboratory for testing.

4.4.2.3 Shelby Tube Sampling

Relatively undisturbed samples of cohesive material will be recovered from borings using 36-in.-long, 3-in.-diameter, thin-wall, seamless, stainless steel sampling tubes (aka Shelby tubes) in accordance with ASTM D1587 (2015) and SOP-3. The Shelby tubes will be used in conjunction with an Osterberg sampler (or equivalent technology). A stationary piston is positioned at the bottom of the Shelby tube as it is lowered to the bottom of the borehole to prevent disturbed

materials from entering the tube. To obtain a sample, the tube is pushed past the stationary piston in one continuous, relatively rapid motion. The piston remains fixed at the top of the soil to be sampled as the tube is advanced, resulting in suction that aids in retention of the sample. The tube is then carefully removed from the hole and sealed at both ends, packed in an appropriate container[3] to remain upright during transport, and sent to the geotechnical laboratory for analysis. Shelby tube samples will be handled and transported in accordance with ASTM D-4220 Method C—Standard Practices for Preserving and Transporting Soil Samples.

4.4.2.4 Geotechnical Laboratory Analysis

Split-spoon and undisturbed Shelby tube geotechnical samples will be analyzed for the following tests:

- Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass, ASTM Method D-2216-10
- Liquid Limit, Plastic Limit, and Plasticity Index of Soils, ASTM Method D-4318-17, for silt and clay only
- Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis, ASTM Method D-6913-04
- Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation Hydrometer) Analysis, ASTM Method D-7928-16
- Specific Gravity of Soil Solids by Water Pycnometer, ASTM Method D-854-14
- Moisture, Ash, and Organic Matter of Peat and Other Organic Soils, ASTM Method D-2974 or TOC by SW-846 9060A (mod.).

Undisturbed Shelby tube geotechnical samples will be analyzed for the following additional tests:

- Laboratory Determination of Density (Unit Weight) of Soil Specimens, ASTM Method 7263-09
- Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils, ASTM Method D2850-15
- Consolidated Undrained Triaxial Compression Test for Cohesive Soils, ASTM Method D4767-11
- Unit Weight, ASTM D-7263.

[3] If needed, the Shelby tubes may be sectioned into shorter intervals to fit into the container for shipment to the laboratory.

Additional details on standard penetration test, split-spoon, and Shelby tube sampling, and sample processing and handling are provided in in SOP SD-25 (Attachment 1).

4.4.2.5 Investigation-Derived Waste

Drilling mud and excess sediment generated during drilling and sampling activities will be transferred to properly labeled DOT-approved, 55-gallon drums located on the barge deck. The drums will be managed in accordance SOP AP-05 (Attachment 1).

4.4.2.6 Borehole Abandonment

All boreholes will be abandoned with a high-solids bentonite grout and mixed according to the manufacturer's specifications. The bentonite grout will be placed inside the conductor casing through a tremie pipe as the mud-rotary tool assembly is removed. Once the borehole is grouted, the conductor casing will be brought to the barge deck, and any residual sediment left on the casing will be transferred to properly labeled, DOT-approved, 55-gallon drums. The conductor casing and drilling equipment will be decontaminated following the procedures provided in Section 7 and SOP-9 (Attachment 1).

4.4.3 Sonic Boreholes

If needed for Phase 2, sediment borings will be advanced using a sonic drill rig with an Osterberg piston-type sampler to further evaluate potential subsurface NAPL in the Arkema Project Area. The number and locations of samples will be determined based on the results of the Phase 1 sampling.

4.4.3.1 General Drilling Procedures

During advancement of sonic boreholes, the river stage/barge deck elevation will be monitored using a survey-grade GNSS receiver on the DGPS unit, and the sample intervals will be adjusted based on the river stage changes. The river stage and sample interval calculations will be displayed on a white board near the drill rig so the drilling crew can refer to them prior to collecting each sediment sample.

Prior to core advancement and sample collection, all coring and non-disposable sampling equipment will be decontaminated following the procedures provided in Section 7 and SOP-9 (Attachment 1).

Sediment samples will be collected in 2.5-ft drives with Osterberg piston-type sampler (or equivalent technology). The Osterberg sampler will be equipped with a 2.5-ft-long by 3-in.-diameter Shelby Tube, which will allow for the collection of relatively undisturbed samples that will be useful for assessing potential NAPL.

Once the casing is advanced to the approximate top of the sample interval, the Osterberg sampler will be advanced ahead of the end of the casing to collect a representative sediment sample. When the sampler is retrieved, the casing will be advanced to the bottom of the previously sampled interval while potable water is pumped at high pressure through the casing to keep sediment from entering the casing. The sample intervals/casing depths will be adjusted as needed approximately every 15–30 minutes to compensate for tidal or river stage fluctuations in the Willamette River.

Sediments will be continuously collected and logged by an Oregon registered geologist or professional engineer using ASTM D2488 (2017) guidelines, as described in SOP SL-04 (Attachment 1). A boring log (Attachment 2) will be completed for each borehole following guidance provided in SOP SL-06. Sediment cores will be processed as described in SOP-3 (Attachment 1).

4.4.3.2 Investigation-Derived Waste

Excess sediment generated during core processing and sample collection will be transferred to properly labeled DOT-approved, 55-gallon drums located on the deck of the barge. The drums will be managed in accordance SOP-AP-05 (Attachment 1).

4.4.3.3 Borehole Abandonment

All boreholes will be abandoned with a high-solids bentonite grout and mixed according to the manufacturer's specifications. The bentonite grout will be placed inside the casing through a tremie pipe as the casing is withdrawn. Once the borehole is grouted, any residual sediment left on the casing will be transferred to properly labeled, DOT-approved, 55-gallon drums. The drilling equipment will be decontaminated following the procedures provided in Section 7 and SOP-9 (Attachment 1).

4.5 RIVERBANK SOIL

The following sections discuss the field methodology for hand auger boreholes and test pit explorations.

4.5.1 Hand Auger Boreholes

Soil boreholes will be advanced using a 3.25-in.-diameter hand auger at 39 locations along the Arkema Project Area riverbank (Figures A-1 and A-2a-b). Soil samples will be collected at 1-ft intervals to a target depth of 4 ft below ground surface (bgs). Soils will be continuously collected and logged by an Oregon registered geologist or professional engineer using ASTM D2488 (2017) guidelines, as described in SOP SL-04. A boring log (Attachment 2) will be completed for each borehole following guidance provided in SOP SL-06.

A small portion of soil will be retained for field screening of organic vapors using a PID or equivalent organic vapor monitoring instrument in accordance with SOP-12 (Attachment 1). Soils samples will be analyzed for focused COCs for the Arkema Project Area or archived as provided in Figure 3-2d of the work plan. Soil processing will be conducted in accordance with the SOPs in Attachment 1.

Soil samples will be analyzed in accordance with the Riverbank Soil Sample Analysis Decision Tree (Figure 3-2d of the work plan). Selected soil samples will be analyzed for the following (Table A-6):

- DDx
- PCDD/Fs
- PCB congeners
- Asbestos.

The samples will be immediately placed in a cooler with ice for preservation. Additional quality assurance guidelines, including sample handling and the collection of duplicate and rinsate blank samples, are presented in the QAPP (Appendix B to the work plan).

Excess soils generated during hand auger and sampling activities will be transferred to properly labeled DOT-approved, 55-gallon drums located on the barge deck. The drums will be managed in accordance SOP AP-05 (Attachment 1).

The boreholes will be abandoned with bentonite chips and hydrated according to the manufacturer's specifications.

4.5.2 Test Pit Explorations

Shallow test pit explorations will be excavated using a track-mounted backhoe or excavator at six locations in the riverbank area to a depth of approximately 6 ft bgs (Figure A-5). The upper 1–2 ft of soil from the test pit area (approximately 6 ft wide by 8 ft long) will be removed and placed to one side of the excavation. The excavation will be continued using the excavator, placing the soils on the opposite side of the excavation until the appropriate depth and width are obtained. Soil samples greater than 3 ft bgs will be collected using the backhoe or excavator bucket.

Soils will be continuously collected and logged by an Oregon Professional Engineer using ASTM D2488 (2017) guidelines, as described in SOP SL-04. A test pit log (Attachment 2) will be completed for each test pit following guidance provided in SOP SL-06. Detailed field notes will be prepared for each test pit in accordance with SOP AP-02 (Attachment 1). Photographs will be taken of each test pit side wall and sample location.

Select soil samples will be analyzed for the following the following physical properties:

- Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass, ASTM Method D-2216-10
- Liquid Limit, Plastic Limit, and Plasticity Index of Soils, ASTM Method D-4318-17, for silt and clay only
- Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis, ASTM Method D-6913-04
- Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation Hydrometer) Analysis, ASTM Method D-7928-16
- Specific Gravity of Soil Solids by Water Pycnometer, ASTM Method D-854-14
- Moisture, Ash, and Organic Matter of Peat and Other Organic Soils, ASTM Method D-2974 or TOC by SW-846 9060A (mod.)

The samples collected for analysis of moisture content and organic content will be immediately placed in coolers with ice for preservation. The other samples will not need to be cooled. The relatively undisturbed samples collected for shear strength and consolidation testing will be stored vertically and will not be agitated. All geotechnical samples will be hand delivered to the geotechnical laboratory by either a lab courier or the field crew to ensure the integrity of the undisturbed samples. Additional quality assurance guidelines, including sample handling and the collection of duplicate samples, are presented in the QAPP (Appendix B to the work plan).

All excavated soils will be returned to the test pits immediately after soil sampling activities are completed or at the end of the day, whichever comes first. The soils from the deeper portion of the trench will be returned to the trench first. The ground surface in the vicinity of the test pit will be leveled out to prevent future tripping hazards. The boundaries of the test pit will be marked with stakes and DGPS coordinates will be collected in accordance with Section 4.2

4.6 GROUNDWATER DISCHARGE AND COC FLUX

To evaluate the current groundwater flow system, a combination of monitoring wells at the top of the riverbank, piezometers at the toe of riverbank slope, and a stilling well measuring the Willamette River stage will be used to calculate groundwater gradients and estimate flux. Details on field collection for each of these elements is provided below and locations are shown on Figure A-3.

4.6.1 Piezometer Installation

Four piezometers (PZ-1 through PZ-4) will be installed along the toe of the riverbank slope to a target depth of 15 ft bgs using a track-mounted sonic drill rig (Figure A-3). The piezometers will be installed by a well driller licensed in the State of Oregon.

The boreholes will be 6-in. in diameter and will be sampled continuously from ground surface to the bottom of the borehole. Soils will be logged by or under the supervision of an Oregon registered geologist or professional engineer using the ASTM soil classification system in accordance with ASTM D2488 (2017) guidelines, as described in SOP SL-04. A boring log (Attachment 2) will be completed for each piezometer borehole following guidance provided in SOP SL-06. A portion of each sample will be screened for VOCs using a PID in accordance with SOP-12.

The piezometers will be constructed of 2-in.-diameter Schedule 40 PVC with 10 ft of 0.010-inch slot screen. The PVC casing will extend 2–3 ft above the ground surface. Two stainless steel well centralizers will be placed at the bottom and just above the top of the screen to keep the well in the center of the filter pack. No. 10/20 silica sand filter pack (or equivalent filter pack) material will be added to the sonic casing as the casing is removed, keeping several feet of silica sand within the auger or casing to continually fill the void created by the augers or casing as they are retracted. The sand will be poured in slowly to avoid bridging. The filter pack will extend approximately 2 ft above the top of the screen. The piezometer will be pumped and/or surged repeatedly to promote settling of the filter pack. Additional silica sand will be added if significant settling has occurred. A bentonite pellet seal will be placed from the top of the filter pack to the ground surface as the augers are retracted. The bentonite pellets will be added slowly to avoid bridging. An 8-in.-diameter above-ground well monument will be installed.

The top of piezometer casing will be surveyed by a professional land surveyor licensed in Oregon. The elevation of the top of the well casing and the ground surface will be surveyed within 0.01 ft and the horizontal location of each well casing will be surveyed to an accuracy of 0.1 ft. The vertical datum will be NAVD 88 and the horizontal datum will be the North American Datum of 1983-91 adjusted (NAD83/91), consistent with previous survey work at the site.

4.6.2 Groundwater Monitoring

Pressure transducers will be installed in the piezometers along the toe of the riverbank slope. Pressure transducers are already deployed in the monitoring wells on the river side of the groundwater barrier wall and in the stilling well on Dock 1 as part of the monitoring associated with the groundwater extraction and treatment system. Pressure readings will be collected from the transducers every 15 minutes for at least 71 hours, and the measurement times will be synchronized between the monitoring wells, piezometers, and stilling well. Depth to water

measurements will be collected at the notch on each well casing during deployment retrieval activities using an electronic water level meter with an accuracy of 0.01 ft following procedures provided in SOP GW-02 (Attachment 1). The data will be downloaded from each transducer and corrected for barometric pressure (if non-vented transducers are used).

In addition to pressure readings and depth to groundwater measurements, groundwater samples will be collected from each of three well clusters at the top of the riverbank and analyzed for COCs. These samples may be collected as part of the ongoing quarterly groundwater monitoring conducted to evaluate changes in groundwater COC concentrations in the vicinity of the groundwater source control measures. Samples will be collected from shallow wells MWA-2, MWA-61, and MWA-69; intermediate or shallow-intermediate wells MWA-8i, MWA-64i, MWA-67si, and MWA-66i; and deep wells PA-19d and PA-21d. In addition, groundwater samples will be collected from piezometers PZ-1 through PZ-4 to define COC concentrations between the riverbank and the point of discharge (seepage meters) (Figure A-3).

Groundwater sampling will be conducted using low-flow sampling techniques in accordance with SOP GW-03 (Attachment A). The wells will be purged and water quality parameters (temperature, pH, oxidation reduction potential, dissolved oxygen, and specific conductance) will be recorded. A peristaltic pump or equivalent will be used to purge and sample the wells. Sample parameters will be allowed to stabilize prior to sampling. Groundwater samples will be collected in laboratory-supplied sampling containers. The samples will be analyzed for the following constituents (Table A-6):

- DDx
- VOCs.

Groundwater samples will be immediately placed in a cooler with ice for preservation. Additional quality assurance guidelines, including sample handling and the collection of duplicate and rinsate blank samples, are presented in the QAPP (Appendix B to the work plan).

4.6.3 Seepage Meters

Seepage meters will be deployed at eight locations shown on Figure A-3 in accordance with the EPA-approved SOP C of Attachment 1 to the Groundwater Pathway Assessment Pilot Study FSP (Integral 2004), which is provided in Attachment 1 of this FSP. The unit is deployed by divers and rests on the sediment surface. The UltraSeep system will be programmed to collect continuous flow data and multiple samples from each of these stations over the course of 24 hours. At the end of the deployment period, divers will retrieve the UltraSeep system and associated samples.

Transition zone water samples will be collected from the eight seepage meter locations between Docks 1 and 2 for analysis of VOCs and dissolved organic carbon (Figure 3-4). Transition zone samples will be analyzed for the following (Table A-6):

- DDx
- VOCs.

4.7 SEDIMENT POREWATER

Sediment porewater samples will be collected from three locations in support of pre-remedial sediment cap design (Figure A-4). The porewater parameter measurement and sampling will be conducted using a Trident Probe™ (or similar device) in accordance with the EPA-approved SOP B of Attachment 1 to the Groundwater Pathway Assessment Pilot Study FSP (Integral 2004), which is provided in Attachment 1 of this FSP.

The Trident Probe™ (or equivalent system) will be deployed from a small, well-anchored vessel using an aluminum push rod, along with a submersible air-hammer to assist in driving the probe into the sediment. The Trident Probe™ will be used to collect sediment porewater samples from three locations to measure dissolved organic carbon and VOCs in support of sediment cap design (Figure A-4). The samples will be collected at depths of approximately 1, 2, and 3 ft bml to assess any vertical gradients in dissolved organic carbon and VOCs.

Porewater samples will be collected and analyzed for the following (Table A-6):

- Dissolved organic carbon (field filtered using a 0.45 micron filter)
- VOCs.

Samples will immediately be placed in a cooler with ice for preservation. Additional quality assurance guidelines are presented in the QAPP (Appendix B to the work plan).

5 SAMPLE DESIGNATION

Sediment and riverbank soil samples will be assigned an individual sample identification number in the following manner:

Station Type-##-depth

Where:

Station Type:

SC = Sediment Station (Chemistry)

SS = Sediment Station (NAPL)

SN = Sediment Station (Navigation Channel)

RH = Riverbank Hand Auger Boring

GSB = Geotechnical Sediment Boring

GTP = Geotechnical Test Pit Exploration

= Station number
Depth (e.g., 02 = 0 to 2 ft bml).

Porewater samples will be assigned an individual sample identification number in the following manner:

Station Type-#-depth

Where:

Station Type:

SMS = Seepage Meter Station

PW = Porewater Station

= Station number
Depth (e.g., 2 = 2 ft bml).

Groundwater will be assigned an individual sample identification number in the following manner:

GW-##-Date

Where:

= Monitoring well identifier (e.g., MWA-56d)
Date (e.g., 2020-10-28 for October 28, 2020).

Field quality control samples (i.e., equipment rinsates and field blanks) will be assigned an individual sample identification number in the following manner:

EB-## (Equipment Blank - Sample Number starting at 01).

Duplicate sediment samples delivered to the laboratory will be given a blind sample identification (to be determined) that will correspond to the numbering system described above.

6 SAMPLE HANDLING AND ANALYSIS

Sample tracking is an important aspect of field investigation activities, because it documents the proper handling and integrity of the samples. Sample tracking forms for the project will include chain-of-custody forms, sample labels, custody seals, and sample matrix tables. Example forms are located in Attachment 2. Additional details on sampling handling and storage is provide in the QAPP.

6.1 SAMPLING HANDLING PROCEDURES

The following sections describe documentation with sampling and handling procedures. Additional guidance is provided in SOP-5, SOP AP-01 and SOP AP-03 (Attachment 1).

6.1.1 Sample Labels

Sample containers will be clearly labeled with waterproof black ink at the time of sampling. Sample labels will contain the following information:

- Sample identification numbers
- Sample date
- Sample time
- Preservation used, if any (this information will also be included on the chain-of-custody form)
- Initials of sampling personnel.

The sample label will be attached to the sample container prior to, or just after, the container is filled and the lid secured. As an added measure of security, the finished label will be covered with clear packaging tape to protect the ink from moisture and to tightly secure the label to the sample container. Information on the sample label must match the information on the chain-of-custody form and in the site logbook for each sample.

6.1.2 Custody Seal

Custody seals will be used on sample shipping containers (coolers) that will either be shipped or sent by courier to the laboratory as described in SOP AP-03. Custody seals will be attached to the lid and body of the coolers to detect any tampering during shipment. The custody seals will be signed and dated by the sampler or sample shipper. Custody seals are not required for samples delivered by hand directly to the lab unless left unattended.

6.1.3 Sample Matrix Table

Sample matrix table summary logs will be maintained by the field team leader and used to keep track of all phases of the sampling and analysis process for all individual samples. The sample matrix tables will include sample collection date(s), sample identification, field quality control samples, and sample analysis requested. The sample matrix table will also identify blind sample numbers given to the laboratory with corresponding numbering in the field. A sample matrix template is provided in Attachment 2.

6.1.4 Sample Custody/Tracking Procedures

The samples collected must be traceable from the time they are collected until their derived data are used in the final report. In general, the following provisions apply to sample handling and are described in SOP AP-01 and SOP AP-03:

- The field team leader, or sampler, will be responsible for the care and custody of the samples collected until they are properly transferred or dispatched to the laboratory.
- All appropriate documentation forms will be used, including sample labels, chain-of-custody forms, sample logs, and any other appropriate forms. Documentation will be completed neatly using waterproof black ink.
- When transferring possession of samples, the individuals relinquishing and receiving them will sign, date, and note the time on the chain-of-custody form. Containers shipped by common carrier will have the chain-of-custody form enclosed in a watertight container (e.g., plastic resealable bag) and placed in the container prior to sealing.
- Samples will be packaged properly according to the current DOT requirements and promptly dispatched to the laboratory for analysis. Sample containers will be packed in coolers on ice. The coolers will be securely sealed.
- Each cooler will be accompanied by its own chain-of-custody form identifying its contents. A copy of the chain-of-custody form will be retained by the field team leader for inclusion in project records.
- For coolers shipped via express delivery service, custody seals will be affixed to the outside of the coolers (shipping containers). The field team leader, sampler, or shipper will sign and date the custody seals.
- All samples will be shipped via express delivery for overnight delivery or hand delivered to the laboratory.

6.2 FIELD DOCUMENTATION PROCEDURES

The primary methods of documentation that will be used for this project include site logbook, photo logs, sample log forms, field change request forms, and sample matrix table. A description of each of these documentation methods is provided in the following sections. Example field forms are presented in Attachment 2.

6.2.1 Field Logbooks

Field logbooks will be used to document all field sampling activities performed at the project site. The logbooks will contain the date, time, and description of all field activities performed; names of personnel; weather conditions; the names of visitors to the site; areas where photographs were taken; and any other data pertinent to the project. The logbook is the official record of site activities, and will serve as the key to sample designations and locations. In addition, the logbook will document deviations from the project plans and health and safety tailgate meeting minutes.

Requirements for logbooks include the following:

- Logbooks will be sturdy, weatherproof, and bound, with consecutively numbered pages. If multiple logbooks are used, they will be numbered sequentially.
- Entries will be made legibly with waterproof, black (or dark) permanent ink.
- Removal of any pages, even if illegible, will be prohibited. Any mistakes will be crossed out with a single line, initialed, and dated.
- Unbiased, accurate language will be used.
- Entries will be made while activities are in progress or as soon afterward as possible (the time of the observation will be noted and the time that the notation is made will be noted if significantly later than the observation time).
- Each consecutive day's first entry will be made on a new, blank page. Each page of the field logbook will be numbered, dated, and signed by the author.
- The date will appear at the top of each page. The time, based on a 24-hour clock (e.g., 0900 for 9:00 a.m. and 2100 for 9:00 p.m.), also will appear for each entry.
- Blank pages, if any, will be marked "page intentionally left blank."

An example of the field logbook can be found in Attachment 2.

6.2.2 Photo Documentation

Digital photographs will be taken at sampling locations and of selected samples. These photos will help to identify the sampling locations and will provide an accurate visual record of the material being sampled. All photographs taken will be identified in the field logbooks (preferably in a separate section of the book set aside for that purpose). Photographic logs will contain, at a minimum, the file number, date, time, initials of the photographer, and a description of the image in the photograph.

6.2.3 Sample Collection Information Form

Sampling logs and collection forms will be used to document site and sample characteristic data, which should agree with the information recorded in the site logbooks. Field personnel are required to fill out one sample log form for each sample collected. A copy of these forms will be stored in the field office or field files, with the original stored in the project file. A copy of these forms will also be included in the final data report and other documents, as appropriate. At a minimum, the log for each sample will contain the sample number, the date and time of sample collection, and a description of the sampling site, as well as the physical characteristics of the sample, the planned analysis, and the initials of the sampler. Example field forms are located in Attachment 2.

6.2.4 Field Change Request

The field team leader will be responsible for all environmental sampling activities, and will occasionally be required to adjust the field program to accommodate site-specific needs after consultation with the project manager and EPA team. The field team leader will notify the project manager of any significant field changes. The project manager will immediately notify EPA for approval (verbal or written) of any significant field changes. This notification/approval will typically occur via e-mail or telephone, to avoid suspension of fieldwork. The project manager and/or field team leader will follow up these conversations with an e-mail and field change request form that summarizes the approved changes for EPA signature. When it becomes necessary to modify a program or task, the changes will be documented in the chain-of-custody form

The chain-of-custody form is used to document the history of each sample and its handling from its collection through all transfers of custody until it reaches the analytical laboratory. Internal laboratory records will document custody of the sample from the time it is received in the lab through its final disposition. The chain-of-custody form will be filled out after the samples have been collected and will be double-checked prior to the transport of the samples to the laboratory. At a minimum, the chain-of-custody form will contain the following information and follow procedures described in SOP AP-03 (Attachment 1):

- Name of project
- Names of sampling personnel
- Sample identification numbers
- Collection date and time
- Number and type of containers per sample
- Sample matrix
- Sample preservation, if any
- Analysis requested.

The completed chain-of-custody form will be placed in a large capacity Ziploc® bag and secured to the sample transport container. If coolers are used to transport samples, the chain-of-custody form will be taped to the underside of the cooler lid.

7 DECONTAMINATION PROCEDURES

Equipment decontamination will be performed using procedures outlined below. Site personnel will perform decontamination of all equipment prior to removal from the site and between sample locations. All decontamination fluids will be containerized in properly labeled, DOT-approved, 55-gallon drums. If any solvents (e.g., hexane) are utilized during the decontamination process, they will be containerized in separate, properly labeled 5-gallon containers. Investigation-derived wastes will be handled in accordance with Section 8.

The drilling equipment (core tubes, drill rods, drill bits, and conductor casing) will be decontaminated with a pressure washer.

All non-disposable components of the sediment coring equipment (e.g., split spoons), or other equipment used to collect sediment samples that contact the sediments, will be decontaminated as follows:

- Potable water rinse
- Alconox®/Liquinox® detergent wash
- Potable water rinse
- Solvent rinse (if visible contamination is observed)[4]
- Deionized water rinse
- Air dry.

Equipment rinse blanks are used to monitor equipment decontamination procedures and to check for other sources of contamination. As specified in SOP SD-02, equipment rinsate blank samples will be collected once per sampling type (e.g., surface grab sampling, vibracore, split spoon, hand auger, test pit) to determine the effectiveness of the decontamination procedures. Equipment rinse blanks are collected by pouring water over the sample homogenization equipment (i.e., for sediment samples). In the event contamination is detected in the rinsate blanks, a field change to the decontamination procedure would be implemented as outlined in Section 6.2.4.

[4] Solvent rinse will include the use of clean paper towels to remove water followed by a hexane rinse. The hexane solvent rinse is only required if visible non-aqueous phase liquid is observed on the sampling equipment.

8 INVESTIGATION-DERIVED WASTE HANDLING

The primary waste streams anticipated to be generated during this project and the proposed storage/disposal methods are described below. LSS is responsible for the proper characterization and disposal of investigation-derived waste streams.

8.1 SEDIMENT CUTTINGS AND EXCESS/REJECTED SEDIMENT AND SOIL SAMPLES

Sediment cuttings and drilling mud from drilling activities will be placed in properly labeled, DOT-approved 55-gallon drums on the barge deck. The drums on the barge deck will be lifted onto one of the docks at the end of the field event. Excess/rejected sediment and soil samples will also be containerized in properly labeled DOT-approved 55-gallon drums.

All drums will be staged onsite and characterized for offsite disposal in accordance with state and federal regulations. The drums will be managed as described in SOP-11 (Attachment 1).

8.2 DECONTAMINATION WASTEWATERS

Liquid wastes (i.e., decontamination waters) will be potentially contaminated with focused COCs and other chemicals. The presence of any of these constituents in the wastewaters is expected to be diluted; therefore, the wastewaters are not expected to be classified as hazardous waste. Decontamination waters will be containerized in 55-gallon drums as described in SOP-11 (Attachment 1). The drums will be lifted onto one of the docks at the end of the field event, staged onsite, and characterized for offsite disposal in accordance with state and federal regulations.

For solvents (e.g., hexane), decontamination activities will be conducted so as to minimize the potential for spills/releases of wastewaters. Spent decontamination solvents must be stored in leak-proof container(s) with secured lid(s). The lid will remain closed except when the container is being used for decontamination activities. It is anticipated that liquid wastes will be placed in 5-gallon buckets or similar containers for characterization and offsite disposal.

8.3 PERSONAL PROTECTIVE EQUIPMENT/MISCELLANEOUS DEBRIS

Sediment sampling activities will generate personal protective equipment and miscellaneous debris. Gross contamination will be removed from these items, and the items will be placed in plastic bags. Interim storage of these materials in plastic bags is acceptable. The bags will be disposed of at a solid waste facility dumpster at the end of each day.

9 REFERENCES

ASTM. 2000. Standard Practices for Preserving and Transporting Soil Samples R. Designation: D 4220. American Society for Testing and Materials, West Conshohocken, PA.

ASTM. 2004. Standard Test Method for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis. Designation: D 6913. American Society for Testing and Materials, West Conshohocken, PA.

ASTM. 2009. Standard Test Method for Laboratory Determination of Density (Unit Weight) of Soil Specimens. Designation: D 7263. American Society for Testing and Materials, West Conshohocken, PA.

ASTM. 2010. Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass. Designation: D 2216. American Society for Testing and Materials, West Conshohocken, PA.

ASTM. 2011. Consolidated Undrained Triaxial Compression Test for Cohesive Soils, ASTM Method D4767-11. American Society for Testing and Materials, West Conshohocken, PA.

ASTM. 2014. Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer. Designation: D 854. American Society for Testing and Materials, West Conshohocken, PA.

ASTM. 2015a. Standard practice for thin-walled tube sampling of fine-grained soils for geotechnical purposes. Designation: D1587/D1587M-15. American Society for Testing and Materials, West Conshohocken, PA.

ASTM. 2015b. Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils R. Designation: D 2850. American Society for Testing and Materials, West Conshohocken, PA.

ASTM. 2016. Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis. Designation: D 7928. American Society for Testing and Materials, West Conshohocken, PA.

ASTM. 2017a. Standard practice for description and identification of soils (Visual-Manual Procedure). Designation: D2488-17. American Society for Testing and Materials, West Conshohocken, PA.

ASTM. 2017b. Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. Designation: D 4318. American Society for Testing and Materials, West Conshohocken, PA.

ASTM. 2018. Standard test method for standard penetration test (SPT) and Split-Barrel Sampling of Soils. Designation: D1586/D1586M-18. American Society for Testing and Materials, West Conshohocken, PA.

ASTM. Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils. Designation: D 2974. American Society for Testing and Materials, West Conshohocken, PA.

Cohen, R.M, A.P. Bryda, S.T. Shaw, and C.P. Spalding. 1992. Evaluation of visual methods to detect NAPL in soil and water. *Groundwater Monitoring Review* 12(4)132–141.

ERM. 2005. Upland remedial investigation report, Lots 3 &4 and Tract A, Revision 1, Arkema, Inc. Portland Facility. Environmental Resources Management, Portland, OR. December 2005.

Integral. 2004. Portland Harbor RI/FS field sampling plan, groundwater pathway assessment pilot study. Prepared for The Lower Willamette Group, Portland, OR. Integral Consulting Inc., Mercer Island, WA. December 16.

PSEP. 1997. Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound. Prepared for U.S. Environmental Protection Agency, Seattle, WA. Puget Sound Water Quality Action Team, Olympia, WA.

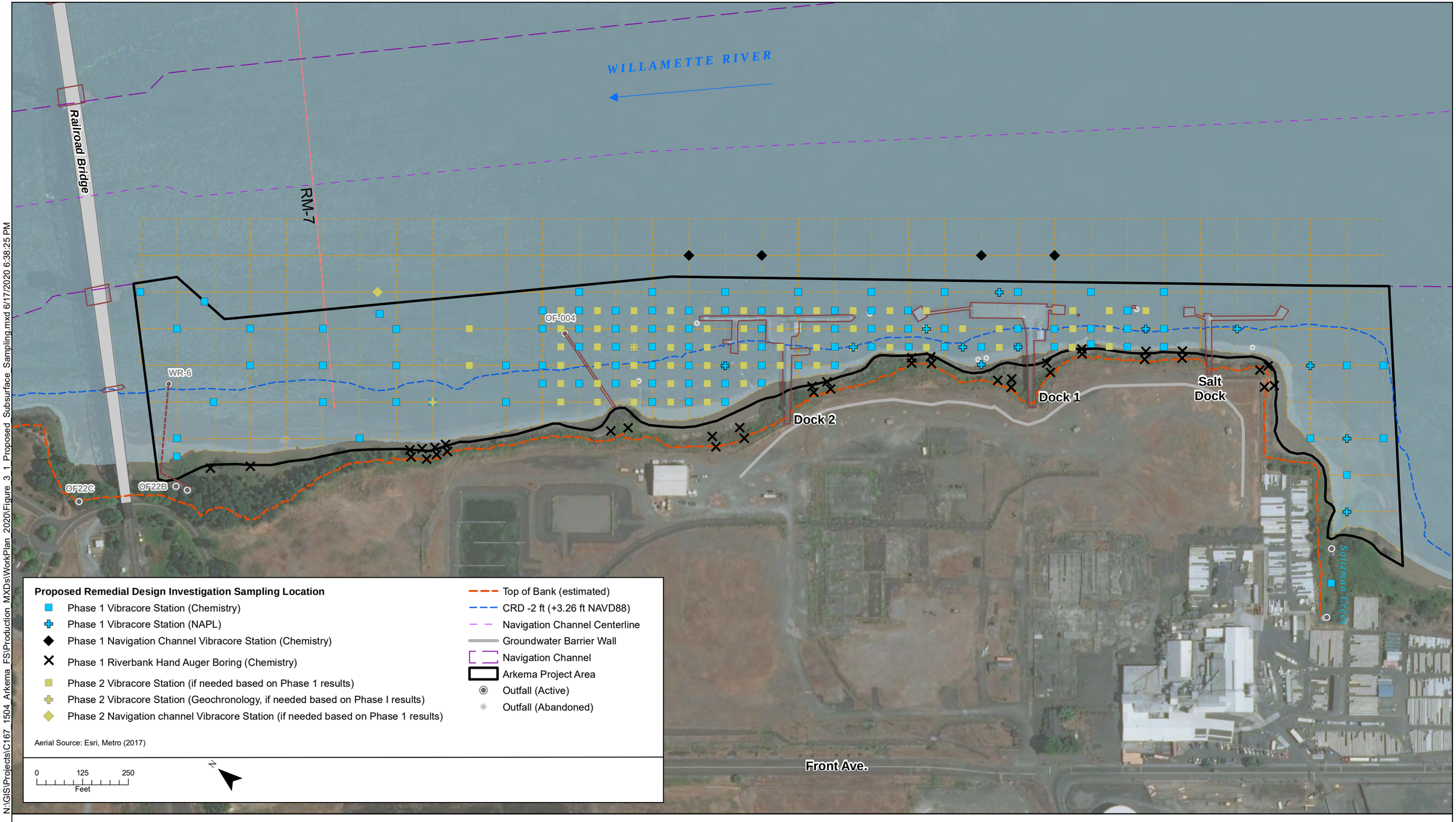
USACE. 2003. Evaluation of dredged material proposed for disposal at island, nearshore, or upland confined disposal facilities—Testing manual. Report ERDC/EL TR-03-1. U.S. Army Corps of Engineers, Engineer Research and Development Center, Environmental Laboratory. January.

USACE. 1995. Dredging elutriate test (DRET) development. Contract Report D-85-1. U.S. Army Corps of Engineers, Waterways Experiment Station. August.

USEPA. 2002. Guidance for quality assurance project plans. EPA QA/G-5. EPA/240/R-02/009. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

USEPA. 2017. Record of decision, Portland Harbor Superfund Site, Portland, Oregon. U.S. Environmental Protection Agency, Region 10, Seattle, WA. January.

Figures

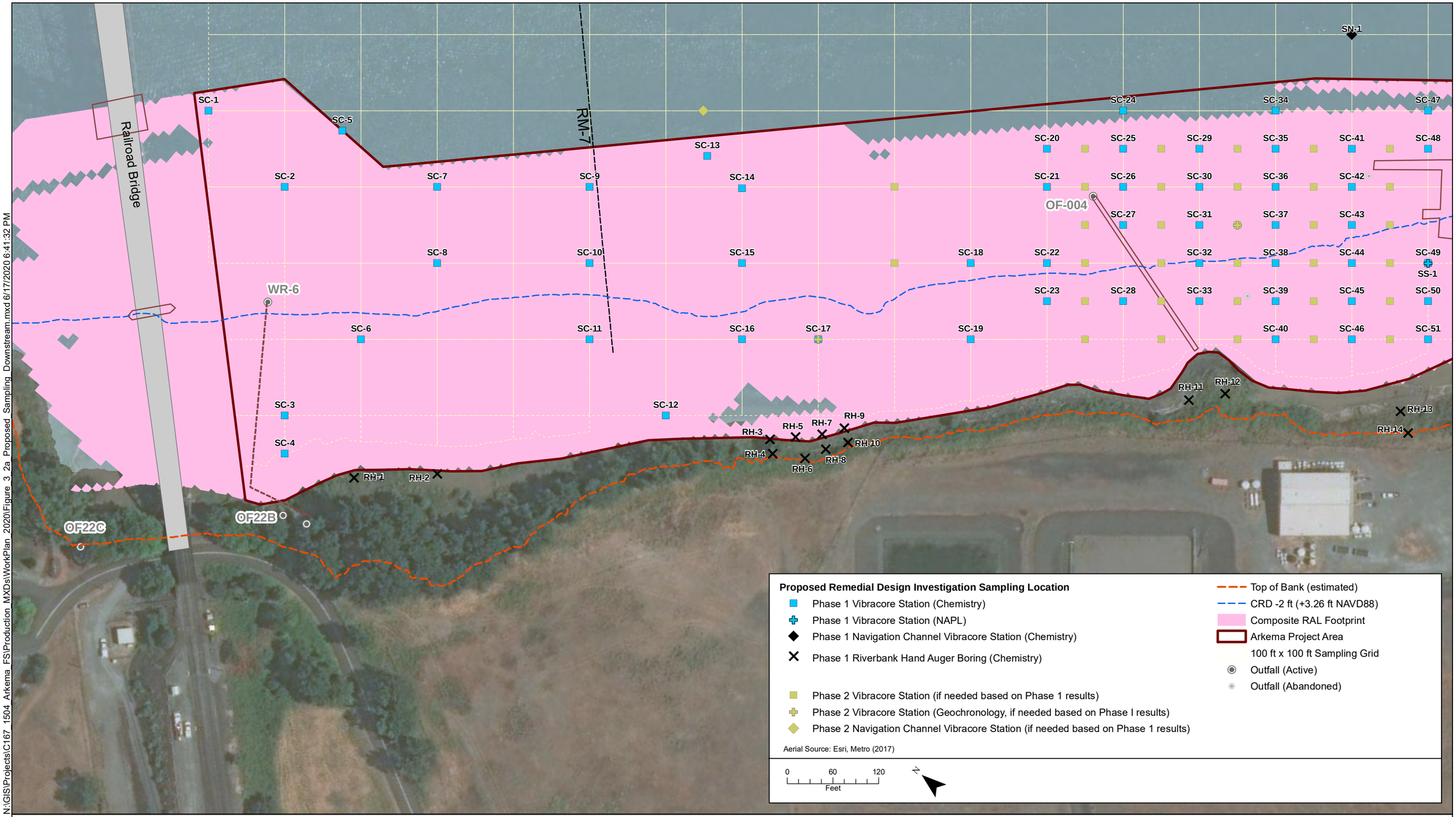


N:\GIS\Projects\C167 1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 3_1 Proposed Subsurface Sampling.mxd 6/17/2020 6:38:25 PM

integral consulting inc.

DRAFT

Figure A-1.
Summary of Proposed Remedial Design Investigation Subsurface Sediment and Riverbank Soil Chemistry Sampling Stations
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_3_2a_Proposed_Sampling_Downstream.mxd 6/17/2020 6:41:32 PM

integral consulting inc.

Note:
1. Composite RAL footprint includes the Focused COCs from the ROD

DRAFT

Figure A-2a.
Detailed Proposed Remedial Design Investigation Sediment and Riverbank Soil Chemistry Sampling Stations Downstream of Dock 2
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167 1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 3_2b Proposed Sampling_Upstream.mxd 6/17/2020 6:44:16 PM

SN-2 SN-3 SN-4

SC-47 SC-57 SC-64 SC-71 SS-6 SC-75 SC-80 SC-86

SC-48 SC-52 SC-58 SC-60 SC-65 SC-68 SC-83

SC-53 SC-61 SC-66 SC-69 SS-3 SC-72 SC-76 SC-78 SC-81 SC-84 SS-8 SC-87 SS-9

SC-54 SC-62 SS-2 SC-67 SC-70 SC-73 SS-4 SC-74 SC-77 SC-79 SC-82 SC-85 SC-88

SS-7

SC-49 SC-55 SC-59 SC-63 SS-5 SS-10 SC-89 SC-90

SS-1

SC-50 SC-56

SC-51

SC-91 SS-11 SC-92

SC-93

SS-12

SC-94

RH-15 RH-16 RH-17 RH-18 RH-19 RH-20 RH-21 RH-22 RH-23 RH-24 RH-25 RH-26 RH-27 RH-28 RH-29 RH-30 RH-31 RH-32 RH-33 RH-34 RH-35 RH-36 RH-37 RH-38 RH-39

Dock 1

Dock 2

Salt Dock

Salzman Creek

Proposed Remedial Design Investigation Sampling Location

- Phase 1 Vibracore Station (Chemistry)
- Phase 1 Vibracore Station (NAPL)
- Phase 1 Navigation Channel Vibracore Station (Chemistry)
- Phase 1 Riverbank Hand Auger Boring (Chemistry)
- Phase 2 Vibracore Station (if needed based on Phase 1 results)
- Phase 2 Vibracore Station (Geochronology, if needed based on Phase I results)
- Phase 2 Navigation Channel Vibracore Station (if needed based on Phase 1 results)

- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Groundwater Barrier Wall
- Composite RAL Footprint
- Arkema Project Area
- 100 ft x 100 ft Sampling Grid
- Outfall (Active)
- Outfall (Abandoned)

Aerial Source: Esri, Metro (2017)

0 60 120
Feet

N

integral consulting inc.

DRAFT

Figure A-2b.
Detailed Proposed Remedial Design Investigation Sediment and Riverbank Soil Chemistry Sampling Stations Upstream of Dock 2
Arkema Project Area Pre-design Investigation Work Plan

P:\Projects\C167 1504 Arkema FS\Production MXDs\Workplan 2020\Figure 3_4 GW Discharge Study.mxd 6/12/2020 8:24:47 AM

WILLAMETTE RIVER

SMS-1 SMS-3 SMS-5 SMS-7

SMS-2 SMS-4 SMS-6 SMS-8

PZ-1 PZ-2 PZ-3 PZ-4

OF-004

Dock 2

Dock 1

Salt Dock

MWA-2 MWA-8i PA-19d MWA-61 MWA-64i MWA-67si MWA-66i MWA-69 PA-21d MWA-49i MWA-46 MWA-56d

GWET Building

Saltzman Creek

- Proposed Piezometer Location
- Proposed Seepage Meter Station
- Monitoring Well with Transducer
- Stilling Well with Transducer
- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Groundwater Barrier Wall
- Groundwater Recovery Well
- Arkema Project Area

0 90 180
Feet

N

integral consulting inc.

Aerial Source: Esri, Metrol (2017)

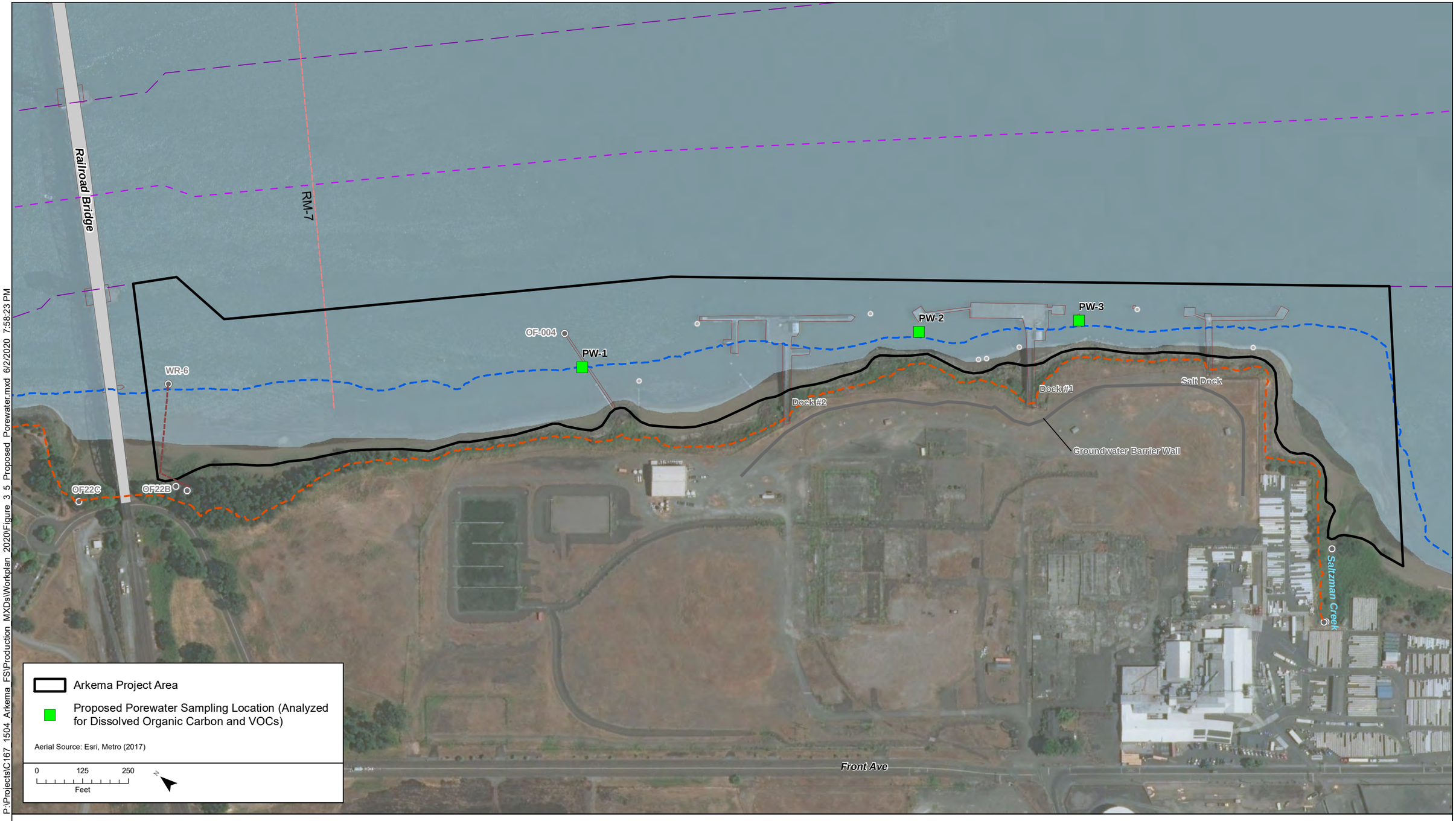
Map Features

- Property Boundary
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Docks and Structures
- Outfall (Active)
- Outfall (Abandoned)

DRAFT

Figure A-3.
Proposed Groundwater Discharge Study
Arkema Project Area Pre-design Investigation Work Plan

P:\Projects\C167 1504 Arkema FS\Production MXDs\Workplan 2020\Figure 3_5 Proposed Porewater.mxd 6/2/2020 7:58:23 PM



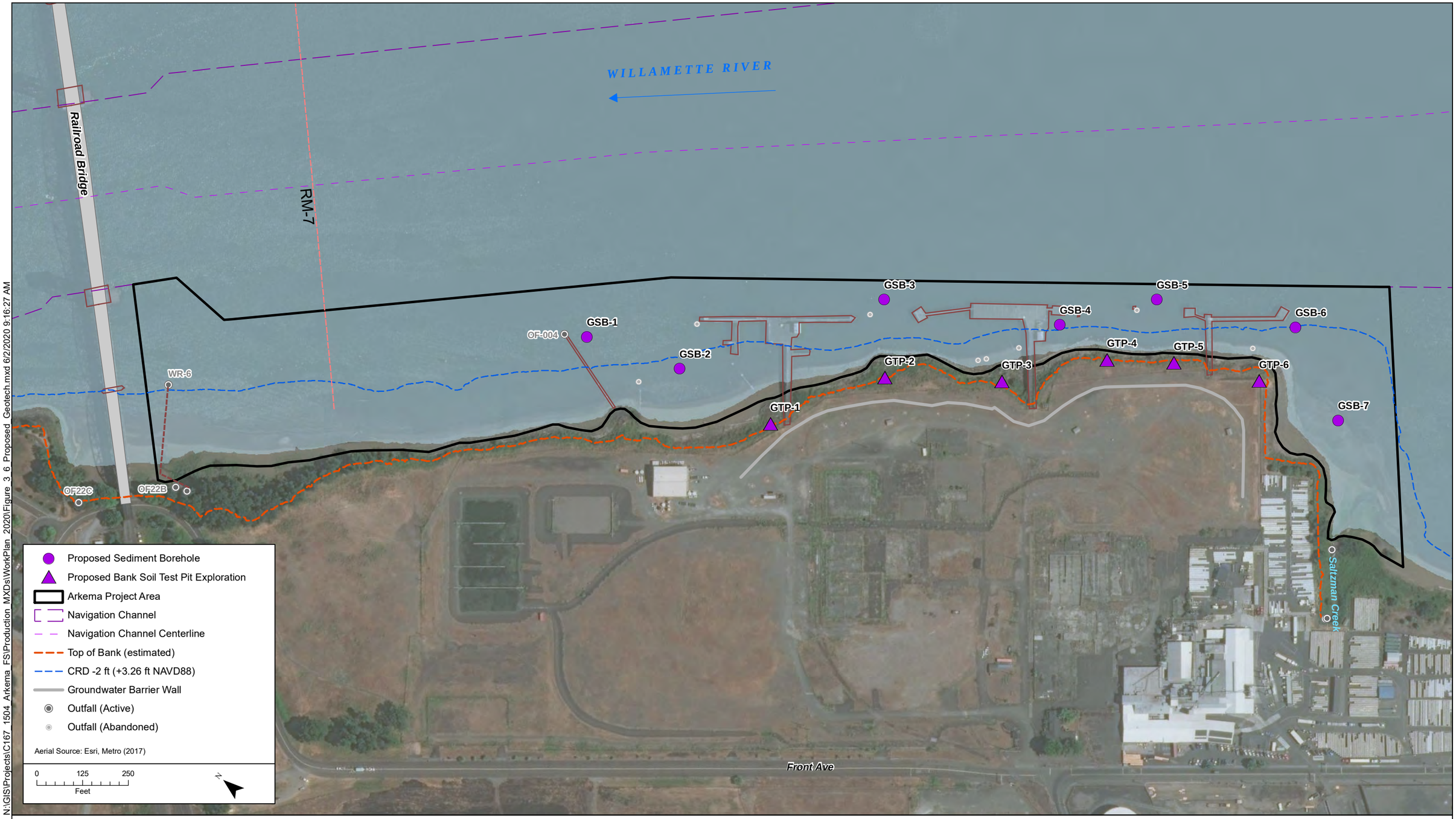
integral consulting inc.

Map Features

- River Miles
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Bridges
- Outfall (Active)
- Outfall (Abandoned)

DRAFT

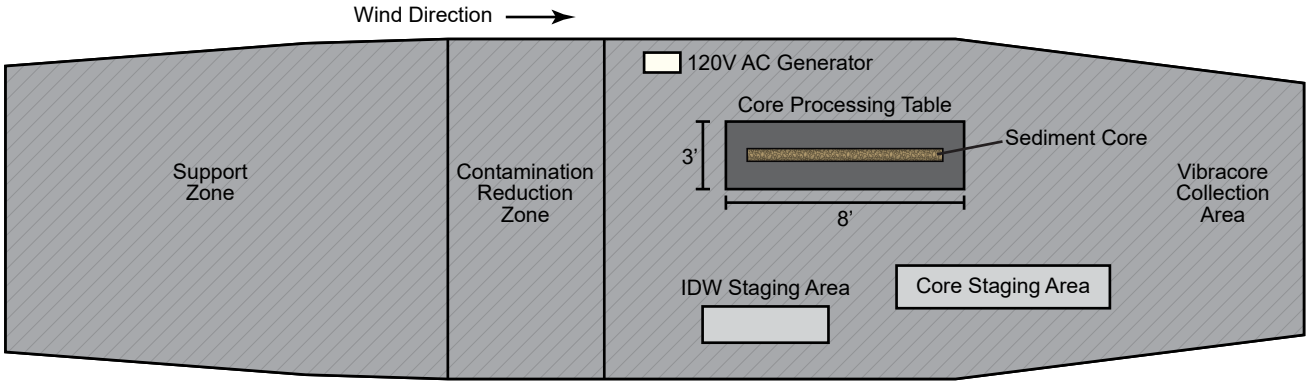
Figure A-4.
Proposed Porewater Sampling Locations
Arkema Project Area Pre-design Investigation Work Plan



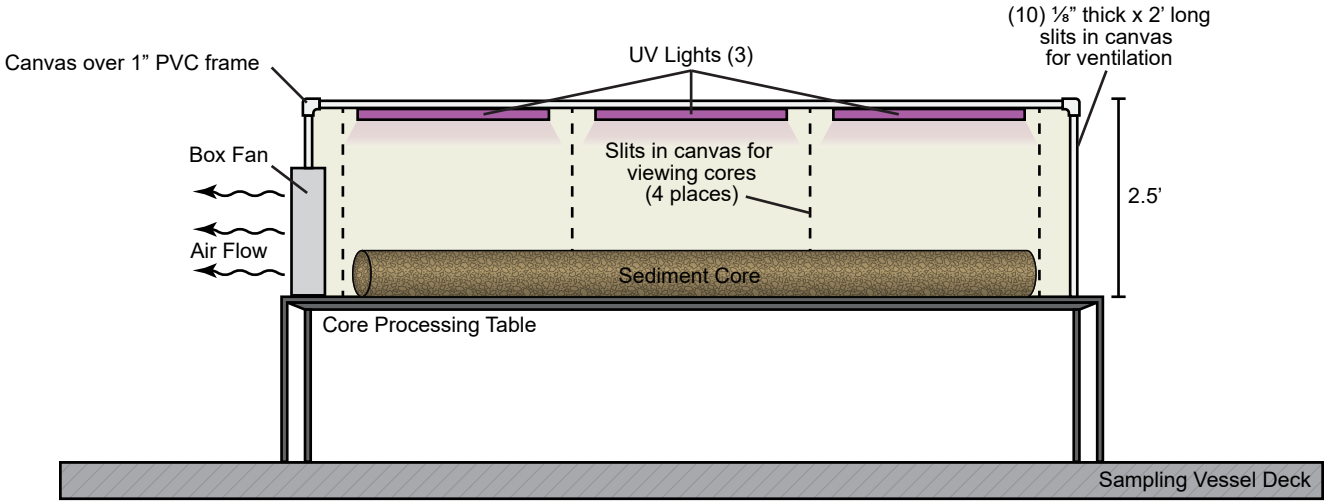
integral consulting inc.

DRAFT

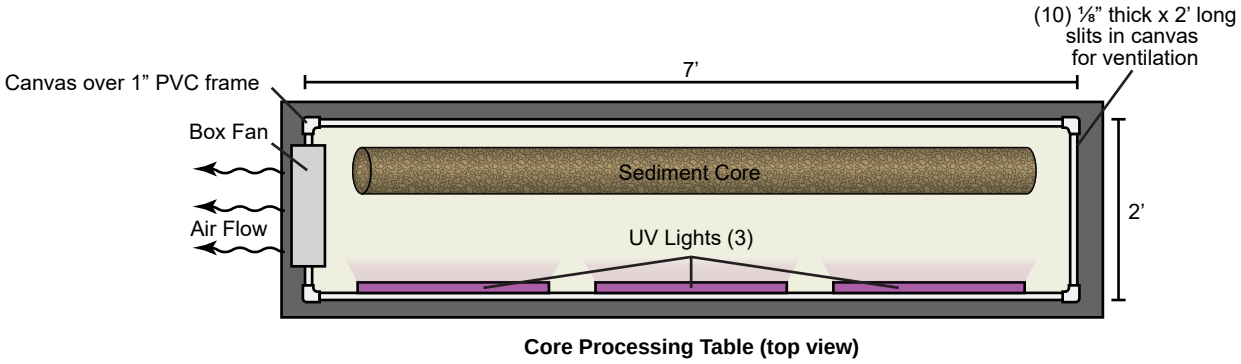
Figure A-5.
Proposed Sediment and Riverbank Soil Geotechnical Sample Locations
Arkema Project Area Pre-design Investigation Work Plan



Conceptual Sampling Vessel Layout (top view)



Core Processing Table (elevation view)



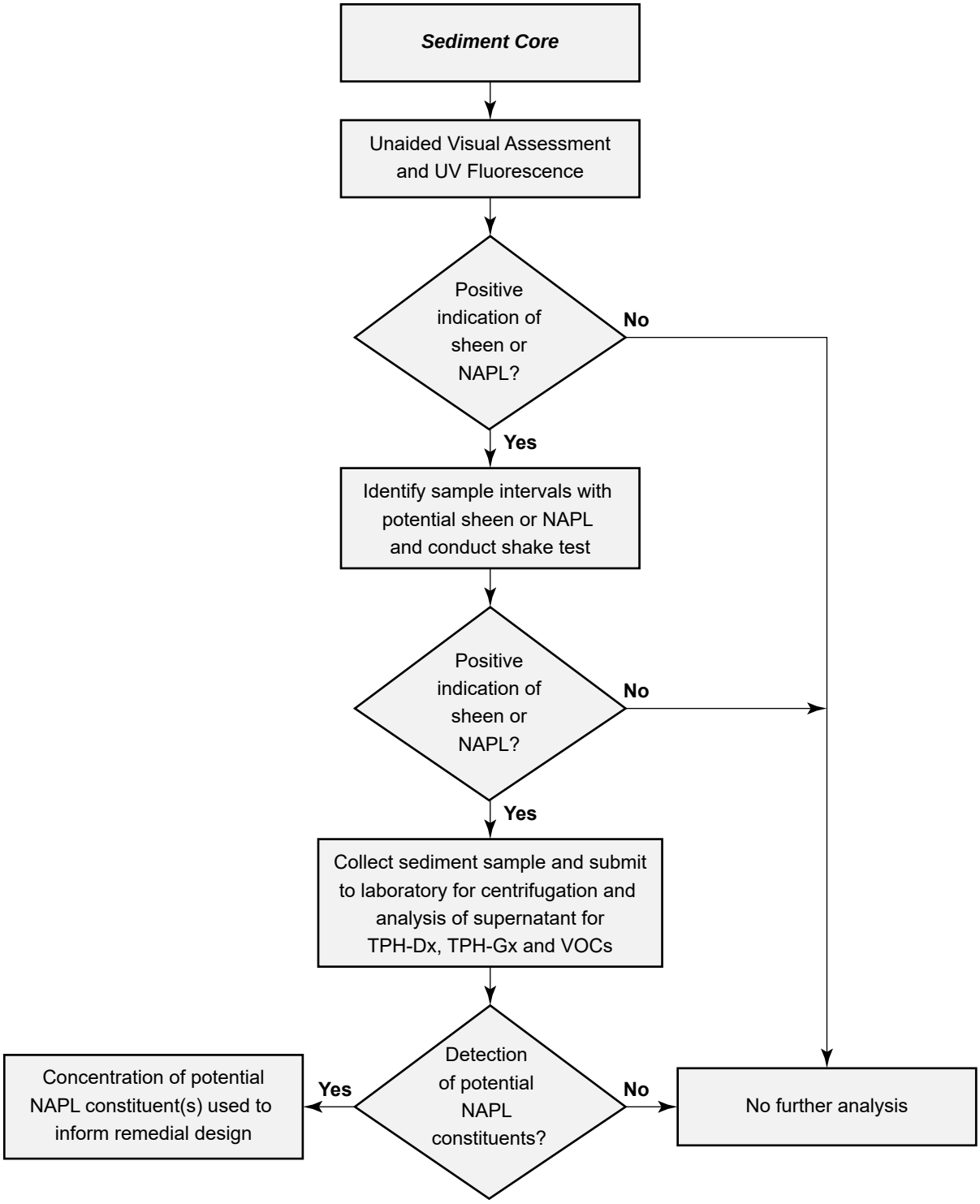
Core Processing Table (top view)

Note: Not to scale

integral consulting inc.

DRAFT

Figure A-6.
Conceptual Sampling Vessel Layout and
Core Processing Table
Arkema Project Area Pre-design Investigation Work Plan



integral consulting inc.

DRAFT

Figure A-7.
Evaluation of Potential Subsurface NAPL
Arkema Project Area Pre-design Investigation Work Plan

Tables

Table A-1. Subsurface Sediment Sample Location Coordinates

		Oregon State Plane (intl feet)		WGS84	
Station ID	Sample Type	x	y	Longitude	Latitude
SC-1	Vibracore chemistry (Arkema Project Area)	7626637.63	704126.14	-122.747693	45.576070
SC-2	Vibracore chemistry (Arkema Project Area)	7626625.30	703985.25	-122.747726	45.575683
SC-3	Vibracore chemistry (Arkema Project Area)	7626395.49	703792.42	-122.748602	45.575137
SC-4	Vibracore chemistry (Arkema Project Area)	7626357.31	703760.38	-122.748748	45.575046
SC-5	Vibracore chemistry (Arkema Project Area)	7626730.56	703975.04	-122.747314	45.575663
SC-6	Vibracore chemistry (Arkema Project Area)	7626536.37	703780.09	-122.748051	45.575114
SC-7	Vibracore chemistry (Arkema Project Area)	7626753.86	703832.04	-122.747208	45.575273
SC-8	Vibracore chemistry (Arkema Project Area)	7626677.25	703767.77	-122.747500	45.575091
SC-9	Vibracore chemistry (Arkema Project Area)	7626882.42	703678.83	-122.746689	45.574862
SC-10	Vibracore chemistry (Arkema Project Area)	7626805.81	703614.56	-122.746981	45.574680
SC-11	Vibracore chemistry (Arkema Project Area)	7626729.21	703550.28	-122.747273	45.574498
SC-12	Vibracore chemistry (Arkema Project Area)	7626716.88	703409.39	-122.747306	45.574111
SC-13	Vibracore chemistry (Arkema Project Area)	7627012.78	703586.77	-122.746170	45.574620
SC-14	Vibracore chemistry (Arkema Project Area)	7627009.60	703524.71	-122.746176	45.574450
SC-15	Vibracore chemistry (Arkema Project Area)	7626934.37	703461.35	-122.746463	45.574270
SC-16	Vibracore chemistry (Arkema Project Area)	7626857.76	703397.07	-122.746755	45.574088
SC-17	Vibracore chemistry (Arkema Project Area)	7626922.04	703320.46	-122.746496	45.573883
SC-18	Vibracore chemistry (Arkema Project Area)	7627127.20	703231.53	-122.745685	45.573655
SC-19	Vibracore chemistry (Arkema Project Area)	7627050.60	703167.26	-122.745977	45.573473
SC-20	Vibracore chemistry (Arkema Project Area)	7627306.39	703251.35	-122.744988	45.573723
SC-21	Vibracore chemistry (Arkema Project Area)	7627268.09	703219.21	-122.745134	45.573632
SC-22	Vibracore chemistry (Arkema Project Area)	7627191.70	703155.03	-122.745425	45.573450
SC-23	Vibracore chemistry (Arkema Project Area)	7627153.18	703122.79	-122.745572	45.573359
SC-24	Vibracore chemistry (Arkema Project Area)	7627408.97	703206.88	-122.744582	45.573609
SC-25	Vibracore chemistry (Arkema Project Area)	7627370.67	703174.74	-122.744728	45.573518
SC-26	Vibracore chemistry (Arkema Project Area)	7627332.37	703142.60	-122.744874	45.573427
SC-27	Vibracore chemistry (Arkema Project Area)	7627294.06	703110.46	-122.745020	45.573336
SC-28	Vibracore chemistry (Arkema Project Area)	7627217.46	703046.19	-122.745313	45.573153
SC-29	Vibracore chemistry (Arkema Project Area)	7627434.95	703098.14	-122.744469	45.573312
SC-30	Vibracore chemistry (Arkema Project Area)	7627396.65	703066.00	-122.744615	45.573221
SC-31	Vibracore chemistry (Arkema Project Area)	7627358.34	703033.86	-122.744761	45.573130
SC-32	Vibracore chemistry (Arkema Project Area)	7627320.04	703001.72	-122.744907	45.573039
SC-33	Vibracore chemistry (Arkema Project Area)	7627281.74	702969.58	-122.745053	45.572948
SC-34	Vibracore chemistry (Arkema Project Area)	7627537.53	703053.67	-122.744064	45.573198
SC-35	Vibracore chemistry (Arkema Project Area)	7627499.23	703021.53	-122.744210	45.573107
SC-36	Vibracore chemistry (Arkema Project Area)	7627460.92	702989.39	-122.744356	45.573016
SC-37	Vibracore chemistry (Arkema Project Area)	7627422.62	702957.26	-122.744502	45.572925
SC-38	Vibracore chemistry (Arkema Project Area)	7627384.32	702925.12	-122.744648	45.572834
SC-39	Vibracore chemistry (Arkema Project Area)	7627346.02	702892.98	-122.744794	45.572743
SC-40	Vibracore chemistry (Arkema Project Area)	7627307.72	702860.84	-122.744940	45.572652
SC-41	Vibracore chemistry (Arkema Project Area)	7627563.51	702944.93	-122.743951	45.572902
SC-42	Vibracore chemistry (Arkema Project Area)	7627525.20	702912.79	-122.744097	45.572811
SC-43	Vibracore chemistry (Arkema Project Area)	7627486.90	702880.65	-122.744243	45.572720
SC-44	Vibracore chemistry (Arkema Project Area)	7627448.60	702848.51	-122.744389	45.572629
SC-45	Vibracore chemistry (Arkema Project Area)	7627410.30	702816.37	-122.744535	45.572538
SC-46	Vibracore chemistry (Arkema Project Area)	7627371.99	702784.23	-122.744681	45.572447
SC-47	Vibracore chemistry (Arkema Project Area)	7627666.09	702900.46	-122.743545	45.572788
SC-48	Vibracore chemistry (Arkema Project Area)	7627627.78	702868.33	-122.743691	45.572697
SC-49	Vibracore chemistry (Arkema Project Area)	7627512.88	702771.91	-122.744130	45.572424
SC-50	Vibracore chemistry (Arkema Project Area)	7627474.57	702739.77	-122.744276	45.572333
SC-51	Vibracore chemistry (Arkema Project Area)	7627436.27	702707.63	-122.744422	45.572242
SC-52	Vibracore chemistry (Arkema Project Area)	7627692.06	702791.72	-122.743432	45.572492
SC-53	Vibracore chemistry (Arkema Project Area)	7627653.76	702759.58	-122.743578	45.572401

Table A-1. Subsurface Sediment Sample Location Coordinates

		Oregon State Plane (intl feet)		WGS84	
Station ID	Sample Type	x	y	Longitude	Latitude
SC-54	Vibracore chemistry (Arkema Project Area)	7627615.46	702727.44	-122.743724	45.572310
SC-55	Vibracore chemistry (Arkema Project Area)	7627577.16	702695.30	-122.743870	45.572219
SC-56	Vibracore chemistry (Arkema Project Area)	7627540.27	702664.35	-122.744011	45.572131
SC-57	Vibracore chemistry (Arkema Project Area)	7627794.64	702747.26	-122.743027	45.572378
SC-58	Vibracore chemistry (Arkema Project Area)	7627756.34	702715.12	-122.743173	45.572287
SC-59	Vibracore chemistry (Arkema Project Area)	7627641.43	702618.70	-122.743611	45.572014
SC-60	Vibracore chemistry (Arkema Project Area)	7627820.62	702638.51	-122.742914	45.572082
SC-61	Vibracore chemistry (Arkema Project Area)	7627782.32	702606.37	-122.743060	45.571991
SC-62	Vibracore chemistry (Arkema Project Area)	7627744.02	702574.23	-122.743206	45.571900
SC-63	Vibracore chemistry (Arkema Project Area)	7627705.71	702542.09	-122.743352	45.571809
SC-64	Vibracore chemistry (Arkema Project Area)	7627923.20	702594.05	-122.742509	45.571968
SC-65	Vibracore chemistry (Arkema Project Area)	7627884.90	702561.91	-122.742655	45.571877
SC-66	Vibracore chemistry (Arkema Project Area)	7627846.60	702529.77	-122.742801	45.571786
SC-67	Vibracore chemistry (Arkema Project Area)	7627808.80	702497.72	-122.742945	45.571695
SC-68	Vibracore chemistry (Arkema Project Area)	7627949.18	702485.30	-122.742395	45.571672
SC-69	Vibracore chemistry (Arkema Project Area)	7627910.88	702453.16	-122.742541	45.571580
SC-70	Vibracore chemistry (Arkema Project Area)	7627873.14	702419.81	-122.742685	45.571486
SC-71	Vibracore chemistry (Arkema Project Area)	7628051.76	702440.84	-122.741990	45.571557
SC-72	Vibracore chemistry (Arkema Project Area)	7627975.15	702376.56	-122.742282	45.571375
SC-73	Vibracore chemistry (Arkema Project Area)	7627936.85	702344.42	-122.742428	45.571284
SC-74	Vibracore chemistry (Arkema Project Area)	7628001.13	702267.82	-122.742169	45.571079
SC-75	Vibracore chemistry (Arkema Project Area)	7628180.32	702287.63	-122.741472	45.571147
SC-76	Vibracore chemistry (Arkema Project Area)	7628103.71	702223.35	-122.741764	45.570965
SC-77	Vibracore chemistry (Arkema Project Area)	7628065.41	702191.21	-122.741910	45.570874
SC-78	Vibracore chemistry (Arkema Project Area)	7628167.99	702146.75	-122.741505	45.570760
SC-79	Vibracore chemistry (Arkema Project Area)	7628129.69	702114.61	-122.741651	45.570669
SC-80	Vibracore chemistry (Arkema Project Area)	7628308.87	702134.42	-122.740953	45.570737
SC-81	Vibracore chemistry (Arkema Project Area)	7628232.27	702070.14	-122.741245	45.570555
SC-82	Vibracore chemistry (Arkema Project Area)	7628200.60	702043.57	-122.741366	45.570480
SC-83	Vibracore chemistry (Arkema Project Area)	7628334.85	702025.68	-122.740840	45.570441
SC-84	Vibracore chemistry (Arkema Project Area)	7628296.55	701993.54	-122.740986	45.570350
SC-85	Vibracore chemistry (Arkema Project Area)	7628258.25	701961.40	-122.741132	45.570259
SC-86	Vibracore chemistry (Arkema Project Area)	7628437.43	701981.21	-122.740435	45.570327
SC-87	Vibracore chemistry (Arkema Project Area)	7628360.83	701916.93	-122.740727	45.570145
SC-88	Vibracore chemistry (Arkema Project Area)	7628322.52	701884.79	-122.740873	45.570054
SC-89	Vibracore chemistry (Arkema Project Area)	7628605.62	701469.63	-122.739723	45.568937
SC-90	Vibracore chemistry (Arkema Project Area)	7628669.89	701393.03	-122.739464	45.568732
SC-91	Vibracore chemistry (Arkema Project Area)	7628388.13	701417.68	-122.740566	45.568778
SC-92	Vibracore chemistry (Arkema Project Area)	7628516.69	701264.47	-122.740048	45.568368
SC-93	Vibracore chemistry (Arkema Project Area)	7628375.80	701276.80	-122.740599	45.568391
SC-94	Vibracore chemistry (Arkema Project Area)	7628122.02	701118.78	-122.741573	45.567938
SN-1	Vibracore chemistry (Navigation Channel)	7627678.28	703043.37	-122.743514	45.573181
SN-2	Vibracore chemistry (Navigation Channel)	7627806.84	702890.16	-122.742995	45.572770
SN-3	Vibracore chemistry (Navigation Channel)	7628192.51	702430.53	-122.741440	45.571540
SN-4	Vibracore chemistry (Navigation Channel)	7628321.07	702277.32	-122.740921	45.571129
SS-1	Vibracore NAPL/Sheen (Arkema Project Area)	7627512.88	702771.91	-122.744130	45.572424
SS-2	Vibracore NAPL/Sheen (Arkema Project Area)	7627776.13	702535.97	-122.743076	45.571797
SS-3	Vibracore NAPL/Sheen (Arkema Project Area)	7627942.85	702415.05	-122.742412	45.571478
SS-4	Vibracore NAPL/Sheen (Arkema Project Area)	7627968.73	702306.43	-122.742300	45.571183
SS-5	Vibracore NAPL/Sheen (Arkema Project Area)	7627964.66	702237.21	-122.742308	45.570993
SS-6	Vibracore NAPL/Sheen (Arkema Project Area)	7628147.98	702326.16	-122.741602	45.571250
SS-7	Vibracore NAPL/Sheen (Arkema Project Area)	7628065.41	702191.21	-122.741910	45.570874
SS-8	Vibracore NAPL/Sheen (Arkema Project Area)	7628328.69	701955.23	-122.740857	45.570247

Table A-1. Subsurface Sediment Sample Location Coordinates

		Oregon State Plane (intl feet)		WGS84	
Station ID	Sample Type	x	y	Longitude	Latitude
SS-9	Vibracore NAPL/Sheen (Arkema Project Area)	7628489.38	701763.72	-122.740209	45.569734
SS-10	Vibracore NAPL/Sheen (Arkema Project Area)	7628541.34	701546.24	-122.739982	45.569142
SS-11	Vibracore NAPL/Sheen (Arkema Project Area)	7628452.41	701341.07	-122.740307	45.568573
SS-12	Vibracore NAPL/Sheen (Arkema Project Area)	7628299.20	701212.52	-122.740891	45.568209

Table A-2. Riverbank Soil Sample Location Coordinates

		Oregon State Plane (intl feet)		WGS84	
Station ID	Sample Type	x	y	Longitude	Latitude
RH-1	Riverbank Soil	7626391.36	703670.55	-122.748605	45.574802
RH-2	Riverbank Soil	7626465.65	703590.11	-122.748306	45.574587
RH-3	Riverbank Soil	7626780.49	703284.67	-122.747044	45.573774
RH-4	Riverbank Soil	7626768.41	703270.05	-122.747090	45.573733
RH-5	Riverbank Soil	7626804.73	703261.12	-122.746947	45.573711
RH-6	Riverbank Soil	7626791.19	703233.73	-122.746997	45.573635
RH-7	Riverbank Soil	7626829.77	703236.63	-122.746847	45.573646
RH-8	Riverbank Soil	7626818.07	703220.41	-122.746891	45.573601
RH-9	Riverbank Soil	7626854.75	703219.46	-122.746747	45.573601
RH-10	Riverbank Soil	7626843.42	703203.55	-122.746790	45.573556
RH-11	Riverbank Soil	7627173.66	702896.99	-122.745467	45.572741
RH-12	Riverbank Soil	7627210.45	702865.71	-122.745320	45.572658
RH-13	Riverbank Soil	7627340.54	702674.73	-122.744792	45.572144
RH-14	Riverbank Soil	7627325.34	702648.57	-122.744848	45.572072
RH-15	Riverbank Soil	7627407.60	702632.81	-122.744525	45.572035
RH-16	Riverbank Soil	7627393.13	702604.13	-122.744579	45.571955
RH-17	Riverbank Soil	7627620.60	702554.04	-122.743685	45.571835
RH-18	Riverbank Soil	7627611.82	702539.85	-122.743718	45.571795
RH-19	Riverbank Soil	7627656.26	702530.52	-122.743544	45.571773
RH-20	Riverbank Soil	7627648.57	702510.41	-122.743572	45.571717
RH-21	Riverbank Soil	7627855.52	702395.23	-122.742751	45.571417
RH-22	Riverbank Soil	7627845.69	702386.07	-122.742789	45.571392
RH-23	Riverbank Soil	7627891.01	702357.00	-122.742609	45.571315
RH-24	Riverbank Soil	7627878.47	702343.76	-122.742656	45.571278
RH-25	Riverbank Soil	7627959.69	702175.14	-122.742321	45.570822
RH-26	Riverbank Soil	7627987.64	702148.34	-122.742209	45.570751
RH-27	Riverbank Soil	7627968.66	702134.91	-122.742281	45.570712
RH-28	Riverbank Soil	7628082.71	702102.79	-122.741833	45.570633
RH-29	Riverbank Soil	7628069.23	702078.75	-122.741883	45.570566
RH-30	Riverbank Soil	7628173.60	702054.65	-122.741473	45.570508
RH-31	Riverbank Soil	7628163.95	702044.74	-122.741509	45.570480
RH-32	Riverbank Soil	7628280.68	701915.93	-122.741040	45.570136
RH-33	Riverbank Soil	7628262.27	701904.80	-122.741110	45.570104
RH-34	Riverbank Soil	7628346.25	701839.95	-122.740775	45.569932
RH-35	Riverbank Soil	7628331.34	701827.90	-122.740832	45.569898
RH-36	Riverbank Soil	7628442.91	701644.12	-122.740377	45.569403
RH-37	Riverbank Soil	7628465.21	701633.84	-122.740289	45.569376
RH-38	Riverbank Soil	7628415.33	701604.54	-122.740480	45.569292
RH-39	Riverbank Soil	7628435.23	701586.93	-122.740401	45.569246

Table A-3. Groundwater Pathway Assessment Sample Location Coordinates

		Oregon State Plane (intl feet)		WGS84	
Station ID	Sample Type	x	y	Longitude	Latitude
PZ-1	Groundwater Elevation	7627501.13	702654.97	-122.744163	45.572102
PZ-2	Groundwater Elevation	7627669.72	702548.44	-122.743493	45.571823
PZ-3	Groundwater Elevation	7627869.64	702403.38	-122.742697	45.571441
PZ-4	Groundwater Elevation	7627939.70	702252.98	-122.742407	45.571034
SMS-1	Porewater	7627812.92	702708.34	-122.742952	45.572272
SMS-2	Porewater	7627705.33	702611.11	-122.743361	45.571998
SMS-3	Porewater	7627909.25	702590.13	-122.742563	45.571956
SMS-4	Porewater	7627813.25	702507.86	-122.742929	45.571723
SMS-5	Porewater	7628004.65	702477.37	-122.742178	45.571654
SMS-6	Porewater	7627909.42	702392.59	-122.742541	45.571414
SMS-7	Porewater	7628083.43	702377.60	-122.741860	45.571386
SMS-8	Porewater	7627987.43	702295.34	-122.742226	45.571153

Table A-4. Porewater Sample Location Coordinates

		Oregon State Plane (intl feet)		WGS84	
Station ID	Sample Type	x	y	Longitude	Latitude
PW-1	Porewater	7627257.79	703068.96	-122.745143	45.573213
PW-2	Riverbank Soil	7627922.65	702425.79	-122.742478	45.571501
PW-3	Riverbank Soil	7628228.11	702110.07	-122.741252	45.570658

Table A-5. Sediment and Riverbank Geotechnical Sample Location Coordinates

		Oregon State Plane (intl feet)		WGS84	
Station ID	Sample Type	x	y	Longitude	Latitude
GSB-1	Sediment	7627330.68	703113.39	-122.744878	45.573346
GSB-2	Sediment	7627426.92	702863.91	-122.744475	45.572670
GSB-3	Sediment	7627931.34	702556.59	-122.742473	45.571866
GSB-4	Sediment	7628186.75	702144.38	-122.741431	45.570755
GSB-5	Sediment	7628410.24	701985.85	-122.740541	45.570337
GSB-6	Sediment	7628595.75	701646.17	-122.739781	45.569420
GSB-7	Sediment	7628476.09	701393.44	-122.740220	45.568718
GTP-1	Soil	7627471.44	702576.83	-122.744270	45.571886
GTP-2	Soil	7627768.79	702418.51	-122.743092	45.571475
GTP-3	Soil	7627966.62	702166.40	-122.742293	45.570799
GTP-4	Soil	7628196.65	701984.15	-122.741375	45.570316
GTP-5	Soil	7628307.90	701839.32	-122.740925	45.569928
GTP-6	Soil	7628419.88	701628.27	-122.740465	45.569358

Table A-6. Summary of Samples and Analyses

Analysis	Number of Samples			
	Field Samples	Field Duplicates[a]	Equipment Rinse Blanks	Total
Sediments				
Surface Sediment (if needed for Phase 2)				
PCB Congeners	TBD			
Organochlorine pesticides (DDx only)[b]	TBD			
PCDD/Fs	TBD			
PAHs	TBD			
Subsurface Sediment				
Organochlorine pesticides (DDx only)[b]	392	20	1	413
PCDD/Fs	392	20	1	413
PCB Congeners	392	20	1	413
PAHs	40	2	1	43
Chlorobenzene	300	15	1	316
NAPL Assessment				
VOCs	96	5	1	102
NWTPH-Dx	96	5	1	102
NWTPH-Gx	96	5	1	102
Geotechnical Parameters				
Water content, unconsolidated undrained triaxial shear strength, Atterberg limits, consolidated undrained triaxial shear strength, unit weight, particle size by sieve, particle size by hydrometer, specific gravity by pycnometer, DRET, and EET	TBD	TBD	TBD	TBD
Sediment Stability (if needed for Phase 2)				
Cesium 137	TBD			
Lead 210	TBD			
Additional Analytes				
Organochlorine pesticides (full list)	15	1	1	17
Chlorinated herbicides	15	1	1	17
TAL Metals	15	1	1	17
VOCs	15	1	1	17
Soils				
Asbestos	80	4	NA	84
PCB Congeners	148	8	1	157
Organochlorine pesticides (DDx only)[b]	148	8	1	157
PCDD/Fs	148	8	1	157
Water content, unconsolidated undrained triaxial shear strength, Atterberg limits, consolidated undrained triaxial shear strength, unit weight, particle size by sieve, particle size by hydrometer, specific gravity by pycnometer, DRET, and EET	TBD	TBD	TBD	TBD
Groundwater (Monitoring Wells and Piezometers)				
VOCs	13	1	1	15
Organochlorine pesticides (DDx only)[b]	13	1	1	15
Transition Zone Water (UltraSeep Meter)				
Organochlorine pesticides (DDx only)[b]	8	1	1	10
VOCs	8	1	1	10

Table A-6. Summary of Samples and Analyses

Analysis	Number of Samples			
	Field Samples	Field Duplicates[a]	Equipment Rinse Blanks	Total
Sediment Porewater (Trident Probe)				
DOC	9	1	1	11
VOCs	9	1	1	11

Notes:

Field duplicate and blank samples will be analyzed at the same laboratory as the primary field samples.

DOC = dissolved organic carbon
DRET = dredge elutriate test
EET = effluent elutriate test
NA = not applicable
PCB = polychlorinated biphenyl
PCDD/F = polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran
TBD = to be determined
TOC = total organic carbon
VOC = volatile organic compound

[a] Field duplicates collected at a frequency of 1 in 20 natural samples. One equipment blank will be collected for each type of sampling equipment.

[b] DDx only = 2,4'- and 4,4'-isomers of DDT, DDD, and DDE.

Table A-7. Sample Containers and Preservation Requirements

Analysis	Laboratory	Container Type	Container Size	Preservation	Holding Time
Sediments and Soils					
Metals	Eurofins/TestAmerica	WMG	8 oz.	None	6 months
Mercury	Eurofins/TestAmerica	WMG	8 oz.	None	28 days
Radiochemistry	Teledyne	WMG	16 oz.	≤6°C	6 months
PCB Congeners	Eurofins/TestAmerica	WMG	8 oz.	<-10°C in the dark	1 year
Organochlorine pesticides	Eurofins/TestAmerica	WMG	8 oz.	≤6°C	14 days/40 days [a]
Chlorinated herbicides	Eurofins/TestAmerica	WMG	8 oz.	≤6°C	14 days/40 days [a]
PAHs	Eurofins/TestAmerica	WMG	8 oz.	≤6°C	14 days/40 days [a]
Chlorinated dioxins/furans	Eurofins/TestAmerica	WMG	8 oz.	<-10°C in the dark	1 year
NWTPH-Dx	Eurofins/TestAmerica	WMG	8 oz.	≤6°C	14 days
NWTPH-Gx	Eurofins/TestAmerica	WMG with Septa	2 oz.	No headspace, ≤6°C Do not freeze	14 days
Volatile organic compounds	Eurofins/TestAmerica	Terra Core™ kit	--	≤6°C Do not freeze	14 days
Chlorobenzene	Eurofins/TestAmerica	Terra CoreTM kit	--	≤6°C Do not freeze	14 days
Asbestos	Eurofins/TestAmerica	WMG	8 oz.	None	None
Groundwater					
Organochlorine pesticides	Eurofins/TestAmerica	AG	250 mL	≤6°C	7 days/40 days[b]
Volatile organic compounds	Eurofins/TestAmerica	AG	3 x 40 ml w/septum	No headspace; HCl to pH < 2; ≤6°C	14 days
Sediment Porewater					
Dissolved organic carbon[c]	Eurofins/TestAmerica	AG	250 ml	≤6°C	28 days
Volatile organic compounds	Eurofins/TestAmerica	AG	3 x 40 ml w/septum	No headspace; HCl to pH < 2; ≤6°C	14 days

Table A-7. Sample Containers and Preservation Requirements

Analysis	Laboratory	Container Type	Container Size	Preservation	Holding Time
Field Blanks					
Volatile organic compounds	Eurofins/TestAmerica	AG	3 x 40 mL w/septum	No headspace; HCl to pH < 2; ≤6°C	14 days
NWTPH-Gx	Eurofins/TestAmerica	AG	3 x 40 mL w/septum	No headspace; HCl to pH < 2; ≤6°C	14 days
Dissolved organic carbon	Eurofins/TestAmerica	AG	250 mL	≤6°C; H_2SO_4 to pH < 2	28 days
Chloride	Eurofins/TestAmerica	HDPE	250 mL	None	28 days
PAHs	Eurofins/TestAmerica	AG	250 mL	≤6°C	7 days/40 days[b]
Metals	Eurofins/TestAmerica	HDPE	250 mL	HNO_3 to pH < 2	6 months
PCB Congeners	Eurofins/TestAmerica	AG	1 L	≤6°C	1 year
Organochlorine pesticides	Eurofins/TestAmerica	AG	250 mL	≤6°C	7 days/40 days[b]
Chlorinated herbicides	Eurofins/TestAmerica	AG	1 L	≤6°C	7 days/40 days[b]
Chlorinated dioxins/furans	Eurofins/TestAmerica	AG	1 L	0-4°C in the dark	1 year
Radiochemistry	Teledyne	AG	2 x 1 L	≤6°C: HNO3 to pH < 2	6 months
NWTPH-Dx	Eurofins/TestAmerica	AG	250 mL	HCl to pH < 2; ≤6°C	7 days

Notes:

-- = not applicable
AG = amber glass
HCl = hydrochloric acid
HDPE = high density polyethylene
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
TBD = to be determined
VOA = volatile organic analysis
WMG = wide mouth glass

[a] Holding time is 14 days to extraction and extracts must be analyzed within 40 days from extraction.
[b] The holding time is 7 days from collection to extraction and 40 days from extraction to analysis.
[c] Sample will be filtered and preserved at the laboratory.

Table A-8. Sample Size, Containers, and Holding Times for Geotechnical Sample Analysis

Analysis	Matrix	Method	Container Type and Size	Transport and Storage	Holding Time
Water Content	Soil or Sediment	ASTM D-2216	Jar or sealed bag; 50 g	Watertight container. Room temperature.	Not specified.
Unconsolidated, Undrained Triaxial Shear Strength		ASTM D-2850	Intact tube; Cylinder 33 mm dia. by 66 mm long, minimum	ASTM D-4220 Method C - Intact core Room temperature.	
Atterberg Limits		ASTM D-4318	Jar or sealed bag; 200 g for particles < 0.43 mm.	Watertight container. Room temperature.	
Consolidated, Undrained Triaxial Shear Strength		ASTM D-4767	Intact tube; Three cylinders 33 mm dia. by 66 mm long, minimum	ASTM D-4220 Method C - Intact core Room temperature.	
Unit Weight		ASTM D-7263	Intact tube; Cylinder 30 mm dia. for particles < 3 mm.	ASTM D-4220 Method C - Intact core Room temperature.	
Particle Size by Sieve		ASTM D-6913	500 g for particles < 4.75 mm	Watertight container. Room temp.	
Particle Size by Hydrometer		ASTM D-7928	500 g	Watertight container. Room temperature.	
Specific Gravity by Water Pycnometer		ASTM D 854-14	100 g	Watertight container. Room temperature.	
Dredge Elutriate Test (DRET)	Sediment/Surface Water	USACE	Bulk samples 4 L sediment 12 L surface water	NA	
Effluent Elutriate Test (EET)		USACE	Bulk samples 4 L sediment 12 L surface water	NA	

Notes:

ASTM = ASTM International

USACE = U.S. Army Corps of Engineers

Attachment 1

Standard Operating Procedures

STANDARD OPERATING PROCEDURE (SOP) AP-01

SAMPLE PACKAGING AND SHIPPING

SCOPE AND APPLICATION

This SOP describes specific requirements for sample packaging and shipping to ensure the proper transfer and documentation of environmental samples collected during field operations. Procedures for the careful and consistent transfer of samples from the field to the laboratory are outlined herein. This SOP also presents the method to be used when packing samples that will either be hand delivered or shipped by commercial carrier to the laboratory.

EQUIPMENT AND SUPPLIES REQUIRED

Make sure that you have the equipment and supplies necessary to properly pack and ship environmental samples, including the following:

- Project-specific sampling and analysis plan (SAP)
- Project-specific field logbook
- Sealable airtight bags in assorted sizes (e.g., Ziploc®)
- Wet ice in doubled, sealed bags; frozen Blue Ice®; or dry ice
- Cooler(s)
- Bubble wrap
- Fiber-reinforced packing tape, clear plastic packing tape, and duct tape
- Scissors or knife
- Chain-of-custody (COC) forms
- COC seals
- Large plastic garbage bags (preferably 3 mil [0.003 in.] thick)
- Paper towels
- "Fragile," "This End Up," or "Handle With Care" labels
- Mailing labels
- Air bills for overnight shipment

PROCEDURE

Customize the logistics for sample packaging and shipping to each study. If necessary, transfer samples from the field to a local storage facility where they can be frozen or refrigerated. Depending on the logistics of the operation, field personnel may transport samples to the laboratory or use a commercial courier or shipping service. In the latter case, Integral field personnel must be aware of any potentially limiting factors to timely shipping, such as availability of overnight service and weekend deliveries to specific areas, and shipping regulations regarding "restricted articles" (e.g., dry ice, formalin) prior to shipping the samples.

SAMPLE PREPARATION

Take the following steps to ensure the proper transfer of samples from the field to the laboratories:

At the sample collection site:

1. Document all samples using the proper logbooks or field forms (see SOP AP-02), required sample container identification (i.e., sample labels with tag numbers), and COC form (example provided in SOP AP-03). Fill out the COC form as described in SOP AP-03, and use the sample labeling techniques provided in SOP AP-04.
2. Make all applicable laboratory quality control sample designations on the COC forms. Clearly identify samples that will be archived for future possible analysis. Label these samples as follows: "Do Not Analyze: Hold and archive for possible future analysis." Some laboratories interpret "archive" to mean that they should continue holding the residual sample after analysis.
3. Notify the laboratory contact and the Integral project quality assurance/quality control (QA/QC) coordinator that samples will be shipped and the estimated arrival time. Send copies of all COC forms to Integral's project QA/QC coordinator or project manager, as appropriate.
4. Keep the samples in the possession of the sampling personnel at all times. Lock and secure any temporary onsite sample storage areas to maintain sample integrity and COC requirements.
5. Clean the outside of all dirty sample containers to remove any residual material that may lead to cross-contamination.
6. Complete the COC form as described in SOP AP-03, and retain the back (pink) copy for project records prior to sealing the cooler. Check sample containers against the COC form to ensure all the samples that were collected are in the cooler.

7. Store each sample container in a sealed plastic bag that allows the sample label (example provided in SOP AP-03) to be read. Before sealing the bags, ensure that volatile organic analyte (VOA) vials are encased in a foam sleeve or in bubble wrap.
8. If the samples require storage at a specific temperature, place enough ice in the sample cooler to maintain the temperature (e.g., 4°C) throughout the sampling day.

At the sample processing area (immediately after sample collection) take the following steps:

1. If the samples require a specific storage temperature, then cool the samples and maintain the temperature prior to shipping. For example, place enough ice in each sample cooler to maintain the temperature at 4°C until processing begins at the testing laboratory.
2. Be aware of holding time requirements for project-specific analytes and arrange the sample shipping schedule accordingly.
3. Place samples in secure storage (i.e., locked room or vehicle) or keep them in the possession of Integral sampling personnel before shipment. Lock and secure any sample storage areas to maintain sample integrity and COC requirements.
4. Store samples in the dark (e.g., keep coolers shut).

At the sample processing area (just prior to shipping), do the following:

1. Check sample containers against the COC form to account for all samples intended for shipment.
2. Choose cooler(s) of appropriate size and make sure they are clean of gross contamination inside and out. If the cooler has a drain, close the drain and secure it with duct tape.
3. Line the cooler with bubble wrap and place a large plastic bag (preferably with a thickness of 3 mil), open, inside the cooler.
4. Individually wrap each glass container (which was sealed in a plastic bag at the collection site) in bubble wrap and secure with tape or a rubber band. Place the wrapped samples in the large plastic bag in the cooler, leaving room for ice to keep the samples cold (i.e., 4°C).
5. If temperature blanks have been provided by the testing laboratory, place one temperature blank in each sample cooler.
6. If the samples require a specific storage temperature, add enough wet ice or Blue Ice® to maintain that temperature during overnight shipping (i.e., 4°C). Always overestimate the amount of ice that will be required. Keep ice in a sealed plastic bag, which is placed in a second sealed plastic bag to prevent leakage. Avoid separating the samples from the ice with excess bubble wrap because it may insulate the samples from the ice. After adding all samples and ice to the cooler, use bubble wrap (or other

available clean packing material) to fill any empty space and prevent the samples from shifting during transport.

7. If possible, consolidate all VOA samples in a single cooler and ship them with (a) trip blank(s) if the project-specific QA project plan calls for them.
8. Sign, date, and include any tracking numbers provided by the shipper on the COC form. Remove the back (pink) copy of the original COC form and retain this copy for the project records.
9. Seal the rest of the signed COC form in a bag and tape the bag to the inside of the cooler lid. Each cooler should contain an individual COC form for the samples contained inside it. If time is short and it becomes necessary to combine all the samples onto a single set of COC forms and ship multiple coolers together, then indicate on the outside of the appropriate cooler, "Chain-of-Custody Inside."
10. After the cooler is sufficiently packed to prevent shifting of the containers, close the lid and seal it with fiber-reinforced packing tape. Tape the cooler around the opening, joining the lid to the bottom, and around the circumference of the cooler at both hinges.
11. As security against unauthorized handling of the samples, apply two COC seals across the opening of the cooler lid (provided with example field forms). Place one seal on the front right portion of the cooler and one on the back left. Be sure the seals are properly affixed to the cooler to prevent removal during shipment. Additional tape across the seal may be necessary if the outside of the cooler is wet.

SAMPLE SHIPPING

Hand Delivery to the Testing Laboratory

1. Notify the laboratory contact and the Integral project QA/QC coordinator that samples will be delivered to the laboratory and the estimated arrival time.
2. When hand-delivering environmental samples, make sure the testing laboratory receives them on the same day that they were packed in the coolers.
3. Fax or scan and e-mail copies of all COC forms to the Integral project QA/QC coordinator. Note: It may be necessary to photocopy the COC form on a slightly darker setting so the form is readable after it has been faxed. Never leave the original COC form in the custody of non-Integral staff.

Shipped by Commercial Carrier to the Laboratory

1. Apply a mailing label to the cooler with destination and return addresses, and add other appropriate stickers, such as "This End Up," "Fragile," and "Handle With Care." If the shipment contains multiple coolers, indicate on the mailing label the number of coolers that the testing laboratory should expect to receive (e.g., 1 of 2; 2 of 2). Place clear tape over the mailing label to firmly affix it to the cooler and to protect it from the weather. This is a secondary label in case the air bill is lost during shipment.
2. Fill out the air bill and fasten it to the handle tags provided by the shipper (or the top of the cooler if handle tags are not available).
3. If samples must be frozen (–20°C) during shipping, make sure that dry ice has been placed in the sample cooler. Be aware of any additional shipping, handling, and special labeling requirements that the shipper may require.
4. Make sure that benthic infauna samples have been preserved with formalin in the field prior to shipping. Be aware of any additional shipping, handling, and special labeling requirements that the shipper may require for these samples.
5. Notify the laboratory contact and the Integral project QA/QC coordinator that samples will be shipped and the estimated arrival date and time. If environmental samples must be shipped at 4°C or –20°C, choose overnight shipping for delivery next morning. Fax or scan and e-mail copies of all COC forms to the Integral project QA/QC coordinator. Note: It may be necessary to photocopy the COC form on a slightly darker setting so the form is readable after faxing. Never leave the original COC form in the custody of non-Integral staff.

STANDARD OPERATING PROCEDURE (SOP) AP-02

FIELD DOCUMENTATION

SCOPE AND APPLICATION

This SOP describes the Integral procedure for accurate record-keeping in the field for the purposes of ensuring that samples can be traced from collection to final disposition.

Document all information relevant to field operations properly to ensure that activities are accounted for in written records to the extent that someone not present at the site could reconstruct the activity without relying on the memory of the field crew. Several types of field documents are used for this purpose and should be consistently used by field personnel. Field documentation should include only a factual description of site-related activities and observations. Field personnel should not include superfluous comments or speculation regarding the field activities or observations.

FIELD LOGBOOKS

During field sampling events, field logbooks must be used to record all daily activities. The purpose of the field logbook is to document events and record data measured in the field to the extent that someone not present at the site could reconstruct the activity without relying on the memory of the field crew. The project manager (or designee) should issue a field logbook to the appropriate site personnel for the direction of onsite activities (e.g., reconnaissance survey team leader, sampling team leader). It is this designee's responsibility to maintain the site logbook while it is in his or her possession and return it to the project manager or turn it over to another field team.

Make entries in the field logbook as follows:

1. Document all daily field activities in indelible ink in the logbook and make no erasures. Make corrections with a single line-out deletion, followed by the author's initials and the date. The author must initial and date each page of the field logbook. The author must sign and date the last page at the end of each day, and draw a line through any blank space remaining on the page below the last entry.

2. Write the project name, dates of the field work, site name and location (city and state), and Integral job number on the cover of the field logbook. If more than one logbook is used during a single sampling event, then annotate the upper right-hand corner of the logbook (e.g., Volume 1 of 2, 2 of 2) to indicate the number of logbooks used during the field event. Secure all field logbooks when not in use in the field. The following is a list of the types of information that is appropriate for entry in the field notebook:
   - Project start date and end date
   - Date and time of entry (24-hour clock)
   - Time and duration of daily sampling activities
   - Weather conditions at the beginning of the field work and any changes that occur throughout the day, including the approximate time of the change (e.g., wind speed and direction, rain, thunder, wave action, current, tide, vessel traffic, air and water temperature, thickness of ice if present)
   - Name and affiliation of person making entries and other field personnel and their duties, including what times they are present
   - The location and description of the work area, including sketches, map references, and photograph log, if appropriate
   - Level of personal protection being used
   - Onsite visitors (names and affiliations), if any, including what times they are present
   - The name, agency, and telephone number of any field contacts
   - Notation of the coordinate system used to determine the station location
   - The sample identifier and analysis code for each sample to be submitted for laboratory analysis, if not included on separate field data sheets
   - All field measurements made (or reference to specific field data sheets used for this purpose), including the time of collection and the date of calibration, if appropriate
   - The sampling location name, date, gear, water depth (if applicable), and sampling location coordinates, if not included on separate field data sheets
   - For aquatic sampling, the type of vessel used (e.g., size, power, type of engine)
   - Specific information on each type of sampling activity
   - The sample type (e.g., groundwater, soil, surface sediment), sample number, sample tag number, and any preservatives used, if not included on separate field data sheets
   - Sample storage methods

- Cross-references of numbers for duplicate samples
- A description of the sample (source and appearance, such as soil or sediment type, color, texture, consistency, presence of biota or debris, presence of oily sheen, changes in sample characteristics with depth, presence/location/thickness of the redox potential discontinuity [RPD] layer, and odor) and penetration depth, if not included on separate field data sheets
- Estimate of length and appearance of recovered cores, if not included on separate field data sheets
- Photographs (uniquely identified) taken at the sampling location, if any
- Details of the work performed
- Variations, if any, from the project-specific sampling and analysis plan (SAP) or standard operating protocols and reasons for deviation
- Details pertaining to unusual events that might have occurred during sample collection (e.g., possible sources of sample contamination, equipment failure, unusual appearance of sample integrity, control of vertical descent of the sampling equipment)
- References to other logbooks or field forms used to record information (e.g., field data sheets, health and safety log)
- Any field results not appearing on the field data sheets (if used), including station identification and location, date, and time of measurement
- Sample shipment information (e.g., shipping manifests, chain-of-custody (COC) form numbers, carrier, air bill numbers, time addresses)
- A record of quantity of investigation-derived wastes (if any) and storage and handling procedures.

3. During the field day, as listed above, record in the logbook a summary of all site activities. Provide a date and time for each entry. The information need not duplicate anything recorded in other field logbooks or field forms (e.g., site health and safety officer's logbook, calibration logbook, field data sheets), but should summarize the contents of the other logbooks and refer to the pages in these logbooks for detailed information.
4. If measurements are made at any location, record the measurements and equipment used, or refer to the logbook and page number(s) or field forms on which they are recorded. All maintenance and calibration records for equipment should be traceable through field records to the person using the instrument and to the specific piece of instrumentation itself.

5. Upon completion of the field sampling event, the sampling team leader will be responsible for submitting all field logbooks to be copied. A discussion of copy distribution is provided below.

FIELD DATA FORMS

Occasionally, additional field data forms are generated during a field sampling event (e.g., groundwater monitoring form, sediment core profile form, water quality measurement form) to record the relevant sample information collected. For instructions regarding the proper identification of field data forms, sampling personnel should consult the project-specific SAP.

Upon completion of the field sampling event, the sampling team leader will be responsible for submitting all field data forms to be copied. A discussion of copy distribution is provided below.

PHOTOGRAPHS

In certain cases, photographs (print or digital) of sampling stations may be taken using a camera-lens system with a perspective similar to the naked eye. Ensure that photographs include a measured scale in the image, when practical. If you take photographs of sample characteristics and routine sampling activities, avoid using telephoto or wide-angle shots, because they cannot be used in enforcement proceedings. Record the following items in the field logbook for each photograph taken:

1. The photographer's name or initials, the date, the time of the photograph, and the general direction faced (orientation)
2. A brief description of the subject and the field work shown in the picture
3. For print photographs, the sequential number of the photograph and the roll number on which it is contained
4. For digital photographs, the sequential number of the photograph, the file name, the file location, and back-up disk number (if applicable).

Upon completion of the field sampling event, the sampling team leader is responsible for submitting all photographic materials to be developed (prints) or copied (disks). Place the prints or disks and associated negatives in the project files (at the Integral project manager's location). Make photocopies of photo logs and any supporting documentation from the field logbooks, and place them in the project files with the prints or disks.

EQUIPMENT CALIBRATION RECORDS

Record in the field logbook all equipment calibration records, including instrument type and serial number, calibration supplies used, calibration methods and calibration results, date, time, and personnel performing the calibration. Calibrate all equipment used during the investigation daily, at a minimum, in accordance with the manufacturers' recommendations.

DISTRIBUTION OF COPIES

When the field team has returned from the sampling event, the field team leader is responsible for making sure that the field documentation is 1) scanned and placed into the project file on the portal (in a subfolder named Field under Working_Files), and 2) a copy of all field logbooks and additional field data forms is made and placed into the project file. Both the scanned copy and the hard copy will be available for general staff use.

The original field logbooks and forms will be placed in a locked file cabinet for safekeeping. One file cabinet at each Integral office will contain the original field documentation for multiple projects. The original field documentation will be filed at the Integral office where the project manager is located.

SET-UP OF LOCKING FILE CABINET

Place each project in its own file folder in a locking file cabinet. On the folder label, include the project name and contract number. Each project folder will include up to six kinds of files:

- Field logbook(s)
- Additional field data forms
- Photographs
- COC forms
- Acknowledgment of Sample Receipt forms
- Archive Record form (to be completed only if samples are archived at an Integral field storage facility or Integral laboratory).

STANDARD OPERATING PROCEDURE (SOP) AP-03

SAMPLE CUSTODY

SCOPE AND APPLICATION

This SOP describes Integral procedures for custody management of environmental samples.

A stringent, established program of sample chain of custody will be followed during sample storage and shipping activities to account for each sample. The procedure outlined herein will be used with SOP AP-01, which covers sample packaging and shipping; SOP AP-02, which covers the use of field logbooks and other types of field documentation; and SOP AP-04, which covers sample labeling.

SAMPLE CUSTODY

A sample is considered to be in a person's custody if any of the following criteria are met:

1. The sample is in the person's possession
2. The sample is in the person's view after being in his or her possession
3. The sample has been transferred to a designated secure area to prevent tampering after it was in the person's possession.

At no time is it acceptable for samples to be outside of Integral personnel's custody unless the samples have been transferred to a secure area (i.e., locked up). If the samples cannot be placed in a secure area, then an Integral field team member must physically remain with the samples (e.g., at lunch time one team member must remain with the samples).

CHAIN-OF-CUSTODY FORMS

Chain-of-custody (COC) forms ensure that samples are traceable from the time of collection through processing and analysis until final disposition. The COC form is critical because it documents sample possession from the time of collection through final disposition. The form also provides information to the laboratory regarding what analyses are to be performed on the samples that are shipped.

Complete the COC form after each field collection activity and before shipping the samples to the laboratory. Sampling personnel are responsible for the care and custody of the samples

until they are shipped. The individuals relinquishing and receiving the samples must sign the COC form(s), indicating the time and date of the transfer, when transferring possession of the samples.

Record on the COC form the project-assigned sample number and the unique tag number at the bottom of each sample label. The COC form also identifies the sample collection date and time, type of sample, project name, and sampling personnel. In addition, the COC form provides information on the preservative or other sample pretreatment applied in the field and the analyses to be conducted by referencing a list of specific analyses or the statement of work for the laboratory. The COC form is sent to the laboratory along with the sample(s).

PROCEDURES

Use the following guidelines to ensure the integrity of the samples:

1. At the end of each sampling day and prior to shipping or storage, enter information for all samples on a COC form. Check the information against the sample container labels and tags and field logbook entries.
2. Do not sign the COC form until the team leader has checked the information for inaccuracies. Make corrections by drawing a single line through any incorrect entry, and then initial and date it.
3. Mark out any blank lines remaining on the COC form, using single lines that are initialed and dated. This procedure will prevent any unauthorized additions.
4. Sign and date each COC form. At the bottom of each COC form is a space for the signatures of the persons relinquishing and receiving the samples and the time and date of the transfer. The time the samples were relinquished should match exactly the time they were received by another party. Under no circumstances should there be any time when custody of the samples is undocumented.
5. If samples are being sent by a commercial carrier not affiliated with the laboratory, such as FedEx or United Parcel Service (UPS), record the name of the carrier on the COC form. Also enter on the COC form any tracking numbers supplied by the carrier. The time of transfer should be as close to the actual drop-off time as possible. After signing the COC forms and retaining a copy (e.g., the pink copy if the COC form is in triplicate, or an electronic or photocopy if not), seal them inside the transfer container.
6. If errors are found after the shipment has left the custody of sampling personnel, make a corrected version of the forms and send it to all relevant parties. Fix minor errors by making the change on a copy of the original with a brief explanation and signature. Errors in the signature block may require a letter of explanation.

Upon completion of the field sampling event, the sampling team leader is responsible for providing copies of all COC forms to the project chemist or laboratory coordinator. A discussion of copy distribution is provided in SOP AP-02.

CUSTODY SEAL

As security against unauthorized handling of the samples during shipping, affix two signed and dated custody seals to each sample cooler. Place the custody seals across the opening of the cooler prior to shipping. Be sure the seals are properly affixed to the cooler so they cannot be removed during shipping. Additional tape across the seal may be prudent.

SHIPPING AIR BILLS

When samples are shipped from the field to the testing laboratory via a commercial carrier (e.g., FedEx, UPS), the shipper provides an air bill or receipt. Upon completion of the field sampling event, the sampling team leader will be responsible for submitting the sender's copy of all shipping air bills to be copied at an Integral office. A discussion of copy distribution is provided in SOP AP-02. Note the air bill number (or tracking number) on the applicable COC forms or, alternatively, note the applicable COC form number on the air bill to enable the tracking of samples if a cooler becomes lost.

ACKNOWLEDGMENT OF SAMPLE RECEIPT FORMS

In most cases, when samples are sent to a testing laboratory, an Acknowledgment of Sample Receipt form is faxed to the project QA/QC coordinator the day the samples are received by the laboratory. The person receiving this form is responsible for reviewing it, making sure that the laboratory has received all the samples that were sent, and verifying that the correct analyses were requested. If an error is found, call the laboratory immediately, and document any decisions made during the telephone conversation, in writing, on the Acknowledgment of Sample Receipt form. In addition, correct the COC form and fax the corrected version to the laboratory.

Submit the Acknowledgment of Sample Receipt form (and any modified COC forms) to be copied. A discussion of copy distribution is provided in SOP AP-02.

ARCHIVE RECORD FORMS

On the rare occasion that samples are archived at an Integral office, it is the responsibility of the project manager to complete an Archive Record form. This form is to be accompanied by a

copy of the COC form for the samples, and will be placed in a locked file cabinet. The original COC form remains with the samples in a sealed resealable (e.g., Ziploc®) bag.

STANDARD OPERATING PROCEDURE (SOP) AP-06

NAVIGATION AND STATION POSITIONING

SCOPE AND APPLICATION

This SOP describes procedures for accurate navigation and station positioning required to ensure quality and consistency in collecting samples. Station positioning must be both absolutely accurate, in that it correctly defines a position by latitude and longitude, and relatively accurate, in that the position must be repeatable, allowing field crews to reoccupy a station location in the future (e.g., for long-term monitoring programs).

This SOP is structured as follows:

- Procedures
- Equipment capabilities
- Basic data collection, navigation, and file transfer.

PROCEDURES

A global positioning system (GPS) is used to obtain latitude and longitude coordinates for locations where samples are to be collected and to verify the accuracy of coordinates through use of control points and post-processing differential correction to industry standards.

For most sampling events, the GPS unit is used to direct the sampling team to the proposed sampling location, having loaded target locations onto the device prior to field deployment. For some sampling events, the GPS unit is used to record positions on the fly, in the field.

A typical positioning objective is to accurately determine and record the positions of all sampling locations to within 2 m. Positioning accuracies on the order of 1 to 5 m can be achieved[1] but may be diminished during times when the geometry of the satellites above the GPS antenna does not provide the optimum signal. The time intervals during the day when accuracies are decreased are available on Trimble Navigation Limited's (Trimble's) web site: http://www.trimble.com/gnssplanningonline/#/Settings.

[1] GPS accuracy depends on the unit (Table 1).

Use of Control Points

GPS accuracy should be verified at the beginning and end of each sampling day through use of one (or more) known horizontal control point(s) in the study area. The GPS position reading at any given station can then be compared to the known control point. All GPS signal propagation is controlled by the U.S. government (the U.S. Department of Defense for satellite signals and the U.S. Coast Guard for differential corrections).

Daily GPS Activities

A consistent routine should be established for each day's positioning activities. After successful reception of differential signals is confirmed, the GPS can be powered up and the software booted. As stated above, accuracy of the system should be verified through use of a horizontal control point.

The sampling team will proceed to the vicinity of a target station location selected by the team leader. That station location is then selected from a number of preloaded station locations that have been entered into the integrated navigation system database. Once the station has been selected, the positioning data are displayed on the computer screen or hand-held unit to assist in proceeding to the station and in maintaining the station position during sampling. A confirmed position is recorded electronically each time a sample collection is attempted (i.e., during sediment grab sampling and coring, the locations of both accepted and rejected grab samples or cores are recorded). Upon recovery of the sampling device, the station position latitude and longitude coordinates from the archived GPS file are read and recorded in the field logbook or on log sheets as a backup to the GPS record. The sampling time and water depth are also recorded, if applicable. Ancillary information recorded in the field logbook may include personnel operating the GPS, tidal phase, type of sampling activity, and the time when coordinates were collected.

On-Water Sampling Events

For on-water GPS navigation, an assessment should be made of the type of vessel that will be used to do the work and from what type of structure (e.g., side davit, A-frame, moon pool) the sampling equipment be deployed. A GPS antenna must be installed immediately above the location where the sampling equipment will be deployed.

> **Note:** On-water GPS navigation can be affected by overhead structures. If sampling from a boat is conducted underneath a bridge or adjacent to tall buildings, a laser range finder such as the Trimble TruPulse 200 Rangefinder may be needed. If sampling is performed in deep water from a boat (e.g., collecting sediments with a remotely operated vehicle), it may be necessary to install an ultrashort baseline (USBL) underwater acoustic positioning system on the sampling equipment. The USBL

system is set up differently from a common GPS unit. **This SOP does not address USBL or laser range-finder navigation.**

When a GPS antenna is mounted on a movable A-frame, the antenna should face up when the A-frame is extended out. The antenna may be mounted on an angle when the A-frame is retracted and not in use. This will optimize satellite signal reception during sampling.

If an antenna cannot be mounted exactly above the point of sampling, an offset should be incorporated into the navigation software so that each time a sample is taken, the correct location of its deployment will be accurately recorded/placed on the map (Figure 1).

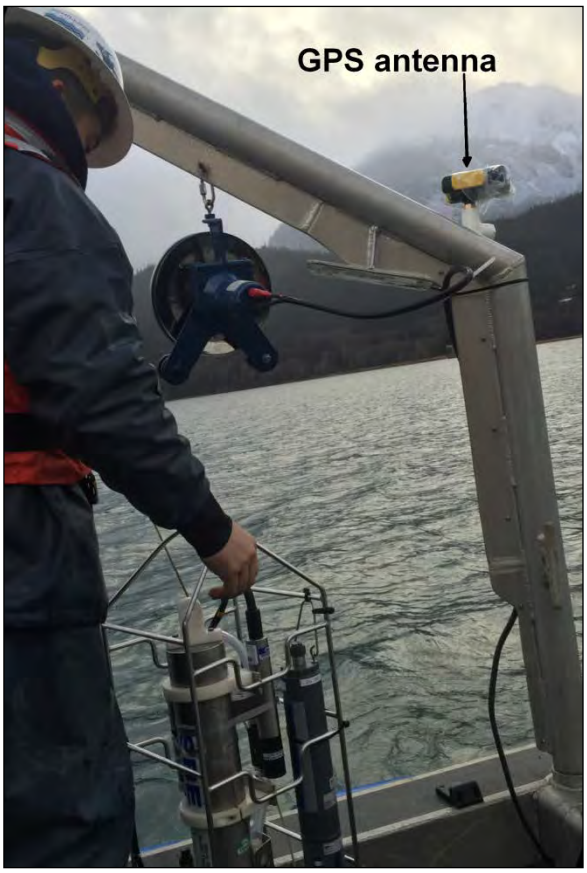


Figure 1. GPS Antenna Mounted with an Offset from the Winch Location

GPS antennae can be connected through a cable or via wireless Bluetooth® connection. Bluetooth® connections are typically limited by distances less than 10 m. If the GPS antenna is to be mounted at distances beyond 10 m, a cable connection may be needed.

The GPS antenna should be mounted vertically, with the dome facing toward the sky, at the time of deployment. The GPS antenna can be mounted on top of a davit or A-frame, or offset

over a cabin roof or other boat structure. The GPS antenna may be coupled with a receiver such as the Trimble Pro XH model and connected to a Trimble Yuma tablet or field laptop. The Yuma tablet is waterproof and therefore does not need to be situated inside a cabin (consult user manual for its operation). However, if a standard laptop is used for navigation, there must be enough cable available to connect the laptop to the antenna from inside a cabin or protected area, unless a Bluetooth® connection is available.

1. Mount the GPS antenna for receiving differential corrections on a convenient fixture outside the cabin.
2. Locate the differential corrections receiver and the computer in the cabin. Orient the video screen of the computer to allow the vessel operator to observe on-screen positioning data from the helm. A second monitor may be necessary if the distance between navigator and boat operator makes this setup impractical.
3. Alternatively, manually place a GPS antenna as close as possible to where the sampling will occur (e.g., the moon pool on a barge), and direct the vessel operator to the sampling station location.
4. Once the sampling vessel is anchored or is maintaining its position at the sampling station location, record the horizontal coordinates of the station on the GPS unit and in the field logbook. In some instances, coordinates should be recorded once the sampling device (e.g., core or grab sampler) has contacted the bottom of the water body, or if collecting surface water samples, when the sampling device is in the water at a specific sampling depth.

All target GPS coordinates should be loaded into the GPS unit before field sampling activities begin. The navigator should make sure that the sampling coordinate system is set up according to field sampling plan specifications (e.g., World Geodetic System 1984 [WGS84] or a site-specific state plane, if required). To facilitate navigation, additional background files containing georeferenced aerial photos or polygons of river edges, facility structures, etc. may be preloaded as well.

After sample collection, actual sample location positioning will be checked for precision against the target sampling location to ensure that samples were collected at the target location within the project's navigational error specifications (e.g., within ± 2 to 10 m from the target, depending on project data quality objectives).

EQUIPMENT CAPABILITIES

GPS Units

Integral maintains up-to-date navigation equipment and some units may not be listed in this SOP. However, the basic principles of GPS navigation, field setup, and data collection are, for

the most part, similar to the ones described herein. Integral owns several types of Trimble GPS units, such as the GeoXH, Yuma with a ProXH receiver, and Juno 3B.

The GeoXH GeoExplorer 2008 series (Figure 2) runs the Windows Mobile operating system, and the newer Juno 3B (Figure 3) runs Windows Handheld Professional. The Trimble Yuma rugged tablet computer (Figure 4) runs the Windows 7 Professional operating system. All units utilize Trimble TerraSync software for GPS data collection. The GeoXH and Yuma are capable of offering submeter accuracy (the Yuma has an internal GPS antenna capable of 2 to 5 m accuracy, but requires an external ProXH antenna for subfoot accuracy). The Juno is capable of 1 to 3 m post-processed accuracy. Table 1 presents an accuracy comparison between the different units. Integral also owns a Trimble TruPulse 200 laser range finder (described in the "Sources of Error" section, below).

Figure 2. GeoXH GeoExplorer 2008 Series Unit

Figure 3. Trimble Juno

Figure 4. Trimble Yuma Rugged Tablet Computer with Pro XH Receiver Mounted on a Waist Belt

Table 1. GPS Unit Comparison

GPS Unit	Horizontal Accuracy[a,b]	Vertical Accuracy[a,b]
GeoXH handheld 2008	≥15 cm–1 m	≥ 2x horizontal error
Yuma with ProXH antenna	≥15 cm–1 m	≥ 2x horizontal error
Yuma without ProXH antenna	2–5 m	≥ 2x horizontal error
Juno 3B	2–5 m	≥ 2x horizontal error

Notes:

[a] The stated accuracy assumes post-processing differential correction.

[b] The vertical and horizontal precisions are provided for each GPS point to a specified confidence level.

Sources of Error

GPS error is temporal- and location-specific depending on satellite locations and atmospheric conditions. Obtaining high-accuracy GPS data requires rigorous data collection techniques, and data collection can be compromised by inconsistent antenna height, obstructed view of the sky (e.g., tree canopy, docks, bridges), available satellites in view, station occupation time, atmospheric conditions, and distance from the base station. A laser range finder can be used with the unit if the target location is obstructed by tree canopy or structures. Consistently achieving 15 to 30 cm horizontal accuracy for large field-collection efforts requires preplanning and optimal conditions. Users should confirm GPS accuracy by collocating GPS coordinate collection with a surveyed monument (i.e., base station) prior to high-accuracy fieldwork. Users must set the positional dilution of precision (PDOP) value to 6 as the standard setup for accuracy. However, if field conditions preclude receiving a good satellite signal, the PDOP can be set to "Productivity" in the TerraSync software during fieldwork. This will allow the unit to accept available satellite signals to navigate to a target location; an example of the means for this adjustment is shown in Figure 5 (not applicable for the Juno). Setting the PDOP to Productivity will, however, decrease the level of accuracy in the field.

Figure 5. Recommended TerraSync GPS Settings

Differential Correction

Estimated accuracies for 18012 corrected positions are as follows:

Range	Percentage
0-15cm	27.3%
15-30cm	43.1%
30-50cm	15.4%
0.5-1m	11.1%
1-2m	2.7%
2-5m	0.4%
>5m	0.0%

Figure 6. Error Ranges from Differential Correction Report

To achieve optimal accuracy, GPS data must be post-processed using GPS Pathfinder Office. Differential correction reduces errors and provides a report that states the estimated horizontal accuracies in error ranges. With the GeoHX and Yuma (with ProXH antenna), the average horizontal error of most GPS field efforts is typically within 0.5 m, although individual station location errors may range from <15 cm to >1 m (Figure 6). With the Juno, the average horizontal error in the field is typically 2 to 5 m. Vertical error is at a minimum 2 to 3 times that of horizontal error, but vertical error is not estimated with the differential correction report. The corrected GPS data include horizontal and vertical precision calculated to a specified confidence level.

Integral's geographic information system (GIS) staff can assist with loading station coordinates and base maps onto the GPS units prior to fieldwork mobilization.

Following field collection, Integral GIS staff can assist with transferring, correcting, archiving, and preparing source files for integration into Integral's data management processes. If a project requires greater accuracy and less uncertainty, a licensed surveyor can provide subcentimeter horizontal and vertical location accuracy using a survey-grade GPS unit or total station instrument.

BASIC DATA COLLECTION, NAVIGATION, AND FILE TRANSFER

This section outlines basic data collection, navigation, and file transfer using Trimble's TerraSync software. Questions regarding GPS use for fieldwork should be directed to Integral's GIS team. GPS settings related to data accuracy (PDOP, signal-to-noise ratio [SNR], etc.) should not be changed.

If new to using Trimble software, it is strongly recommended that a mock data collection event be conducted *before* actual data collection begins in the field. Any area outside of an office building, in a nearby parking lot, or anywhere that is relatively free of obstructions such as tall buildings or large trees will suffice.

Basic Data Collection

Create a New File

1. In the upper left corner, select Data from the Section button.
2. Directly below in the Subsection button, select New and then New File.
3. In the New File screen, set File Type to Rover, Location to Default, type in a File Name, and set Dictionary Name to Generic (unless a specific data dictionary has been created).
4. Confirm antenna height dialogue appears. Enter the correct height if collecting vertical. Select OK.

Create (Log) GPS Features

1. Tap Create, and the Collect Features screen appears. If the generic data dictionary is chosen (typical), there are three feature options: Point_generic, Line_generic, and Area_generic.
2. To record a point feature, select Point_generic and tap Create. An attribute entry screen will appear, and the GPS unit will start logging positions. All logging positions will be averaged to compute a final GPS position. The running number of logging positions appears next to the pencil icon at the top of the screen.
3. While the unit is logging positions, remain stationary and fill out the Comment field. The Comment field is a text field that can have any combination of letters, numbers, or symbols (up to 30 characters). Typically, by the time the Comment field is completed, the unit has logged enough positions. Approximately 20 to 30 positions are sufficient; however, a minimum of 40 to 60 logged positions is required for a greater level of positioning accuracy. In theory, a greater number of positions results in a more accurate final position, although additional factors also contribute to accuracy (satellite distribution, canopy cover, etc.); with a very large number of positions, there comes a point of diminishing returns.
4. To stop logging positions and to record the feature, press OK. This returns you to the Collect Features screen.

Line and area features are collected in much the same manner, except that the user walks along the alignment or outline of the feature instead of remaining in place. The pace of the walk should be rather slow, to allow the GPS unit to log enough positions along the way. A line feature will simply create a line that follows the walked path. An area feature will always be a closed polygon, so if the end is not at the point of beginning, the GPS will automatically

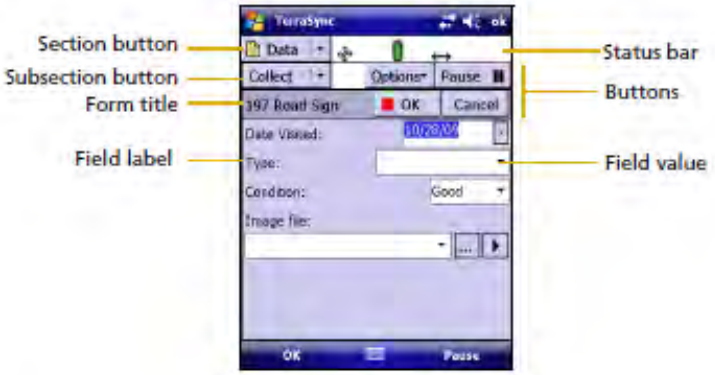
close the loop by connecting the first and last position, regardless of how far apart the two might be. During collection of lines and features, position logging can be paused if there is a need to deviate from the line. Operations are resumed by tapping Resume.

The map can be viewed at any time while features are being collected:

1. Tap the Section button and select Map.
2. To go back to data collection, tap the Section button again, and select Data.
3. To end data collection, tap the Collect button and select Close.

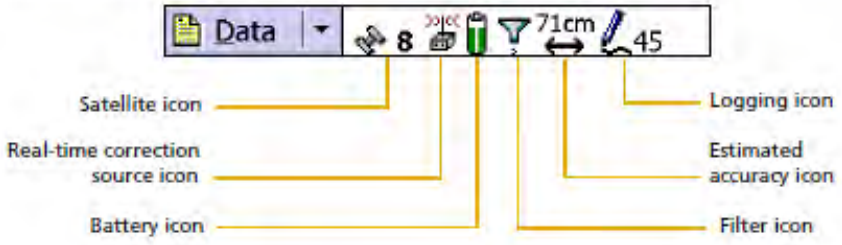
The TerraSync interface and icons are shown below:

The screen below shows elements that are common to all screens in the TerraSync software:



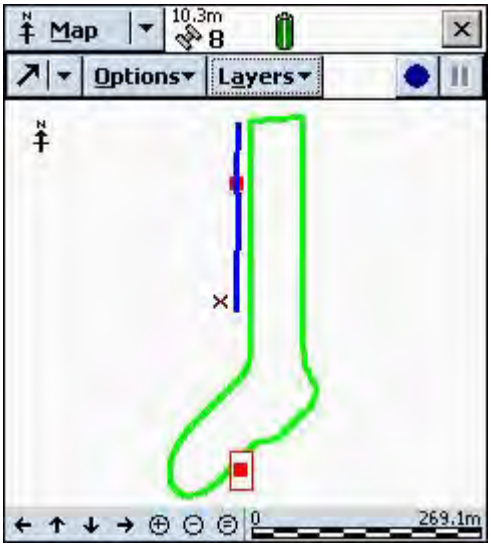
Status bar

The status bar appears at the top of the TerraSync software screen and provides basic status information about the connected GPS receiver. For information about how to connect to a GPS receiver, see Connecting to a GPS receiver, page 48.

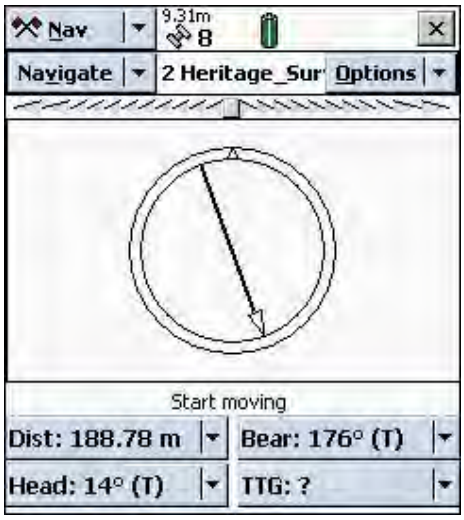


Navigation

The Navigation section of the program permits users to navigate from their current position (small red ×) to a selected target or feature.



1. To open the Navigation section, tap the Section List button and select Navigation.
2. To navigate to a point, select the desired point feature in Map view. The selected feature will be displayed as the boxed point feature symbol (at right).
3. Tap Options—Set Nav Target in Map view. The navigation target will now be displayed as a blue crossed-flags navigation target symbol.
4. Select Navigation from the section list, and note the following items (depicted in the example to the right):
   - Target's identification and type (2 Heritage_Survey_pt)
   - Distance to target (188.78 m)
   - Bearing to target (176°); the arrow pointer indicates the bearing graphically
   - User's current heading (14°); the pointer on top of the dial represents the user's heading.



TerraSync's "compass" depends on a series of GPS positions to detect the direction of travel, so users must keep moving for the compass to stay in an active state. If they stop, the compass will wander and drift.

Users follow the arrow pointer until the target feature is reached. As the target is approached, an alert tone will sound, and the view changes to a zoomed-in representation of the target feature and the current GPS position.

File Transfer

Data files are transferred to and from the GPS unit using the Data Transfer utility. This utility is part of the GPS Pathfinder Office software but can also be used as a stand-alone program (free to download onto any computer).

1. Before using the software, connect the GPS unit to your computer via the universal serial bus (USB) cable. Microsoft Mobile Device Center (Windows 7) should successfully connect to the GPS unit.
2. Once that connection is successful, open GPS Pathfinder Office; select Utilities and then Data Transfer (if you are using the stand-alone version, simply open the program).
3. In the device box, select GIS Datalogger on Windows. It should show the GPS as successfully connected. There are two options—Send and Receive.
4. To download your data, select the Receive tab, and hit Add and then Data File. The files that appear are the files in the GPS unit. Any files that have not been downloaded (or modified since the last download) will be selected in bold.
5. Click Open; the Files to Receive dialog box appears. A list of all files that will be downloaded appears, and you can remove any from the list as needed.
6. Click Transfer All; a message box showing summary information about the transfer appears.

Transferring data on the Yuma tablet is done somewhat differently. With the Yuma, the GPS and the computer are both on the same device. The difference is that the files still need to be transferred to and from the computer portion of the device. The easiest method is to use a thumb drive.

1. To load data onto the unit (Send, in the Data Transfer utility), point the path to the thumb drive containing the files to upload.
2. To download data, follow the instructions above, and take note as to where the files are being transferred in the Yuma computer, in the Destination field.
3. After transferring files, navigate to the files in Windows Explorer and copy them to the thumb drive.

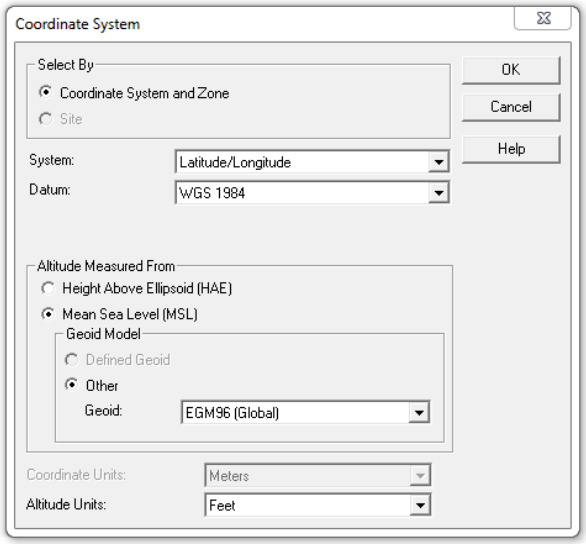
Loading Background Files

File Types

Background layers supported by TerraSync include vector data (.shp) and raster data (.bmp, .jpg, .sid, and .tif). The raster data must be uploaded with a world file (.wld, .jgw, .tfw, .sdw), which tells TerraSync the coordinate system in which the data is projected. All data should be projected into WGS84 before it is uploaded to the GPS unit.

Uploading to the GPS Unit

1. To transfer background data to the GPS unit, open the file in Pathfinder.
2. Set the coordinate system of the Pathfinder Office display to WGS 1984 by going to Options > Coordinate System.
3. To open the background file, go to File > Background and navigate to the file by clicking Add.
4. To check that it is displaying correctly, click on View > Map. Once it is displayed in Pathfinder, it can be transferred to the GPS unit.
5. Connect the GPS unit to the computer and click Utilities > Data Transfer.
6. On the Send tab, click Add > Background and add the file.
7. Click Transfer All for the file to be uploaded to the unit.



Displaying on the GPS Unit

1. Open TerraSync on the GPS unit and click on the drop-down menu next to Setup.
2. Go to Map, click Layers > Background Files, and choose the background file.
3. Click OK and the file will be added to the map.

STANDARD OPERATING PROCEDURE (SOP) GW-02

MEASUREMENT OF DEPTH TO WATER

SCOPE AND APPLICATION

This SOP describes the required equipment and the procedures used for the collection of water level data. Alternate equipment may be used if necessary, as long as the general procedures described below are followed. Typically water levels are collected from all the site wells as expeditiously as possible so that the water level data can be used to create potentiometric surface maps that are representative of a "single" point in time. This SOP does not address interpretation of water level data and the special care and hydraulic expertise that should be used to interpret water level data sets in unique environments (i.e., tidally influenced wells).

Depth to groundwater surface is measured using an electric water level meter. A light on the water level meter illuminates and an alarm sounds when the weighted probe tip contacts the water surface in the well and completes an electronic circuit. The measured depth to water is determined to within 0.01 ft by noting the point on the probe cable that corresponds to the measuring point at the top of the well/piezometer casing at the initial point of contact. The measuring point should be notched at the lip of the casing, typically either on the high side or on the north side.

EQUIPMENT AND REAGENTS REQUIRED

- Electronic water level indicator (Solinst® or equivalent)
- Potable and distilled/deionized water
- Alconox® or Liquinox® detergent
- Tape measure with stainless steel weights
- Disposable bailer (if light, nonaqueous-phase liquid [LNAPL] conditions are unknown)

PROCEDURES

Water Level Measurements

1. Check the operation of the meter by turning on the indicator switch and pressing the test button.
2. Open well cap to allow equilibration with ambient atmospheric pressure.
3. Monitor air quality at the well head if volatile contaminants are or may be present, or as specified by the project-specific health and safety plan.
4. Check for possible presence of LNAPL using a new 3-ft long disposable bailer affixed to nylon rope if conditions are unknown. Gradually lower the bailer until the bottom of the bailer is approximately 2 ft below the top of the water surface. Slowly raise the bailer to the surface and measure the product thickness using a tape measure. Record the measurement in the field logbook. Properly dispose of the bailer.
5. Decontaminate the probe and graduated cable with an Alconox® or Liquinox® solution followed by a distilled or deionized water rinse.
6. Hold the water level indicator and cable reel above the well casing and lower indicator probe and cable gradually into well until a tone (e.g., buzzer) and/or the indicator light illuminates, denoting that the indicator probe has made contact with the water surface. Stop lowering the cable.
7. Note the point on the graduated cable that corresponds to the measuring point at the top of the casing when the electronic circuit is first completed. If necessary, grasp tape with thumb and index finger exactly at the measuring point marked at the top of the well casing. Pull tape out of well slowly and read the measurement.
8. Draw the cable about 1 ft above the surface of the water, then lower it and repeat Steps 6 through 8. If the two readings differ by more than 0.01 ft, repeat until the measured readings stabilize. Water level records should always use the measurement taken as the indicator is lowered into the well, not as it is raised.
9. Remove the cable from the well or piezometer.
10. Record the stabilized depth-to-water measurement in the field logbook.
11. Decontaminate the probe and graduated cable with Alconox® and tap-water wash and distilled or deionized water, as appropriate.

12. Lower a weighted steel measuring tape slowly from center of well or piezometer if the total depth of the well needs to be measured. Alternately, the water level meter can be used to measure the total depth of the well. However, when measuring the total depth, the depth from the measuring point of the probe to the bottom of the probe must be **added** to the measurement because the graduated cable is referenced to the point of the probe where the electronic circuit is completed. Sounding the bottom of the well prior to sampling of the well is **NOT** recommended because of the potential for resuspension of settled formation solids in the well.
13. Draw tape up very slowly until it is taut again when the weight hits the bottom or until the tape slackens noticeably.
14. Note the tape reading at level of casing top. Record this as well depth in the field logbook to the nearest 0.01 ft.

STANDARD OPERATING PROCEDURE (SOP) GW-03

LOW-FLOW GROUNDWATER SAMPLING

SCOPE AND APPLICATION

This SOP presents the methods to be used for monitoring well purging and groundwater sampling using low-flow (minimal drawdown) sampling methods. The procedures outlined in this SOP are in accordance with groundwater sampling methods recommended by USEPA (1992, 1996). Details on site-specific sampling activities, equipment selection (i.e., pumps), site-specific field parameters, field quality control and quality assurance (QA/QC) samples, and laboratory analyses are presented in the work plan, field sampling plan (FSP), or quality assurance program plan (QAPP). Where possible, sampling should first be conducted in areas least affected by chemicals of interest, followed by increasingly affected areas (i.e., clean to dirty).

EQUIPMENT REQUIRED

- Electronic water level meter
- Groundwater parameter meter capable of measuring field parameters required by the FSP or the QAPP
- Flow-through cell
- Sampling equipment (one from list):
  - Submersible pump (bladder or Grundfos®): pump, control box, power source (typically a portable generator or 12V battery)
  - Peristaltic pump: pump with pump head, silicone tubing, tubing connectors, power source (typically 12 V battery)
- Decontamination equipment and supplies (buckets, scrub brushes, deionized or distilled water, potable water, and Liquinox® or Alconox® detergent)
- Groundwater sampling forms and logbook
- Sample tubing (type and length are project- and site-dependent)
- Sample tags/labels and appropriate documentation (e.g., chain-of-custody forms, logbook, and groundwater sample collection forms)

- Insulated cooler(s), chain-of-custody seals, Ziploc® bags
- Sample containers with preservative (if required), coolers, and ice.

PROCEDURES

The following sections provide guidelines for preparation for purging, well purging, and groundwater sampling.

Preparation for Purging

Preparation for purging includes inspecting the condition of the well, monitoring health and safety conditions, and calibrating and decontaminating sampling equipment. General procedures are presented below:

1. Ensure that the area around well head is clean and free of debris. If necessary, place a plastic drop cloth around well head to prevent sampling equipment from coming into contact with the ground surface.
2. Inspect condition of well (e.g., well in locked position, tightness of cap, measuring point well marked, disturbance of surface casing, straightness of well casing, condition of concrete pad). Indicate condition of well on the sampling form.
3. Remove well cap. If the site health and safety plan (HSP) identifies organic compounds as potential contaminants of concern, screen well headspace and breathing-zone headspace (if specified in the HSP) for organic vapors using the appropriate field monitoring instrument (e.g., photoionization detector).
4. Decontaminate all equipment (as specified in the FSP, QAPP, or in accordance with SOP GW-01) before use in each well. Wear nitrile gloves and/or other protective equipment as specified in the site-specific HSP during possible water-contact or equipment-contact activities. At a minimum, change gloves between each well or when it is possible for potential contaminants to be introduced into the well.
5. Measure water level using a decontaminated electronic water level meter as described in SOP GW-02 when the water level in the well has equilibrated.
6. Obtain a sample from the well using a bailer and observe the contents for evidence of free floating product (SOP GW-02), if suspected (see FSP or QAPP). Alternatively, measure free product thickness using an oil–water interface probe.
7. Calculate the well casing volume as follows:

$$\text{well casing volume (gal)} = \pi(r^2)(h)(7.48\ \text{gal/ft}^3)$$

Where:

h = height of water in the well casing (i.e., depth to bottom of the well minus depth to water) in feet

r = radius of the inside of the well casing in feet.

8. Calibrate water quality meters for measuring field parameters as appropriate. At a minimum, collect temperature, pH, and specific conductance measurements during purging and prior to sampling. Other field parameters, including dissolved oxygen, redox potential, and turbidity (recommended for inorganics) may be required as specified in the work plan or FSP. Record equipment calibration and maintenance in the field logbook. Decontaminate meters between wells by rinsing with distilled or deionized water. Manage rinsate water used for these measurements in the same manner as purge water, as defined in the work plan or FSP.

Well Purging

Monitoring wells are purged before groundwater samples are collected for analyses. The purpose of well purging is to remove stagnant groundwater from the well. Field parameters (i.e., pH, temperature, specific conductance, redox potential, dissolved oxygen, and turbidity) are measured during the purging process to verify that stagnant water has been removed and that groundwater conditions are stable prior to sampling to ensure a representative groundwater sample is collected. A variety of pumps can be used to purge and sample the monitoring well (refer to the FSP or QAPP for the specified pump type). Refer to the manufacturer's instructions for operation of the specified pump. General procedures for purging are as follows:

1. Remove well cap.
2. Connect pump.

   Submersible Pump (bladder or Grundfos):

   a. Remove the pump from the pump holder and rinse with distilled water.

   b. Connect appropriate length of tubing to pump.

   c. Connect the pump to control box.

   d. Connect the control box to the power supply.

   Peristaltic Pump:

   a. Connect new or pre-cleaned tubing to peristaltic pump.

   b. Connect the pump to the power supply.

c. Lower the pump intake or intake tubing (as applicable) into the water column. The pump intake should be placed at the middle or slightly above the middle of the screened interval in confined aquifers (USEPA 1996) or in unconfined aquifers not screened across the water table. Place the pump intake near the top of the water column for unconfined aquifers screened across the water table (USEPA 1996).

3. Insert multimeter into flow-through cell. Connect the discharge hose from the pump to the flow-through cell. Direct discharge from flow-through cell to an appropriately sized container to manage purge water. **DO NOT** immerse water quality meter probes into purge water containing free product because this may damage the probes.
4. Turn on the pump. Conduct purging at a rate that will minimize drawdown in the well (i.e., purge at a rate less than or equal to recharge, if possible). Recommended purge rates are generally less than 0.13 gal/min (0.5 L/min) (USEPA 1996), or a rate that results in minimal (i.e., less than 0.3 ft) of drawdown in the well. Actual purge rates will vary based on aquifer material and well construction.
5. Record field parameters on the groundwater sampling form or logbook every 3 to 5 minutes. Purging should continue at a constant rate until the water quality parameters have stabilized for three successive measurements according to the stabilization criteria provided in the table below (USEPA 1996). In the event that even very low purge rates result in evacuation of the well, collect groundwater samples for laboratory analyses as soon as sufficient groundwater accumulates in the well, regardless of the stabilization of field parameters.

Field Parameter	Stabilization Criteria
Temperature	± 1°C
pH	± 0.1 standard units
Specific Conductance	± 3 percent
Dissolved Oxygen	± 10 percent
Redox Potential	± 10 mV
Turbidity (nephelometric turbidity units)	± 10 percent

Groundwater Sample Collection

Groundwater sampling is conducted following proper purging of the well. Where possible, groundwater samples for analyses should be collected directly from the pump discharge at the lowest rate possible to minimize cross contamination, suspension of solids, and aeration of the sample.

Sample groundwater after the water quality parameters have stabilized. The general procedures for groundwater sample collection are as follows:

1. Turn down flow rate on the control box so that water flow is stopped or minimal while maintaining sufficient pressure in the system to prevent water in the tubing or flow-through cell from flowing back into the well. If a peristaltic pump is used, turn off the pump. Take care not to release the pump head because the loss of suction will cause the water in the tubing to drain back into the well.
2. Disconnect the pump discharge hose from flow-through cell or cut the tubing just before the connection to the flow-through cell.
3. Introduce groundwater samples directly from the pump discharge tube into the proper sample container and fill it to capacity. Place a bucket beneath the sampling tube to catch any unsampled water. Target analytes, container types, and preservatives are specified in the FSP or QAPP.
4. Collect groundwater samples for multiple compounds in the recommended following order (USEPA 1992):
    - Volatile organic compounds (VOCs)
    - Dissolved gases and total organic carbon (TOC)
    - Semivolatile organic compounds (SVOCs)
    - Metals and cyanide
    - Major water quality cations and anions
    - Radionuclides.
5. Increase pump flow rate slightly so that the flow rate is approximately the same as was used for purging and fill necessary sample bottles. If sampling for VOCs, flow rate should be just enough to create a trickle of water. If sampling for other analytes, flow rate may be increased. When collecting samples for VOCs, direct the flow from the pump discharge down the side of the sample container to minimize aeration. Hold caps in hand to minimize contamination of sample. Fill all VOC sample containers to the top. A positive meniscus at the top of the container will help ensure that no air is trapped inside when cap is screwed down on the container. No air bubbles should be trapped in the sample when the container is sealed. VOC sample bottles must be checked after filling to ensure no air bubbles are present. Invert the bottle and lightly tap it to release any bubbles beneath the cap. If an air bubble is present, the VOC sample must be retaken using a fresh bottle.

6. Conduct field filtration, if required by the FSP or QAPP (recommended for inorganic analytes). If applicable, attach a new, disposable filter cartridge (typically 0.45 μm) to the discharge line. Collect filtered samples last and pre-rinse them by running a minimum of 0.25 gal of groundwater through them prior to collecting the sample (USEPA 1996). Introduce filtered water directly into the appropriate sample container. Note that alternate field filtration methods may be specified in the FSP or QAPP.
7. Collect QA/QC samples (i.e., duplicate, equipment rinsate, trip blank, laboratory matrix spike, and laboratory matrix spike duplicate, as applicable) at the same time by filling all bottles from the same flow. The number and types of QA/QC samples are specified in the FSP or QAPP.
8. Label sample bottles with date, sample number, time, sampler's name, and type of preservative, as described in the project-specific QAPP and in accordance with SOP AP-04. Place sample bottles in a cooler or on ice to keep samples cool (4°C). Samples must be cooled continuously from the time of collection to the time of receipt at the laboratory, as described in SOP AP-01.
9. Reconnect the discharge tubing to the flow-through cell with the multimeter. Continue pumping for 1 to 2 minutes and collect a set of post-sampling field parameters. Record the parameters on the groundwater sampling form or in the logbook.
10. Remove pump and/or tubing from the well. Close and lock the well. Decontaminate the sampling equipment in accordance with SOP GW-01. Purge, wash, and rinse water should be managed as specified in the FSP or QAPP.
11. Complete chain-of-custody form, package samples for shipment, and ship samples or arrange for courier to laboratory.
12. Document all field observations made and data generated in conjunction with the sample collection on the groundwater field sampling form.

REFERENCES

USEPA. 1992. RCRA ground-water monitoring: draft technical guidance. U.S. Environmental Protection Agency, Office of Solid Waste, Washington, DC.

USEPA. 1996. Low-flow (minimal drawdown) ground-water sampling procedures. EPA/540/S-95/504. U.S. Environmental Protection Agency, Office of Research and Development, Office of Solid Waste and Emergency Response, Washington, DC.

STANDARD OPERATING PROCEDURE (SOP) SD-02

PREPARATION OF FIELD QUALITY CONTROL SAMPLES FOR SEDIMENTS

SCOPE AND APPLICATION

This SOP describes the purpose, preparation, and collection frequency of field duplicate samples, field replicate samples, matrix spike/matrix spike duplicates, equipment rinsate blanks, bottle blanks, trip blanks, temperature blanks, environmental blanks, and reference materials (i.e., a standard reference material, a certified reference material, or other reference material; for the purposes herein, all types of reference materials are referred to as standard reference material, or SRM) for sediment sampling efforts. Not all of the field quality control samples discussed in this SOP may be required for a given project. The specific field quality control samples will be identified in the project-specific field sampling plan (FSP) and quality assurance project plan (QAPP). For most projects, Integral's recommended field quality control samples are an equipment rinsate blank, a field duplicate, and trip blanks if samples are to be analyzed for volatile organic compounds (VOCs). Definitions of all potential quality control samples are described below.

As part of the quality assurance/quality control (QA/QC) program, all field quality control samples will be sent to the laboratories "blind." To accomplish this, field quality control samples will be prepared and labeled in the same manner as regular samples, with each quality control sample being assigned a unique sample number that is consistent with the numbering for regular samples. All of the containers with preservatives that are required to complete the field quality control sample for the applicable analyte list shall be labeled with the same sample number. The sample ID for field quality control samples should allow data management and data validation staff to identify them as such and should be recorded only in the field logbook. Under no circumstances should the laboratory be allowed to use reference materials, rinsate blanks, or trip blanks for laboratory quality control analysis (i.e., duplicates, matrix spike, and matrix spike duplicates). To prevent such an occurrence, regular samples should be selected and marked on the chain-of-custody/sampling analysis request (COC/SAR) form or the laboratory should be instructed to contact the project QA/QC coordinator to select appropriate samples for each sample group.

Field quality control samples will be prepared at least once per sampling event, and certain types will be prepared more often at predetermined frequencies. If the number of samples taken does not equal an integer multiple of the intervals specified in this SOP, the number of

field quality control samples is specified by the next higher multiple. For example, if a frequency of 1 quality control sample per 20 is indicated and 28 samples are collected, 2 quality control samples will be prepared. Field quality control samples for sediment sampling activities should be prepared consistent with the requirements discussed below and at the frequency indicated unless different frequency requirements are listed in the FSP and QAPP.

The following table lists the quality control sample types and suggested frequencies for sediment sampling programs. Because sediment quality control sampling may require assessment of site cross-contamination, additional blanks may be required. A detailed explanation of each quality control sample type with the required preparation follows.

Table 1. Field Quality Control Sample Requirements

Quality Control Sample Name	Abbreviation	Preparation		Frequency[a]
		Location	Method	
Duplicate	DUP	Sampling site	Additional natural sample	One per 20 samples. May not be applicable if REP is being collected.
Replicate	REP	Sampling site	Additional natural sample	One replicate per 20 samples. May not be applicable if DUP is being collected.
Matrix spike/matrix spike duplicate	MS/MSD	Sampling site	Additional sample bottles filled for laboratory quality control requirements	One per 20 samples.
Equipment rinsate blank	ER	Sampling site	Deionized water collected after pouring through and over decontaminated equipment	Minimum of one per sampling event per type of sampling equipment used and then 1 per 20 thereafter.
Filter wipe	FW	Sampling site	Whatman filter papers (organic analysis) and Ghost Wipes (metals/mercury analysis) will be wiped over decontaminated equipment	Minimum of one per sampling event per type of sampling equipment used and then 1 per 20 thereafter.
Filter paper blank	FB	Sampling site	Clean, unused Whatman filter papers (organic analysis) and Ghost Wipes (metals/mercury analysis) will be sent to the analytical laboratory	Minimum of one for each lot number of filter papers used.
Bottle blank	BB	Field	Unopened bottle	One per sample episode or one per bottle type.
Trip blank	TB	Laboratory	Deionized water with preservative	One pair per each VOC sample cooler shipment.

Quality Control Sample Name	Abbreviation	Preparation		Frequency[a]
		Location	Method	
Temperature blank	TMB	Laboratory	Deionized water	One per sample cooler.
Environmental blank	EB	Field	Bottle filled at sample site with deionized water	One per 20 samples.
Standard reference material	SRM	Field laboratory or sampling site	SRM ampules or other containers for each analyte group	One set per 50 samples or one per episode.

[a] Frequencies provided here are general recommendations; specific frequencies should be provided in the project-specific FSP or QAPP.

FIELD DUPLICATE SAMPLES

Field duplicate (or split) samples are collected to assess the homogeneity of the samples collected in the field and the precision of the sampling process. Field duplicates will be prepared by collecting two aliquots for the sample and submitting them for analysis as separate samples. Field duplicates will be collected at a minimum frequency of 1 per 20 samples or once per sampling event, whichever is more frequent. The actual number of field duplicate samples collected during a sampling event will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of field duplicate collection may vary by EPA region or state).

FIELD REPLICATE SAMPLES

Field replicate samples are co-located samples collected in an identical manner over a minimum period of time to provide a measure of the field and laboratory variance, including variance resulting from sample heterogeneity. Field replicates will be prepared by collecting two completely separate samples from the same station and submitting them for analysis as separate samples. Field replicates will be collected at a minimum frequency of 1 per 20 samples or once per sampling event, whichever is more frequent. If field duplicate samples are collected, then it is unlikely that field replicate samples will also be collected during a sampling event. The actual number of field replicate samples collected during a sampling event will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of field duplicate collection may vary by EPA region or state).

MATRIX SPIKE/MATRIX SPIKE DUPLICATES

The matrix spike/matrix spike duplicate (MS/MSD) analyses provide information about the effect of the sample matrix on the design and measurement methodology used by the laboratory. To account for the additional volume needed by the laboratory to perform the analyses, extra sample volumes may be required to be collected from designated sediment stations. MS/MSDs may be collected at a minimum frequency of 1 per 20 samples or once per sampling event, whichever is more frequent. The actual number of extra bottles collected during a sampling event will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements may vary by analyte group).

EQUIPMENT RINSATE BLANKS

Equipment rinsate blanks will be used to help identify possible contamination from the sampling environment and/or from decontaminated sampling equipment. Equipment rinsate blanks will be prepared by pouring laboratory distilled/deionized water through, over, and into the decontaminated sample collection equipment, and then transferring the water to the appropriate sample containers and adding any necessary preservatives. Equipment rinsate blanks will be prepared for all inorganic, organic, and conventional analytes at least once per sampling event per the type of sampling equipment used. The actual number of equipment rinsate blanks prepared during an event will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of equipment rinsate blank collection may vary by EPA region or state).

FILTER WIPES

Filter wipe samples will be used to help identify possible contamination from the sampling environment or from the decontaminated sediment sampling equipment (e.g., sediment grab sampler, stainless-steel bowls and spoons, shovel, trowel).

Filter wipe samples will be prepared by grasping a piece of clean, ashless filter wipe/paper with decontaminated tongs and/or tweezers and wiping down all surfaces of dry, decontaminated equipment that comes into contact with the sediment sample (e.g., stainless-steel spoon, inside of sediment grab sampler). Whatman filter papers will be used for organic analysis and Ghost Wipes will be used for metals/mercury analysis. The filter wipes/papers will be from the same lot used to prepare the filter paper blanks (see below), and the filter lot number will be clearly noted in the field logbook. One filter wipe/paper will be used for each equipment type, solid matrix type, and analysis type. For example, if two pieces of equipment were used for sediment sampling (trowel and stainless-steel spoon) and both metals and

organic compounds were being analyzed, then a total of four filter wipes/papers would be sent to the analytical laboratory.

Tongs and/or tweezers will be used to handle the filter wipe/paper, and all sediment sample-exposed surfaces will be thoroughly wiped down using one piece of filter wipe/paper (per equipment type and for each analysis). The filter wipe sample will then be placed into a labeled certified pre-cleaned sample jar provided by the analytical laboratory. The filter wipe/paper box will be stored in a clean glass container and must NOT be stored in a plastic bag. In moist environments, the filters should be wrapped thoroughly in aluminum foil to protect them from moisture.

Filter wipe samples will be prepared for all inorganic and organic analytes at least once per sampling event per the type of sampling equipment used. The actual number of filter wipe samples prepared during an event will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of filter wipe sample collection may vary by EPA region or state).

FILTER PAPER BLANKS

Whenever a filter wipe sample is prepared in the field, a filter paper blank will also be prepared in the field to evaluate potential background concentrations present in the filter paper used for the equipment filter wipe sample.

Filter paper blanks will be prepared by using tongs and/or tweezers to remove the clean ashless filter paper from its box. Whatman filter papers will be used for organic analysis and Ghost Wipes will be used for metals/mercury analysis. The filter papers will be from the same lot used to prepare the filter wipe samples (see above), and the filter lot number will be clearly noted in the field logbook. One filter wipe/paper will be sent to the analytical laboratory for each type of analysis to be performed (i.e., inorganic or organic analytes). The filter paper blank will be placed into a labeled certified pre-cleaned sample jar provided by the analytical laboratory.

Filter paper blanks will be collected at a minimum frequency of one for each filter lot number. The actual number of filter paper blanks prepared during an event will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of filter paper blank collection may vary by EPA region or state).

BOTTLE BLANKS

The bottle blank is an unopened sample bottle. Bottle blanks are submitted along with sediment samples to ensure that contaminants are not originating from the bottles themselves because of improper preparation, handling, or cleaning techniques. If required, one bottle

blank per lot of prepared bottles will be submitted for analysis. If more than one type of bottle will be used in the sampling (e.g., high-density polyethylene or glass), then a bottle blank should be submitted for each type of bottle and preservative. The actual number of bottle blanks analyzed during a project will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP as the requirements on frequency of bottle blank analysis may vary by EPA region or state).

To prepare a bottle blank in the field, set aside one unopened sample bottle from each bottle lot sent from the testing laboratory. Label the bottle as "Bottle Blank" on the sample label (and in the "Remarks" column on the COC/SAR form), and send the empty bottle to the laboratory with the field samples.

TRIP BLANKS

Trip blanks will be used to help identify whether contaminants may have been introduced during the shipment of the sediment samples from the field to the laboratory for VOC analyses only. Trip blanks are prepared at the testing laboratory by pouring distilled/ deionized water into two 40-mL VOC vials and tightly closing the lids. Each vial will be inverted and tapped lightly to ensure no air bubbles exist.

The trip blanks will be transported unopened to and from the field in the cooler with the VOC samples. A trip blank is labeled and placed inside the cooler that contains newly collected VOC samples and it remains in the cooler at all times. A trip blank must accompany samples at all times in the field. One trip blank (consisting of a pair of VOC vials) will be sent with each cooler of samples shipped to the testing laboratory for VOC analysis.

TEMPERATURE BLANKS

Temperature blanks will be used by the laboratory to verify the temperature of the samples upon receipt at the testing laboratory. Temperature blanks will be prepared at the testing laboratory by pouring distilled/deionized water into a vial and tightly closing the lid. The blanks will be transported unopened to and from the field in the cooler with the sample containers. A temperature blank shall be included with each sample cooler shipped to the testing laboratory.

ENVIRONMENTAL BLANKS

The environmental (field) blank is prepared in the field to evaluate potential background concentrations present in the air and in the distilled/deionized water used for the final decontamination rinse. If unpreserved bottles are to be used, then the appropriate preservative (i.e., for metals samples use a 10 percent nitric acid solution to bring sample pH

to 2 or less) must be added, as may be required. Environmental blanks should be collected at a minimum frequency of 1 in 20 samples. The actual number of environmental blanks analyzed during a project will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of environmental blank analysis may vary by EPA region or state).

To prepare an environmental blank in the field, open the laboratory-prepared sample bottle while at a sample collection site, fill the sample bottle with distilled/deionized water, and then seal it. Assign the environmental blank a unique sample number, label the bottle, and then send the bottle to the laboratory with the field samples.

REFERENCE MATERIALS

SRMs are samples containing known analytes at known concentrations that have been prepared by and obtained from EPA-approved sources. The SRMs have undergone multi-laboratory analyses using a standard method that provides certified concentrations. When available for a specific analyte, SRMs provide a measure of analytical performance and/or analytical method bias (i.e., accuracy) of the laboratory. Several SRMs may be required to cover all analytical parameters. For all analytes where available, one SRM will be analyzed at a frequency of one per 50 samples. The actual number of SRMs analyzed during a project will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of SRM analysis may vary by EPA region or state).

STANDARD OPERATING PROCEDURE (SOP) SD-04

SURFACE SEDIMENT SAMPLING

SCOPE AND APPLICATION

This SOP defines and standardizes the methods for collecting surface sediment samples from freshwater or marine environments. Surface sediments are defined as those from 0 to at most 10 cm below the sediment-water interface. The actual definition of surface sediments is typically program-specific and depends on the purpose of the study and the regulatory criteria (if any) to which the data will be compared.

This SOP utilizes and augments the procedures outlined in USEPA (1997) and ASTM (2003) guidelines. A goal of this SOP is to ensure that the highest quality, most representative data are collected, and that these data are comparable to data collected by different programs that follow the USEPA (1997) guidelines.

SUMMARY OF METHOD

Sediment samples for chemical and toxicity analysis are collected using a surface sediment sampling device (e.g., grab sampler) or hand implements (i.e., spoons, scoops, shovels, or trowels). If a sample meets acceptability guidelines, overlying water is carefully siphoned off the surface in a grab sampler, and the sediment is described in the field logbook. Depending upon the type of analysis to be performed, sediment samples for chemical analysis may be collected directly from an undisturbed surface (e.g., volatile organic compounds and sulfides), or may be homogenized using decontaminated, stainless-steel containers and utensils prior to being placed in sample jars. Sediment from several sampler casts or exposed sediment locations may also be composited and homogenized prior to being placed in sample jars.

SUPPLIES AND EQUIPMENT

A generalized supply and equipment list is provided below. Additional equipment may be required depending on project requirements.

- Sampling device
  - Grab sampler or box corer (see examples below in procedures for "Sediment Sample Collection")

  - Stainless-steel spoon, scoop, shovel, or trowel
- Field equipment
  - Siphoning hose
  - Stainless-steel bowls or containers
  - Stainless-steel spoons, spatulas, and/or mixer
  - Stainless-steel ruler
  - Project-specific decontamination supplies (e.g., Alconox™ detergent, 0.1 N nitric acid, methanol, hexane, distilled/deionized water)
  - Personal protective equipment for field team (e.g., rain gear, safety goggles, hard hats, nitrile gloves)
  - First aid kit
  - Cell phone
  - Camera
  - Sample containers
  - Ziploc® bags
  - Bubble wrap
  - Sample jar labels
  - Clear tape
  - Permanent markers
  - Indelible black-ink pens
  - Pencils
  - Coolers
  - Ice
- Documentation
  - Waterproof field logbook
  - Field sampling plan
  - Health and safety plan
  - Correction forms
  - Request for change forms
  - Waterproof sample description forms.

PROCEDURES

Sediment Sample Collection with a Grab Sampler

Use a sampler that obtains a quantifiable volume of sediment with minimal disturbance of the surrounding sediments to collect sediment for chemical and biological analyses. The sampler should be composed of a material such as stainless steel or aluminum, or have a noncontaminating coating such as Teflon™. Samplers capable of providing high-quality sediment samples include grab-type samplers (e.g., van Veen, Ekman, Smith-McIntyre, Young grab, Power Grab and modified-ponar grab) and box cores (Soutar, mini-Soutar, Gray-O'Hara, spade core). Some programs require a sampler that collects from a specific area (e.g., 0.1 m^2). Most sampling devices are typically a standard size; however, some non-standard sizes are available to meet the requirements of specific programs. Grab samplers, especially van Veen grab and Ekman grab, are the most commonly used samplers to collect surface sediment. Power Grab samplers are often used for programs requiring collection of sediment deeper than 10 cm (4 in.) or in areas with debris.

Depending on grab weight and water depth, use a hydraulic winch system to deploy the heavier samplers at a rate not exceeding 1 m/second. As the grab nears the bottom, decrease the descent speed to about 0.3 m/second to minimize the bow wake and disturbance of the surface sediment associated with sampler descent. Once the sampler hits the bottom, close the jaws slowly and bring the sampler to the deck of the vessel at a rate not exceeding 1 m/second to minimize any washing and disturbance of the sediment within the sampler. At the moment the sampler hits the bottom, record the time, water depth, and location of sample acquisition in the field logbook.

Retrieve and secure the sampler, and carefully siphon off any overlying water. Inspect the sample to determine acceptability using the criteria detailed in USEPA (1997), except when noted in the project-specific field sampling plan. These criteria include but are not limited to the following:

- There is minimal or no excessive water leakage from the jaws of the sampler
- There is no excessive turbidity in the water overlying the sample
- The sampler is not over-penetrated
- The sediment surface appears to be intact with minimal disturbance
- There is no anthropogenic (i.e., man-made) debris in the sampler
- The program-specified penetration depths are attained.

If the sample meets acceptability criteria, record the sample collection location using a global positioning system (GPS) and enter observations onto a sample collection form or the field logbook. Depending on programmatic goals, remove the sampling interval specified in the field sampling plan. Use a decontaminated stainless-steel ruler to measure the sample

collection depth (0 to 10 cm) within the sampler. To prevent possible cross-contamination, do not use sediments touching the margins of the sampler.

Take a photograph of the sediment in the grab sampler and in the stainless-steel bowl in the field. Verify that the station number or sample ID, time, and date are shown in the photograph.

Typically, sediment from a minimum of three separate casts of the sampler is composited at each station (see project-specific field sampling plan). Once the sample has been characterized, subsample the sediment for chemical and biological analyses using a decontaminated stainless-steel spoon.

Sediment Sample Collection with Hand Implements

Obtain a quantifiable volume of sediment with minimal disturbance of the surrounding sediments to collect sediment for chemical and biological analyses. Hand implements (e.g., spoons, scoops, shovels, or trowels) must be composed of stainless steel.

Use GPS to locate the sampling site and approach the location carefully to avoid disturbing the area of sediment to be sampled. Prior to sample collection, describe and characterize the undisturbed surface sediment in the field logbook. If necessary, expose the sediment surface by clearing an approximately 1-ft^2 area at the sampling site of any rocks greater than approximately 5 in. Remove any anthropogenic (i.e., man-made) debris and organic material on the sediment surface. Note any material removed from the sampling site in the field logbook.

Using a decontaminated, stainless-steel hand implement (i.e., spoon, scoop, shovel, or trowel), excavate the sediment to 10 cm. Place the sediment in a decontaminated stainless-steel bowl and use a decontaminated stainless-steel ruler to confirm that the correct sampling interval has been collected. If the full sample collection interval (i.e., 10 cm) has not been reached, collect additional sediment, place it in the stainless-steel bowl, and reconfirm the sampling interval. Continue this process until the full sample collection interval (0 to 10 cm) has been reached.

Take a photograph of the excavated hole from where the sediment sample was removed. Verify that the station number or sample ID, time, and date are shown in the photograph.

Sample Processing

Complete all sample collection forms, labels, custody seals, and chain-of-custody forms, and record sample information in the field logbook.

Collect samples for volatile compounds (either organics or sulfides) using a decontaminated stainless-steel spoon while sediment is still in the grab sampler or, if the sample is collected using a hand implement, in the stainless-steel bowl. Sediments for volatile analysis are not homogenized. Tightly pack the volatile organics sample jar with sediment (to eliminate obvious air pockets) and fill it so that no headspace remains in the jar. Alternatively, if there is

adequate water in the sediment, fill the container to overflowing so that a convex meniscus forms at the top, and then carefully place the cap on the jar. Once sealed, the jar should contain no air bubbles.

Place the remaining sediment in the grab sampler in a precleaned, stainless-steel bowl; sediment collected using hand implements are already in a stainless-steel bowl. Once a sufficient amount of sediment has been collected, mix the sediment using a decontaminated stainless-steel spoon until it is of uniform color and texture throughout.

If required for analysis, collect samples for grain-size tests before any large rocks are removed from the homogenized sediment. Identify any rocks that are greater than 0.5 in. in diameter. Determine their percentage contribution to the homogenized sediment volume, note it on the sediment field collection form or in the field logbook, and then discard the rocks.

Dispense the sediment into precleaned sample jars for the various chemical or biological analyses. For toxicity testing, fill sample jars to the top with sediment to minimize available headspace. This procedure will minimize any oxidation reactions within the sediment. For chemical analysis, sample containers may be frozen for storage. Leave enough headspace to allow for sediment expansion.

After dispensing the sediment, place the containers into coolers with ice and either ship them directly to the analytical laboratories or transport them to a storage facility.

REFERENCES

ASTM. 2003. *Standard Practice for Collecting Benthic Macroinvertebrates with Ekman Grab Sampler*. ASTM Standards on Disc, Volume 11.05.

USEPA. 1997. Recommended protocols for sampling marine sediment, water column, and tissue in Puget Sound. Prepared for Puget Sound Estuary Program, U.S. Environmental Protection Agency, Seattle, WA, and Puget Sound Water Quality Action Team, Olympia, WA. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

STANDARD OPERATING PROCEDURE (SOP) SD-08

SEDIMENT CORE COLLECTION USING A VIBRACORER

SCOPE AND APPLICATION

This SOP describes the procedure for collecting and processing sediment core samples using a vibracore system, which collects continuous and relatively undisturbed sediment cores. This method of sediment coring is performed from a boat and uses high-frequency low-amplitude vibration to break down the frictional resistance of the sediment and allow the core tube to penetrate into the sediment with minimal distortion. It is best used for sampling coarse, consolidated sediment and very cohesive sediment, where static weight (e.g., piston-type or conventional gravity corers) will not produce adequate penetration into the sediment. In addition, the vibracorer offers a high rate of production, superior retention of shallow samples, and a greater sample volume compared to conventional drilling equipment.

Vibracorers generally consist of a metal corer barrel (usually a 4-in.-outside-diameter, aluminum core barrel) with a location-dedicated polycarbonate or Lexan®-lined core tube, and a vibrator mechanism attached to the top of the barrel. The vibration is created either by an electric motor, a hydraulic system, or a pneumatic piston attached to the top of the barrel. Therefore, a generator or air compressor is needed on board to power the corer. The pneumatic piston does not have the same function as a piston in a piston corer. Because vibracorers generally do not have a piston in the corer, some compaction and/or bypass will occur, and recovery will be less than 100 percent.

A continuous sediment sample is retained within the tubing with the aid of a stainless-steel core cutter/catcher or nosecone attached to the bottom of each aluminum tube.

It is always best to keep the core in a vertical position to prevent the top layers of sediment (i.e., the top 5 to 15 cm) from slumping. However, in many cases, it is not feasible to process the core in a vertical position because the tripod needs to be at least twice the height of corer, and sectioning and logging the sample would have to be performed from a ladder. For studies that specify sectioning the sample into coarse intervals (>20 cm), processing the core in a horizontal position will generally not significantly disrupt the stratigraphy. For studies that specify shorter intervals (<5–10 cm), processing the core in a horizontal position is likely to disrupt stratigraphy. In this case, the top layers of sediment that have high water content should be sectioned while the core is in a vertical position, and when the sediment becomes thicker, the corer can be laid horizontally.

PROCEDURES

Decontamination

To prevent potential cross-contamination of samples, all reusable sediment sampling equipment must be decontaminated prior to use at each station and between field replicates.

Before each station is sampled, decontaminate the inner surfaces of the corer or core tube liner and all stainless-steel sample compositing equipment. Prior to sampling, all core liners will be washed in sequence with a standard detergent (e.g., Alconox®), rinsed with site water, and then air-dried. During storage and transport, decontaminated core liners will be capped at both ends to prevent contamination. Details on correct decontamination procedures can be found in SOP SD-01, *Decontamination of Equipment—Sediment*. The project-specific field sampling plan (FSP) should also be consulted to determine any project-specific decontamination procedures. The personnel performing the decontamination procedures will wear protective clothing as specified in the site-specific health and safety plan.

All solvent rinsates (if used) will be collected into a bucket or tub and allowed to evaporate over the course of the day. Any rinsate that has not evaporated by the end of the sampling event will be containerized and disposed of in accordance with applicable regulations.

Vibracorer Deployment and Retrieval

The following procedures are based on using the vibracorer aboard a boat equipped with a tripod or A-frame of sufficient height to allow recovery of the core (see project-specific FSP for information on target coring depth), and a power winch. On pontoon boats, the tripod is centered over a hole in the floor, whereas on other boats, the corer may be lowered over the side or stern. To obtain cores of high quality, the boat must be anchored with at least three anchors so the boat will not drift during the coring process.

1. Maneuver the sampling vessel to the targeted sampling location using the positioning procedures and minimum water depth restrictions.
2. Deploy 3- or 4-point anchor system to maintain position; record and monitor position throughout core acquisition.
3. Once on location, measure the water depth (depth to top of sediment) using the onboard depth sounder (fathometer) or lead line and record measured depth in the field logbook. If the water level is affected by tides, obtain tide level measurements and calculate tidal height in feet above mean low water. The date, time, weather, and water conditions (e.g., high wave activity, strong currents, turbidity, tidal flux) should also be recorded in the field logbook.

4. Assemble the decontaminated core tube, liner, core catcher, and cutter heads (or nose cone depending on the model of vibracorer used), using care to not contact decontaminated surfaces. Attach assembled vibracorer to winch cable. Note that several decontaminated catchers and cutterheads will be on hand, in case of loss. Core catchers and cutter heads can be decontaminated and reused for subsequent core collection.
5. Attach a tape measure to the vibracorer or mark the winch cable in 1/2-ft increments to measure penetration depth.
6. Inspect connections of winch cable and electrical or pneumatic lines to confirm they are secure.
7. Signal the winch operator to slowly raise the vibracorer into a vertical position and guide the vibracorer (with core liner, valve, core catcher, and cutterhead in place) overboard until it is clear of the vessel.
8. Using the winch, slowly lower the vibracorer through the water column at a speed of about 1 ft/s to avoid creating a bow wake or overturning of the vibracore. Stop lowering the corer a few feet above the sediment and confirm that the boat has not drifted.
9. Continue lowering the vibracorer until the tip of the core is resting on the sediment or to the depth recorded by the fathometer, depending on the consistency of the sediment. Record the vibracorer depth as derived from the attached tape measure or marked winch cable. Measurements will serve as a basis for determining penetration depth.
10. Resume lowering the corer at about 1 ft/s. When the nosecone or core catcher contacts the sediment, turn on the vibracorer motor. The vibracorer is then allowed to slowly penetrate the sediments. Initially, light tension should be maintained on the cable to keep the corer from tipping over.
11. Lower the vibracorer to the target penetration depth as measured by the attached tape measure or marked winch cable. If the targeted penetration depth is met, proceed to the next step; if refusal is met, retrieve the vibracorer, perform gross decontamination (i.e., rinse with river water and brush off visible sediment from the outside of the core barrel) and re-attempt at new location offset at least 3–5 ft from original location.
12. When the target penetration depth is reached, or refusal occurs, turn off the vibracorer and record the time, penetration depth, angle of the cable relative to the boat, and any other observations.
13. Slowly withdraw the core from the bottom sediments at a constant rate, to keep it upright and not dislodge any sediment from within the core barrel, and raise it to the surface.

14. With the corer hanging in a vertical position, clean the vibracorer assembly by hosing down the equipment with site water prior to bringing the core onboard the sampling vessel. If the corer is not plugged, care should be taken not to direct water into the open end of the core barrel.
15. Slowly guide the core onboard the vessel; use care to avoid jostling that might disturb the integrity of the core. Care must be taken to keep the top end of core elevated to prevent sediment from "pouring" out. Use a sawhorse or equivalent to elevate the top of the core. As soon as the nosecone clears the water surface, the bottom of the corer may be plugged with a rubber stopper to prevent loss of sediment.
16. Before removing the core tube from the vibracorer, visually inspect the nosecone or core cutter/catcher to ensure that proper penetration has been attained and that there is no obvious loss of sediment from the tube. Record any presence of noticeable odors, the core penetration depth, and physical characteristics (e.g., color, texture, odor) of the sediment sample as observed at the ends of the tube in the field logbook or on the Field Sediment Core form. In addition, note any sheen in the water in the field logbook.
17. If the core will be processed horizontally, slowly lay the corer down. Unscrew the cutter head (or nosecone) and carefully remove the core catcher, while retaining as much sediment as possible.
18. While removing the core catcher (or nosecone), be ready to immediately seal the end of the core liner by placing clean aluminum foil and a plastic cap over the open end.
19. Carefully remove the core liner that contains the sample by lifting the lower end from the deck as needed to provide clearance. Affix core cap, wrap with tape, label core liner and end of core, remove valve from top of core liner, stand core upright, and place in a processing rack or tray to allow the sediment at the top of the core to settle. Avoid sudden movements to the core that would disrupt the sediment interface.
20. While waiting for sediment to settle, prepare the Field Sediment Core form. Identify any debris and note its depth in the core and what the debris is, if possible.
21. Once resuspended sediment has settled, measure the length of the recovered core, calculate percent recovery (100 x recovered length/penetration depth), and record in the logbook or on the Field Sediment Core form.
22. Check the core for acceptability. The following acceptability criteria should be satisfied:
    - The core tube is not overfilled with sample so that the sediment surface presses against the bottom of the vibracorer head.
    - Overlying water is present (indicates minimal leakage).
    - The overlying water is not excessively turbid (indicates minimal disturbance).

- The desired penetration depth (see project-specific FSP for required penetration depth) or refusal has been reached.

Depending on requirements of the project-specific FSP, a core may be rejected based on percent recovery. Commonly, a core is deemed unacceptable if recovery is less than 80 percent. If recovery is less than 80 percent, the core sample will be retained for possible processing, while additional sampling attempts are made to collect a core with greater than 80 percent recovery. If subsequent attempts result in recoveries of less than 80 percent, then the sample with the highest percent recovery may be used for analysis. The number of attempts to collect an acceptable sample will be specified in the project-specific FSP. If recovery is less than 80 percent, the core may be acceptable if the penetration depth is deeper than the target core length. In this case, the recovered length should be equal to the target length.

23. Once sufficient time has been allowed for the sediment to settle (i.e., no sediment is suspended in the overlying water), use a decontaminated saw to cut a drain-slit or a decontaminated drill bit to drill in the side of the core liner approximately 1 to 2 in. above the sediment–water interface; allow excess water to drain. Cut excess polycarbonate liner with decontaminated blade and use a siphon to decant off the overlying water. Ensure that the saw blade, drill bit, or siphon does not contact the sediments and that fine-grained suspended sediment is not removed.
24. Cut cores into manageable sections (3–4 ft) aboard the vessel immediately after their retrieval. Cap each section with aluminum foil and plastic caps, and seal with duct tape. Mark the core with permanent marker using a unique number or alphanumeric code identifying sampling location, core number, core section, and segment orientation (i.e., which end is up). Following sectioning, store the cores in an upright position onboard the vessel in a core box and have them transported periodically throughout each field day by small boat to a field processing area where they are to be stored upright under custody on ice or refrigerated at 4°C to await processing.
25. In preparation for next core, thoroughly rinse the interior of the core barrel until all loose sediment has been washed off. Repeat process at next sampling location. Continue coring until requirements are met.

In situations where there is significant surface water depth and/or water current that could cause the vibracorer setup to lean at an unacceptable angle, a buoyant frame or rigid frame configuration should be used.

With the buoyant frame, the vibracorer is maintained in proper vertical position by two guidelines held taut between a float package and a weight stand. The larger weight stand is provided with ballast boxes so that easy-to-find ballasting material such as lead bags or scrap metal can be used in the field. For deployment, the vibracorer is lowered with the weight

stand hanging on its guidelines from the vibrahead. The float package is hooked up to the guidelines when the vibrahead reaches the deck level.

After coring and pull-up, the system is retrieved in the reverse manner. In case of limited deck space or overhead clearance, or to further accelerate the procedure on the water, the weight stand can be left in as overboard cradle.

Sample Handling, Storage, and Processing

Cores should be processed concurrently with core collection, and every effort should be made to ensure cores are processed within 24 hours of collection. Cores awaiting processing will be sealed tightly at both ends and stored upright in ice or in a refrigerator. If core collection outpaces processing such that significant delays in core processing appear likely, core collection will be suspended to allow the core processing to catch up.

As mentioned above, once coring has been completed at a given location, the cores will be transported in an upright position on ice to a designated field processing area, where they will be logged and processed. The field processing area will be equipped with a core-cutting table, core-processing tables, a decontamination area, and a storage area with appropriate refrigeration. Appropriate lighting will be installed in the field processing area so that consistent, high quality photographs can be taken of the opened cores. Care should be taken to create a field processing area that minimizes the potential for outside contamination.

Sample processing includes removing the sample from the liner, recording observations of sample characteristics, mixing subsamples, and distributing the sample to containers for shipping to the testing laboratory. Vibracore processing most often consists of the following steps:

1. Cut each core tube along the long axis using decontaminated hook blade. Rotate the tube 180° and cut again.
2. After each core is cut, move the entire core tube to an aluminum foil-covered table and open it so that it can be systematically logged, described, and photographed.

However, depending on the project-specific FSP, the core may be extruded from the liner and cut into the specified intervals as it emerges or the core liner may be cut into sections, sealed, and shipped intact to the testing laboratory.

Core Observations

1. Verify that the length of the core, water depth, and all required position data have been recorded in the field logbook together with all pertinent observations and communications with the field team leader.
2. After each core is cut open, describe the sediment on a Field Sediment Core form in the field processing area notebook. When recording the information for each core, follow the guidelines below:

- Physical sediment description (i.e., sediment type [e.g., silt, sand], density/consistency, color) (see SOP SL-04, Field Classification of Soil, based on ASTM D 2488-00 [ASTM 2000])
- Odor (e.g., hydrogen sulfide, petroleum, creosote)
- Visual stratification, laminations, and lenses
- Presence/location/thickness of the redox potential discontinuity layer (a visual indication of black is often adequate for documenting anoxia)
- Moisture content
- Vegetation
- Approximate percentage of vegetation
- Debris
- Approximate percentage of debris
- Presence of biological structures (e.g., detritus, shells, tubes, bioturbation, live or dead organisms, chironomids)
- Approximate percentage of biological structures
- Presence of a sheen
- Other distinguishing characteristics or features.

3. Use other observations (e.g., obvious anthropogenic material, dramatic color changes) to define or help define sample intervals (check project-specific FSP for sample interval definition; depending upon the project-specific requirements the sample interval could be based on lithology or it could be set to a specific interval [e.g., 1 ft]).
4. Determine the boundaries of lithologic units primarily by changes in the top two dominant grain sizes estimated visually (e.g., a change from a silty sand to a gravelly sand or to a sandy silt).
5. Photograph the cores after they have been described and before any sediment is removed for processing. It is important for each core section to be photographed with adequate lighting from a standard measured distance from the core. Digital photographs may be used later in the production of digital core logs.

Mixing and Sample Preparation

1. After the sample is characterized and the core observation logged on the Field Sediment Core form, remove the specified sample interval using a stainless-steel spatula or spoon (see project-specific FSP for correct sampling interval). Exercise care to not include sediment that is in direct contact with the core tube. With the approval of the field team leader, and using a decontaminated stainless-steel instrument, carefully remove unrepresentative material (e.g., large shells, stones). Exercise care not to touch the sediment during this process. Note any unrepresentative material removed from the sample in the field processing area notebook.
2. Remove subsamples for analysis of unstable constituents (e.g., volatile organic compounds, acid-volatile sulfides), and place them directly into sample containers without homogenization. Completely fill the sample container so that there is no headspace or entrapped bubbles.
3. Transfer the remainder of the sample interval to a decontaminated stainless-steel bowl for homogenization. If additional sediment volume is required to fill all sample bottles (see project-specific FSP) and multiple cores need to be collected at a given station, cover the compositing bowl covered with aluminum foil (dull side down) to prevent sample contamination (e.g., from precipitation, engine exhaust, splashing water) and place in a cool dark place until the next core from that location is processed.
4. After all the sediment is transferred to the compositing bowl, homogenize the contents of the bowl using stainless-steel spoons until the texture and color of the sediment appears to be uniform.
5. Distribute subsamples to the various containers specified in the project-specific FSP and preserve the samples as specified in the project-specific FSP. Briefly stir the sediment in the compositing bowl between each spoon transfer to the sample containers.
6. Subsequent intervals should be processed in the same way.

Field Quality Control Samples

If additional volumes of sediment are required to perform all analyses including quality control analyses, an additional core may need to be collected from the same location and subsampled and homogenized accordingly. Details on collection of field quality control samples (e.g., field duplicates) will be specified in the project-specific FSP. Details on collection of field quality control samples and preparation of the certified reference materials can be found in SOP SD-02, *Preparation of Field Quality Control Samples—Sediment,* and SOP SD-03, *Preparation of Reference Materials—Sediment*. Not all of the field quality control samples discussed in this SOP may be required for a given project. The specific field quality

control samples will be described in the project-specific FSP and quality assurance project plan.

Field Measurements

A water depth measurement must be collected at every sampling location. Depending on the specific project objectives, it may be necessary to perform field measurements of the *in situ* environment. Possible field measurements include temperature and pH of the sediment at the sediment-water interface and concentration of dissolved oxygen, salinity, or conductivity in the overlying water. Details on collection of field measurements can be found in SOP SD-11, *Field Analyses for Sediment*. The specific field measurements, if any, will be specified in the project-specific FSP.

Station Location Coordinates

Station locations for all field sampling will be determined using a differential global positioning system (DGPS) or by surveying. The accuracy to which the latitude and longitude of a station location is determined will be specified in the FSP. At a minimum, a DGPS capable of providing latitude and longitude coordinates with an accuracy of approximately 3 m is recommended. The DGPS consists of two satellite receivers linked to each other by a VHF telemetry radio system. The receiver will be on the sampling vessel. Details on collection of very accurate station coordinates can be found in SOP AP-06, *Navigation.*

Sample Custody and Shipping

Sample custody will be maintained in accordance with procedures outlined in SOP AP-03, *Sample Custody*. All samples will be packaged and shipped with other samples in accordance with procedures outlined in SOP AP-01, *Sample Packaging and Shipping*.

Troubleshooting

Insufficient Sample

The corer may not collect enough sediment because of 1) inadequate penetration, 2) adequate penetration but poor recovery due to compaction, 3) adequate penetration but poor recovery as a result of bypass, or 4) adequate penetration but loss of sample during retrieval. Compaction and bypass are two different artifacts that are difficult to distinguish and quantify. Following is an approach to identifying the causes and remedies of insufficient sample length. Keep in mind that a combination of these causes may occur:

- **Inadequate Penetration**—Allow more vibration time at the refusal depth, or increase the vibrator frequency.

- **Poor Recovery Due to Compaction**—Compaction is the process of rearranging the sediment particles, so that less volume is occupied by pore water, which results in a shorter column of sediment in the corer than *in situ*. Compaction occurs only in clean coarse silt, sand, and gravel sediments that have a high hydraulic conductivity and are not terminally compacted *in situ*. Fine-grained cohesive sediment (i.e., low hydraulic conductivity) does not compact. The key feature of compaction is that all of the solids ahead of the nosecone are collected as the corer penetrates. So, although the calculated recovery is less than 10 percent, 100 percent of the sediment solids were recovered. Therefore, if the sample has poor recovery, is composed of clean coarse-grained materials, and there is no evidence of sediment falling out the bottom, then the sample is likely to have been compacted. Depending on the project-specific FSP, the specified sample intervals may be shortened proportional to recovery. Because compaction of the solids displaces pore water, minimal compaction is needed for cores that are intended for porewater studies, or cores that will be analyzed for substances that have low K_d values. Vibration in vibracorers is known to rearrange particles, which leads to compaction, so another type of corer may be appropriate if compaction is a problem.
- **Poor Recovery as a Result of Bypass**—Bypass is the process of pushing sediment out of the path of the nosecone/corer as it penetrates the sediment. This is caused by the friction of sediment inside the core liner making it difficult for more sediment to enter the tube. This is most pronounced in fine-grained sediments that have low hydraulic conductivity, or layers of hard and soft sediment, or long cores. The low hydraulic conductivity prevents porewater from being displaced, so compaction cannot occur. Fine-grained sediments in this context are those in which particles cannot be felt between the thumb and forefinger of an ungloved hand. These are generally "sticky" or cohesive sediments. Therefore, if a sample has poor recovery, is fine grained and cohesive, and there is no evidence of sediment falling out the bottom, then some of the sediment column has likely been bypassed.
- **Poor Recovery Because of Loss of Sample during Retrieval**—This is often diagnosed by observing some of the core falling out the bottom as the corer approaches the water surface during retrieval, or a core liner that is empty near the bottom. Sample slipping out the bottom of the corer can be caused by a loss of suction or noncohesive sediment that does not stick to the liner wall. Depending on the specific design of the vibracorer, there are several places at which suction can be lost. These may include the valve seat, the valve assembly, the nose piece, and couplings between the barrel and extensions. To prevent loss of suction, Teflon® plumber's tape should be used on all the threaded connections, and the valve assembly should be clean. For coarse-grained sediment (e.g., clean coarse sand and gravel, and shells) that is non-cohesive and falls out the bottom of the corer, it is sometimes possible to penetrate to a lower layer that is finer grained and will effectively plug the bottom of the core. As mentioned above, core catchers may are used to retain sediment in a vibracorer, although they should not be

used if the surface sediments have high water contents and are to be sectioned at less than about 2 inch intervals.

Because recovery can be an important indicator of corer performance, sediment characteristics, and sample quality, some simple tests can be performed as a diagnostic tool. Penetration of the corer can be measured by putting Velcro® tape on the outside of the corer. Velcro® tape can also be used on the inside of the liner during testing to see how far up inside the liner the sediment interface moves, how much sample slips out the bottom, and how much compaction or bypass occurs.

Notes

1. For long cores that require more than one piece of liner, squarely cut the ends of both pieces with a plastic pipe cutter, butt the ends of the two pieces of liner squarely together and tape them securely so no leaks occur. Do not use too many layers of tape or the liner will not fit into the barrel. Do not use duct tape for this process. Use a high quality tape (i.e., 3M 3750) and dry the tubes before applying.
2. Sometimes tripods are not tall enough to lift the corer so that the barrel will clear the top edge of the liner when removing the liner. To remove the liner in this case, upon unscrewing the cutter head (or nose piece), lower the cutter head (or nose piece) and liner into a pail that has a rope securely tied to the handle. While the corer is raised by the winch, lower the pail through the hole in the deck and into the water (if necessary) until the top edge of the liner clears the bottom edge of the barrel. Then lift it back onto the deck.
3. If the vibracorer does not penetrate significantly or if the cable is let out too quickly, the vibracorer will contact the bottom, tip over, and fall sideways. When this happens, the line will initially go slack, then quickly snap to the side and take up the slack. In this case, reject the core and begin again.
4. A good measure of whether the vibracorer collected the sediment-water interface is to inspect the interface for a thin layer (about 1 mm) of olive green benthic or detrital algae. Also, if the core liner is rotated back and forth gently, the top centimeter will appear to have a gelatinous response.
5. It is sometimes impossible to collect an intact interface because gas bubbles are commonly released from sediment when the corer contacts the sediment. The released gas bubbles entrain surface sediment and cause the overlying water to become turbid. If this is the case, gas bubbles in the sediment can likely be observed through the liner wall.

REFERENCES

ASTM. 2000. Standard practice for description and identification of soils (visual-manual procedure). ASTM Standard Method No. D 2488-00. In: ASTM Book of Standards, Volume 04.08. American Society for Testing and Materials, West Conshohocken, PA.

STANDARD OPERATING PROCEDURE (SOP) SD-25

BORING AND SEDIMENT CORE SAMPLE COLLECTION FOR GEOTECHNICAL ANALYSIS

SCOPE AND APPLICATION

This SOP describes the procedure for drilling borings and collecting sediment core samples for geotechnical analysis. Borings will be installed with drilled borehole methods, such as mud rotary drilling, cased through the water column. For this SOP, mud rotary refers to installation of a fully cased hole using a tricone bit to loosen soil as cuttings. Drill cuttings will be removed using seawater as drilling fluid, unless conditions warrant use of drilling mud. Casings will be advanced by spinning the casing to advance generally ahead of sampling activities.

This SOP may change depending on field conditions, equipment limitations, or limitations imposed by the procedure.

SUPPLIES AND EQUIPMENT

Drilling and sampling equipment will be provided by the drilling contractor (drilling mud, split-spoon samplers, core liners, Shelby tubes, core caps). The Integral field crew will provide the following supplies and equipment:

- Differential global positioning system (DGPS) equipment (if not supplied by contractor), see "Station Location Coordinates" section, below
- Decontamination equipment (see SOP SD-01)
- Sample processing equipment (stainless-steel mixing bowls and spoons)
- Sample processing table(s)
- Electrical tape and wax seals for Shelby tubes
- Laboratory-supplied sample containers, insulated coolers, and ice
- Chain-of-custody forms, custody seals, and sample labels
- Ziploc® bags
- Camera

- Tape measures (for water depth measurements and core logging)
- Sediment probes for field measurements, if applicable per the project field sampling plan (FSP)
- Field logbook, boring log form, and pens
- Project-specific FSP with SOPs
- Project-specific health and safety plan
- Personal protective equipment (safety glasses, steel-toed boots, nitrile gloves, and any other items required by the project-specific health and safety plan)
- Investigation-derived waste containment supplies (garbage bags, drums and labels, as appropriate).

PROCEDURES

Decontamination

1. To prevent potential cross-contamination of samples, decontaminate all reusable sediment sampling equipment prior to use at each station and between field replicates.
2. Before each station is sampled, decontaminate the inner surfaces of the corer or core tube liner and all stainless-steel sample compositing equipment.
3. Prior to sampling, wash all core liners in sequence with a standard detergent (e.g., Alconox®), rinse with site water, and then air-dry.
4. During storage and transport, cap decontaminated core liners at both ends to prevent contamination. Details on correct decontamination procedures can be found in SOP SD-01, "Decontamination of Sediment Sampling Equipment."
5. When performing the decontamination procedures, wear protective clothing as specified in the site-specific health and safety plan.
6. Collect all solvent rinsates (if used) into a bucket or tub and allow to evaporate over the course of the day.
7. Containerize any rinsate that has not evaporated by the end of the sampling event and dispose of in accordance with applicable regulations.

Installation and Sampling

This section provides the procedure for installing geotechnical borings; observations made during geotechnical boring installation will be recorded in the boring log or in the field logbook.

Before sediment borings are installed, Integral will have provided the subcontractor with the target location coordinates. The drill rig will have been positioned by the subcontractor consistent with SOP AP-06, "Navigation and Station Positioning."

1. Once on location, measure the water depth (depth to top of sediment) using the onboard depth sounder (fathometer) or lead line and record measured depth in the field logbook.
2. If the water level is affected by tides, obtain tide level measurements and calculate tidal height in feet above mean low water.
3. Record the date, time, weather, and water conditions (e.g., high wave activity, strong currents, turbidity, tidal flux) in the field logbook.

Sediment borings will be installed by a licensed drilling contractor using mud rotary drilling. Drilling fluid will be recirculated in a closed loop system with cuttings removed in a mud tub. The steel casing that encloses the tooling and drilling fluid will be initially extended into the sediment approximately 2 or 3 ft, or as deep as required to prevent water loss from the casing, before sampling (or casing telescoping) occurs. The drilling operation and casing approach will account for tidal fluctuation. To reach required depth as specified in the sampling and analysis plan (SAP), more than one boring per location may be necessary due to tidal variation. The casing will be advanced to the top of each sample interval and cleaned out (cuttings removed) to confirm that sampling is performed for the required interval.

The driller will perform sampling ahead of the casing to maintain accuracy of the standard penetration testing (SPT) and Shelby tube sampling. In conjunction with the use of drilled casing methodologies, sediment samples will be collected using a standard 2-in.-outer-diameter by 2-ft-long split-spoon sampler driven by a 140-lb hammer, unless otherwise specified. The split-spoon sampler will be advanced to the sampling depth specified in the project SAP. The sampling method used for split-spoon sampling will be ASTM International (ASTM) D1586 (ASTM 2011).

The condition for refusal during drilling is seizing of the drill bit or no advancement following reasonable attempts by the drilling contractor to continue boring. The determination of refusal is a decision made by the drilling contractor. If refusal occurs, the field engineer will contact the supervising engineer to determine if the soil boring is sufficiently deep to abandon, or if repositioning is required within 10 ft of the refusal location. All refusals will be documented with respect to depth, location, and any available information about the obstruction.

The condition of the SPT refusal during sampling is determined to occur when:

- A total of 50 blows have been applied during any one of the three, 6-in. increments of the sample advancement.
- A total of 100 blows have been made.

- There is no observed advance of the sampler during application of 10 successive blows of the hammer.

Sample Handling, Storage, and Processing

Cores are to be processed concurrently with core collection, and every effort should be made to ensure that processing occurs within 24 hours of collection.

Core Staging

1. Tightly seal both ends of cores awaiting processing and store upright in ice or in a refrigerator.
2. If core collection outpaces processing such that significant delays in core processing appear likely, suspend core collection to allow the core processing to catch up.
3. Once coring has been completed at a given location, transport the cores in an upright position on ice to a designated field processing area for logging and processing. The field processing area will be equipped with core-processing tables, a decontamination area, and a storage area with appropriate refrigeration. The field processing area will have appropriate lighting so that consistent, high quality photographs can be taken of the opened cores. It should be set up such that the potential for outside contamination is minimized.

Processing of the split-spoon samples includes removing the sample from the liner, recording observations of sample characteristics (see below), mixing subsamples, and distributing the sample to containers for shipping to the testing laboratory.

Core Observations

1. Verify that the length of the core, water depth, and all required position data have been recorded in the field logbook together with all pertinent observations and communications with the field team leader.
2. After each core is cut open, describe the following sediment characteristics on a boring log form or in the field logbook. When recording the information for each core, use the following guidelines:
   - Physical sediment description (i.e., sediment type [e.g., silt, sand], density/ consistency, color) (see SOP SL-04, "Field Classification of Soil", based on ASTM D 2488-00 [ASTM 2000])
   - Odor (e.g., hydrogen sulfide, petroleum, creosote)
   - Visual stratification, laminations, and lenses
   - Presence/location/thickness of the redox potential discontinuity layer (a visual indication of black is often adequate for documenting anoxia)

- Moisture content
- Presence/absence and type of vegetation
- Approximate percentage of vegetation
- Presence/absence and type of debris
- Approximate percentage of debris
- Presence of biological structures (e.g., detritus, shells, tubes, bioturbation, live or dead organisms, chironomids)
- Approximate percentage of biological structures
- Presence of a sheen
- Other distinguishing characteristics or features.

3. Use other observations (e.g., obvious anthropogenic material, dramatic color changes) to define or help define sample intervals (check project-specific SAP for sample interval definition; depending upon the project-specific requirements the sample interval could be based on lithology or it could be set to a specific interval [e.g., 1 ft]).
4. Determine the boundaries of lithologic units primarily by changes in the top two dominant grain sizes estimated visually (e.g., a change from a silty sand to a gravelly sand or to a sandy silt).
5. Photograph the cores after they have been described and before any sediment is removed for processing. It is important for each core section to be photographed with adequate lighting from a standard measured distance from the core. Digital photographs may be used later in the production of digital core logs.

Split-Spoon Sample Collection and Preparation

1. Collect representative sediment samples for geotechnical laboratory testing from split-spoon samples from within the discrete layer of an individual SPT sample core. Do not composite across multiple SPT samples or within an SPT sample where soil conditions change from one lithology to another.
2. Proceed with sample collection for each discernible and unique layer within an SPT that is of sufficient thickness to collect for testing. (Note: in the boring log form, report the thickness and soil description for discrete layers present within an SPT sample core; however, if a discrete layer lacks sample volume, simply photograph it.)
3. Record the approximate thickness and depth within each sample for thin layers on the log; the geotechnical engineer will classify the soil type.

Shelby Tube Sample Collection and Preparation

1. As Shelby tube samples are collected, describe each tube on the boring log form with the following information:
   - Total recovery (includes recovered/inches advanced)
   - Integrity of Shelby tube (e.g., good condition, dented, bent)
   - Observations about poor handling or retrieval of sample
   - Other miscellaneous observations.
2. Once retrieved, use soil caps to seal the inside of the tube and secure end caps to each end of the tube with electrical tape.
3. Dip the ends in wax and label the tube with the sample ID, time, date, location, and "up" direction.
4. Store and firmly secure all Shelby tubes vertically so that the sediment remains in its *in situ* orientation.
5. Ensure the storage location is protected, to the extent practical, from shocks and vibrations.

Field Quality Control Samples

If additional volumes of sediment are required to perform all analyses, including quality control analyses, an additional core may need to be collected from the same location and subsampled and homogenized accordingly. Details on collection of field quality control samples (e.g., field duplicates) will be specified in the project-specific SAP. Details on collection of field quality control samples can be found in SOP SD-02, "Preparation of Field Quality Control Samples for Sediments." Not all of the field quality control samples discussed in this SOP may be required for a given project. The specific field quality control samples will be described in the project-specific SAP and quality assurance project plan.

Field Measurements

Water depth will be measured at every sampling location. Depending on the specific project objectives, it may also be necessary to perform field measurements of the *in situ* environment. Possible field measurements include temperature and pH of the sediment at the sediment–water interface and concentration of dissolved oxygen, salinity, or conductivity in the overlying water. Details on collection of field measurements can be found in SOP SD-11, "Field Analyses for Sediment." The specific field measurements required, if any, will be specified in the project-specific FSP.

Station Location Coordinates

Station locations for all field sampling will be determined using a DGPS or by surveying. The accuracy to which the latitude and longitude of a station location is determined will be specified in the FSP. At a minimum, a DGPS capable of providing latitude and longitude coordinates with an accuracy of approximately 3 m is recommended. The DGPS consists of two satellite receivers linked to each other by a VHF telemetry radio system. The receiver will be on the sampling vessel. Details on collection of very accurate station coordinates can be found in SOP AP-06, "Navigation and Station Positioning."

Sample Custody and Shipping

1. Maintain sample custody in accordance with procedures outlined in SOP AP-03, "Sample Custody."
2. Package and ship all samples with other samples in accordance with procedures outlined in SOP AP-01, "Sample Packaging and Shipping."

Troubleshooting Insufficient Sample Size

Failure of the corer to collect sufficient sediment volume may be the result of 1) inadequate penetration, 2) adequate penetration but poor recovery due to compaction, 3) adequate penetration but poor recovery as a result of bypass, or 4) adequate penetration but loss of sample during retrieval. Insufficient sample collection may be the result of a combination of these causes. Compaction and bypass are two different artifacts that are difficult to distinguish and quantify. The following is an approach to identifying the causes and remedies of insufficient sample recovery:

- **Poor Recovery Due to Compaction**—Compaction is the process of sediment particles rearranging, such that less volume is occupied by porewater, which results in a shorter column of sediment in the corer than *in situ*. Compaction occurs only in clean coarse silt, sand, and gravel sediments that have a high hydraulic conductivity and are not terminally compacted *in situ*. Fine-grained cohesive sediment (i.e., low hydraulic conductivity) does not compact. The key feature of compaction is that all of the solids ahead of the nosecone are collected as the corer penetrates. So, although the calculated recovery is less than 10 percent, 100 percent of the sediment solids is recovered. Therefore, if the sample has poor recovery, it is composed of clean coarse-grained materials, and there is no evidence of sediment falling out the bottom, then the sample is likely to have been compacted. Depending on the project-specific SAP, the specified sample intervals may be shortened proportional to recovery. Because compaction of the solids displaces porewater, minimal compaction is needed for cores that are intended for porewater studies, or cores that will be analyzed for substances that have low K_d values.

- **Poor Recovery as a Result of Bypass**—Bypass is the process of sediment being pushed out of the path of the nosecone/corer as it penetrates the sediment. This process is caused by the friction of sediment inside the core liner making it difficult for more sediment to enter the tube. Bypass is most pronounced in fine-grained sediments that have low hydraulic conductivity, or layers of hard and soft sediment, or long cores. The low hydraulic conductivity prevents porewater from being displaced, so compaction cannot occur. Fine-grained sediments in this context are those in which particles cannot be felt between the thumb and forefinger of an ungloved hand. These are generally "sticky" or cohesive sediments. Therefore, if a sample has poor recovery, it is fine grained and cohesive, and there is no evidence of sediment falling out the bottom, then some of the sediment column has likely been bypassed.
- **Poor Recovery Because of Loss of Sample during Retrieval**—Sample loss can be diagnosed by observing some of the core falling out the bottom as the corer approaches the water surface during retrieval, or a core liner that is empty near the bottom. Sample slipping out the bottom of the corer can be caused by a loss of suction or noncohesive sediment that does not stick to the liner wall.

Because recovery can be an important indicator of corer performance, sediment characteristics, and sample quality, some simple tests can be performed as a diagnostic tool. Penetration of the corer can be measured by putting Velcro® tape on the outside of the corer. Velcro® tape can also be used on the inside of the liner during testing to see how far up inside the liner the sediment interface moves, how much sample slips out the bottom, and how much compaction or bypass occurs.

REFERENCES

ASTM. 2000. Standard practice for description and identification of soils (visual-manual procedure). ASTM Standard Method No. D 2488-00. In: ASTM Book of Standards, Volume 04.08. ASTM International, West Conshohocken, PA.

ASTM. 2011. Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils in Cohesive Soils. ASTM Standard Method No. D1586. In: ASTM Book of Standards, Volume 04.08. ASTM International, West Conshohocken, PA.

STANDARD OPERATING PROCEDURE (SOP) SL-04

FIELD CLASSIFICATION OF SOIL

SCOPE AND APPLICATION

This SOP establishes the minimum information that must be recorded in the field to adequately document surface soil sampling and soil borehole advancement activities performed during field exploration. The surface soil sampling or borehole log form must be filled out completely for each station.

This SOP presents the field classification of soils to be used by Integral field staff. In general, Integral has adopted the procedures provided in American Society for Testing and Materials (ASTM) Method D-2488-00, Standard Practice for Description and Identification of Soils. ASTM D-2488-00 uses the Unified Soil Classification (USC) system for naming soils. Field personnel are encouraged to study these procedures prior to initiation of fieldwork.

Soil descriptions should be precise and comprehensive without being verbose. The overall impression of the soil should not be distorted by excessive emphasis on minor constituents. In general, the similarities of consecutive soil samples should be emphasized and minor differences de-emphasized. These descriptions will be used to interpret potential contaminant transport properties, rather than interpret the exact mineralogy or tectonic environment. We are primarily interested in engineering and geochemical properties of the soil.

Soil descriptions should be provided on the surface soil field collection form or in the soil description column of the Integral's soil boring log for each sample collected. If there is no difference between consecutive soil samples, subsequent descriptions can be noted as "same as above" or minor changes such as "increasing sand" or "becomes dark brown" can be added.

The format and order of soil descriptions should be as follows:

- Group symbol (in the Unified Symbol column)
- USC name (should be identical to the ASTM D-2488-00 Group Name with the appropriate modifiers)
- Minor components
- Color
- Moisture
- Additional descriptions.

EQUIPMENT AND REAGENTS REQUIRED

- Surface soil field collection form or borehole log form (see SOP SL-06, *Logging of Soil Boreholes*)
- Munsell® soil color chart.

PROCEDURES

The USC is an engineering properties system that uses grain size to classify soils. The first major distinction is between fine-grained soils (more than 50 percent passing the No. 200 sieve [75 μm/0.0029 in.]) and coarse-grained soils (more than 50 percent retained by the No. 200 sieve). Small No. 200 sieves are necessary to classify soils near the cutoff size.

1. Fine-grained soils are classified as either silts or clays. Field determinations of silts and clays are based on observations of dry strength, dilatancy, toughness, and plasticity. Field procedures for these tests are included in ASTM D-2488-00. If these tests are used, include the results in the soil description. If these materials are encountered, perform at least one complete round of field tests for a site, preferably at the beginning of the field investigation. The modifiers "fat" and "lean" are used by ASTM to describe soils of high and low plasticity. The soil group symbols (e.g., CL, MH) already indicate plasticity characteristics, and these modifiers are not necessary in the description. Soils with high plasticity can be emphasized by describing them as "silty CLAY with high plasticity." Plasticity, for example, is an important descriptor because it is often used to interpret whether an ML soil is acting as either a leaky or a competent aquitard. For example, an ML soil can be dilatant/nonplastic and serve as a transport pathway, or it can be highly plastic and very impervious.
2. Coarse-grained soils are classified as either predominantly gravel or sand, with the No. 4 sieve (4.75 mm/0.19 in.) being the division. Use modifiers to describe the relative amounts of fine-grained soil, as noted below:

Description	Percent Fines	Group Symbol
Gravel (sand)	<5 percent	GW, GP (SW, SP)
Gravel (sand) with silt (clay)	5–15 percent	Hyphenated names
Silty (clayey) gravel (sand)	>15 percent	GM, GC (SM, SC)

The gradation of a coarse-grained soil is included in the specific soil name (e.g., fine to medium SAND with silt). Estimating the percent of size ranges following the group name is encouraged for mixtures of silt sand and gravel. Use of the modifiers "poorly graded" or "well graded" is not necessary, as they are indicated by the group symbol.

Show a borderline classification with a slash (e.g., GM/SM). Use this symbol when the soil cannot be distinctly placed in either soil group. Also use a borderline symbol when describing interbedded soils of two or more soil group names when the thickness of the beds are approximately equal, such as "interbedded lenses and layers of fine sand and silt." Do not use a borderline symbol indiscriminately. Make every effort to place the soil into a single group. (One very helpful addition to the soil log form description is the percentage of silt/sand/gravel. Even if the geologist did not have sufficient time to properly define the soil, this percentage breakdown allows classification at a later date).

3. Precede minor components, such as cobbles, roots, and construction debris with the appropriate adjective reflecting relative percentages: trace (0–5 percent), few (5–10 percent), little (15–25 percent), and some (30–45 percent). Use the word "occasional" to describe random particles of a larger size than the general soil matrix (i.e., occasional cobbles, occasional brick fragments). The term "with" indicates definite characteristics regarding the percentage of secondary particle size in the soil name. It is not to be used to describe minor components. If a nonsoil component exceeds 50 percent of an interval, state it in place of the group name.
4. Give the basic color of a soil, such as brown, gray, or red. Modify the color term with adjectives such as light, dark, or mottled, as appropriate. Especially note staining or mottling. This information, for example, may be useful to establish water table fluctuations or contamination in boreholes. The Munsell® soil color chart designation is the Integral color standard. These charts are readily available and offer a high degree of consistency in descriptions between geologists.
5. Define the degree of moisture present in the soil as dry, moist, or wet. Moisture content can be estimated from the criteria listed in Table 3 of ASTM D-2488-00.
6. If observed, note such features as discontinuities, inclusions, joints, fissures, slickensides, bedding, laminations, root holes, and major mineralogical components. Note anything unusual. Additional soil descriptions may be made at the discretion of the project manager or as the field conditions warrant. The surface soil field collection and soil boring log forms list some optional descriptions, as does Table 13 of the ASTM standard. The reader is referred to the ASTM standard for procedures of these descriptions.

The contact between two soil types must be clearly marked on the surface soil field collection or soil boring log forms. If the contact is obvious and sharp, draw it in with a straight line. If

it is gradational, use a slanted line over the interval. In the case where it is unclear, use a dashed line over the most likely interval.

For drilling activities, the field geologist, who has the advantage of watching the drilling rate and cuttings removal and can talk with the driller in real time, has a much better chance of interpreting the interval than someone in the office.

REFERENCE

ASTM D2488 – 00: Standard practice for description and identification of soils (visual-manual procedure). ASTM International.

STANDARD OPERATING PROCEDURE (SOP) SL-06

LOGGING OF SOIL BOREHOLES

SCOPE AND APPLICATION

This SOP describes how to complete a Soil Boring Log form, which must be completed for Integral projects where soil boring techniques are performed during field exploration. A correctly completed form contains all of the information that must be recorded in the field to adequately characterize soil boreholes.

These procedures are adapted from ASTM D-2488-00. Field staff are encouraged to examine ASTM D-2488-00 in its entirety. This SOP represents minor modifications to emphasize environmental investigations rather than geotechnical investigations, for which the standards were written. Because each environmental project is unique and because job requirements can vary widely, the minimum standards presented may need to be supplemented with additional technical descriptions or field test results. However, all soil boring field logs, regardless of special project circumstances, must include information addressed in this SOP to achieve the minimum acceptable standards required by Integral.

LOG FORM INFORMATION

Project Number—Use the standard contract number.

Client—Identify the name of the client and the project site location.

Location—If stations, coordinates, mileposts, or similar markers are applicable, use them to identify the location of the project. If this information is not available, identify the facility (e.g., 20 ft NE of Retort #1).

Drilling Method—Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger, cable tool) and the name of the drill rig (e.g., Mobil B 61, CME 55).

Diameter—Provide the diameter of the borehole. If the borehole has variable diameters, provide the depth interval for each diameter.

Sampling Method—Identify the type of sampler(s) used (e.g., standard split spoon, Dames & Moore sampler, grab).

Drilling Contractor—Provide the name of the drilling contractor.

Integral Staff—Enter the name(s) of Integral staff members performing logging and sampling activities.

Water Level Information—Provide the date, time, depth to static water, and casing depth. Generally, water levels should be taken each day before resuming drilling and at the completion of drilling. If water is not encountered in the boring, this information should be recorded.

Boring Number—Provide the boring number. A numbering system should be developed prior to drilling that does not conflict with other site information, such as previous drilling or other sampling activities.

Sheet—Number the sheets consecutively for each boring and continue the consecutive depth numbering.

Drilling Start and Finish—Provide the drilling start and finish dates and times.

For consecutive sheets, provide (at a minimum) the job number, boring number, and sheet number.

TECHNICAL DATA

Sampler Type—Provide the sampler type (e.g., SS = split spoon, G = grab).

Depth of Casing—Enter the depth of the casing below ground surface immediately prior to sampling.

Driven/Recovery—Provide the length that the sampler was driven and the length of sample recovered in the sampler. This column would not apply to grab samples.

Sample Number/Sample Depth—Provide the sample number. The sample numbering scheme should be established prior to drilling. One method is to use the boring number and consecutive alphabetical letters. For instance, the first sample obtained from boring MW-4 would be identified as 4A, the second would be identified as 4B, and so on. Another method for sample identification is naming the boring number with the depth. For example, the sample from Boring 1 at 10 ft would be labeled B1-10'. The depth of the sample is the depth of the casing plus the length to the middle of the recovered sample to the nearest 0.1 ft. Typically, split spoon samplers are 18 in. long. Samples should be obtained from the middle of the recovered sample. The depth of the sample with the casing at 10 ft would then be 10.7 ft.

Number of Blows—For standard split-spoon samplers, record the number of blows for each 6 in. of sampler penetration. A typical blow count of 6, 12, and 14 is recorded as 6/12/14. Refusal is a penetration of less than 6 in. with a blow count of 50. A partial penetration of 50 blows for 4 in. is recorded as 50/4". Total blows will be recorded for nonstandard split spoons (e.g., 5-ft tube used for continuous sampling).

Blank Columns—Two blank columns are provided. Use these columns for site-specific information, usually related to the chemicals of concern. Examples for a hydrocarbon site would be sheen and photoionization detector readings of the samples.

Depth—Use a depth scale that is appropriate for the complexity of the subsurface conditions. The boxes located to the right of the scale should be used to graphically indicate sample locations as shown in the example.

Surface Conditions—Describe the surface conditions (e.g., paved, 4-in. concrete slab, grass, natural vegetation and surface soil, oil-stained gravel).

Soil Description—Enter the soil classification and definition of soil contacts using the format described in SOP SL-04, *Field Classification of Soil*.

Comments—Include all pertinent observations. Drilling observations might include drilling chatter, rod-bounce (boulder), sudden differences in drilling speed, damaged samplers, and malfunctioning equipment. Information provided by the driller should be attributed to the driller. Information on possible contaminants might include odor, staining, color, and presence or absence of some indicator of contamination. Describe what it is that indicates contamination (e.g., fuel-like odor, oily sheen in drill cuttings, yellow water in drill cuttings).

REFERENCE

ASTM D 2488 – 00: Standard practice for description and identification of soils (visual-manual procedure). ASTM International.

ATTACHMENT 1. SOIL BORING LOG FORM

integral consulting inc.
319 SW Washington St., Suite 1150
Portland, OR 97204
(503) 284-5545

STATION NUMBER
PROJECT
LOCATION
PROJECT NUMBER
LOGGED BY

SAMPLE INFORMATION						STRATA	DESCRIPTION
Sample ID	Depth	Time	Tag No.	% Recov.	Depth (Feet)		USCS group name, color, grain size range, minor constituents, plasticity, odor, sheen, moisture content, texture, weathering, cementation, geologic interpretation, etc.
					2--		
					4--		
					6--		
					8--		
					10--		
					12--		
					14--		

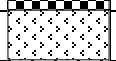
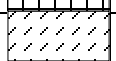
DRILLING CONTRACTOR
DRILLING METHOD
SAMPLING EQUIPMENT
DRILLING STARTED
COORDINATES
SURFACE ELEVATION
DATUM

Location Sketch

ATTACHMENT 2. FIELD CLASSIFICATION OF SOILS, BASED ON UNIFIED SOIL CLASSIFICATION SYSTEM AND ASTM STANDARD D-2488

integral consulting inc.

Field Classification of Soils, Based on Unified Soil Classification System and ASTM Standard D-2488

Major Divisions		Symbol and Pattern		General Soil Description
Coarse-Grained Soils (More than 1/2 of soil >No. 200 sieve size)	**Gravels**	GW		Well-graded gravels or gravel-sand mixtures, little to no fines
		GP		Poorly-graded gravels or gravel-sand mixtures, little to no fines
		GM		Silty gravels or gravel-sand-silt mixtures
		GC		Clayey gravels or gravel-sand-clay mixtures
	Sands	SW		Well-graded sands or gravel-sand mixtures, little to no fines
		SP		Poorly-graded sands or gravelly sands, little to no fines
		SM		Silty sands, sand-silt mixtures
		SC		Clayey sands, sand-clay mixtures
Fine-Grained Soils (More than 1/2 of soil <No. 200 sieve size)	**Silts**	ML		Inorganic silts with slight plasticity
		MH		Inorganic elastic silts
		OL		Organic elastic silts
	Clays	CL		Inorganic clays of low to medium plasticity, lean clays
		CH		Inorganic clays of high plasticity, fat clays
		OH		Organic clays of medium to high plasticity
Highly Organic Soils		Pt		Peat, sample composed primarily of vegetable tissue

Soil Classification Notes

Groundwater, First Observed

Groundwater, Static

Sampling Equipment

SS	Split Spoon
ST	Shelby Tube
GS	Geoprobe® Macrocore Sampler

Sheen Types

NS	No Sheen
LS	Light Sheen
MS	Moderate Sheen
HS	Heavy Sheen

Sample Moisture

Dry	No moisture, dry to touch
Moist	Damp, but no free water
Wet	Visible free water

Sample Plasticity (Fine-Grained Soils)

Non-Plastic -	Cannot be rolled at any moisture content.
Low -	Can barely be rolled, lump cannot be formed when drier than plastic limit.
Medium -	Can easily be rolled, lump crumbles when drier than plastic limit.
High -	Can easily be rolled, but takes considerable time to reach the plastic limit. Lump can be formed without crumbling when drier than the plastic limit.

Particle Size Range (Coarse-Grained Soils)

Gravel -	Fine, Coarse
Sand -	Fine, Medium, Coarse

STANDARD OPERATING PROCEDURE SOP-3:

SUBSURFACE SEDIMENT SAMPLING USING A SPLIT-SPOON SAMPLER AND A GUS OR OSTERBERG SAMPLER EQUIPPED WITH A SHELBY TUBE

Scope and Application

This SOP describes Integral procedures for the collection of subsurface sediment samples using a split-spoon sampler and a Gregory Undisturbed Sampler (GUS) or Osterberg sampler equipped with a Shelby Tube. Sediment cores will be collected following ASTM Method D-1586-84, Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.

Supplies and Equipment

A generalized supply and equipment list is provided below. Additional equipment may be required depending on the project.

- Sampling device:
  - Hollow-stem auger drill rig (or equivalent Sonic rig)
  - Stainless-steel, 1.5-ft-long, 2-in-diameter split spoon; ***or*** 2.5-ft-long, 3-in-diameter split-spoon sampler or Shelby tubes
  - Stainless-steel or other liners, if required
  - Stainless-steel core catchers (as necessary)
  - Core extruder device, drill, ratchet, plugs
  - 55-gallon drums (if required)
- Field equipment:
  - Aluminum foil
  - Duct tape
  - Hack saw
  - Plastic sheeting
  - Pipe cutter

  - Plunger (if necessary)
  - Table or tray
  - Ice (if storing cores)
  - Stainless-steel bowls
  - Stainless-steel spoons, spatulas, and/or mixer
  - Assorted geology supplies (e.g., hand lens, grain-size card, scales, etc.)
  - Decontamination equipment (SOP-9)
  - Personal protective equipment for field team (rain gear, safety goggles, hard hats, nitrile gloves)
  - Photoionization detector (PID)
  - First Aid kit
  - Cell phone
  - Camera
  - Sample containers
  - Ziploc® bags
  - Bubble wrap
  - Clear tape
  - Permanent markers
  - Indelible ink pen
  - Pencils
  - Coolers
- Documentation:
  - Core description forms
  - Waterproof field logbook
  - Field Sampling Plan (FSP)
  - Health and Safety Plan (HASP)
  - Chain-of-custody seals
  - Sample labels
  - Correction forms

Procedures

Hollow-stem auger or equivalent (e.g., Sonic) drilling is used to obtain sediment cores using both split-spoon and GUS or Osterberg samplers equipped with a Shelby tube. Both split-spoons and Shelby tubes can collect similar-sized cores (2-ft-long, 3-in-diameter), although the methods of obtaining the cores differ. Split-spoons are hammered into the sediment, while Shelby tubes are hydraulically or pneumatically (with nitrogen gas) driven into the sediment. In addition, each half of a split-spoon sample is simply pulled apart to expose the core, while the sediment must be extruded from the Shelby tube. Once the core is exposed, the processing and handling of the core sample is identical.

The following sections describe the methods of collecting and "extruding" split-spoon and Shelby tube cores, respectively. Methods for processing and sampling the cores are also included.

Collection of Cores Using a Split-Spoon Sampler

1. Decontaminate the split-spoon sampler, liners (if used), and other equipment in accordance with SOP-9. If a stainless-steel split-spoon sampler without liners is used, the sampler should be fully decontaminated between all samples collected. If liners are used, liners should be fully decontaminated, while the split-spoon should be cleaned with Alconox®, tap or seawater, and a distilled water rinse.
2. Insert stainless-steel liners into the split-spoon sampler, along with sand catchers, if required.
3. Attach the split-spoon sampler to the bottom end of a string of drill rod which extends from the top of the auger, through the hollow stem, and to the bottom of the borehole.
4. Attach a 140-pound (or other appropriate weight) hammer to the top of the drill rod string and drive the sampler into the soil at the bottom of the borehole.

   NOTE: Record the hammer weight and blow counts in the field log. The blow counts are generally recorded for each 6-inch interval.

5. To drive the sampler into the sediment, alternately raise the hammer on a rope, which passes around a rotating cathead, and allow the hammer to free-fall 30 inches by suddenly releasing the tension on the cable.
6. Pull the sampler up from the bottom of the borehole on the drive rods and remove from the bottom of the drive rod string.

7. Remove the top assembly and the drive shoe from the sampler and open the tube by removing one-half of the split barrel. If liners are used, push the sediment from the liner, and arrange the liner sections in the appropriate order, taking care to maintain the integrity of the core.
8. If field organic vapor monitoring is required, immediately collect a representative sample from the sampler and place in a new, labeled Ziploc® bag for screening. The Ziploc® bag should be closed and allowed to sit in ambient air for 10 minutes prior to monitoring with an OVM or PID.
9. Process and subsample the core as described in sections below.
10. Advance the auger and repeat steps 1-9.

Collection of Cores Using GUS or Osterberg Samplers Equipped with Shelby Tubes

1. Decontaminate the Shelby tubes and other equipment in accordance with SOP-9. The Shelby tubes should be fully decontaminated between all samples collected. Core caps should be washed with Alconox® and water, and rinsed with distilled water, in accordance with SOP-9.
2. Attach the GUS or Osterberg sampler equipped with a Shelby tube to the bottom end of a string of drill rod that extends from the top of the auger, through the hollow stem, and to the bottom of the borehole.
3. Lower the coring assembly (rod with GUS or Osterberg sampler) until it is positioned at the sediment/water interface.
4. Hydraulically (or pneumatically) drive the core tube into the sediment until a 2-ft core is obtained.
5. Once the core is brought onboard, remove it from the rod, and immediately cap and tape both ends. It is preferable to put a layer of foil on each end prior to capping. Label the core with station, sampling depth interval, time of collection, and core orientation (top of core).
6. Place the core in an upright box or stand with ice until it is processed. Cover the cores in the holding box with a tarp to prevent sample contamination from airborne particles (e.g., vessel engine gases) and to keep them out of direct sunlight.
7. The Shelby tube cores may be processed on the barge or onshore near the site. During transit, the tubes must remain upright and cool.

8. When prepared to process a core, remove the cap from the upper end of the core (holes present where the core is attached to the sampler and rod). Place the core horizontally in the extruder core holder so that the open end is toward the extruder. Secure the core in the holder and remove the other cap at the bottom of the core. Place an appropriate-sized plug wrapped in foil into the top end of the core, insert the extruder rod and screw, and wind the plug until it touches the top end of the sediment. A tray wrapped in aluminum foil should be placed at the bottom end of the core, and a person wearing nitrile or polyethylene gloves should be present to catch and guide the core as it is extruded. Use a drill or ratchet (depending on how stiff the core is) to wind the screw, pushing the core from the Shelby tube. If the core is particularly stiff, it may be necessary to hit the side of the core tube with a rubber hammer or other device while winding the extruder. Alternatively, if the core is particularly soft, the core may be readily extruded by simply pushing the plug with a rod by hand.
9. If field organic vapor monitoring is required, immediately collect a representative sample from the sampler and place it in a new, labeled Ziploc® bag for screening. The Ziploc® bag should be closed and allowed to sit in ambient air for 10 minutes prior to monitoring with an OVM or PID.
10. Process and subsample the core as described in the following sections.
11. Advance the auger, and repeat steps 1-10.

Sampling and Processing the Subsurface Sediment Cores

1. Once the core is exposed, split the core lengthwise using a decontaminated knife or spoon.
2. If subsamples are to be collected for volatile organics, total sulfides, or acid volatile sulfides, collect them immediately after the core has been split. Use a decontaminated spoon to remove sediment along the entire length of the core for each subsample collected. Place the subsample into the appropriate jar according to the procedures described in SOP-6, label the jar, and place it in a cooler with ice (or blue ice). The volatile organics sample jar should be tightly packed with sediment (to eliminate obvious air pockets) and filled so that there is no headspace remaining in the jar. Alternatively, if there is adequate water in the sediment, the container may be filled to overflowing so that a convex meniscus forms at the top, and the cap carefully placed on the jar. Once sealed, there should be no air bubbles.
3. If required by the field sampling plan, place a sign above the sample, including station number, core depth, and date and time of core collection. In addition, place a measuring stick along the length of the core, and photograph the sediment core. Avoid touching the core with the scale or sign.

4. Describe the core, including such information as the vertical changes in sediment characteristics (e.g., texture, density, and moisture) and distribution of visible contamination, color and odor of the sediments, sediment texture, presence of debris (wood chips, wood fibers, human artifacts), presence of oily sheen, and visible fauna or biological structures in accordance with ASTM Method D2488 (SOP-4). This information should be recorded in the sediment coring log, along with other information listed in SOP-4, Sediment Borehole Logging.
5. Transfer sediment selected for chemical analyses to a decontaminated stainless-steel mixing bowl. Cover the bowl if more sediment from another core is composited with the sample.
6. Mix the sediment in the bowl until well homogenized (visibly uniform) and transfer it into the appropriately sized sample containers for the individual analyses (see SOP-2, Surface Sediment Sampling).
7. Verify that samples have been properly labeled and store them onsite in a cooler at 4°C until they are packaged for shipping (see SOPs 5 and 6).
8. Generally, at completion of sediment sampling activities at a station, collect all spilled and excess material and dispose of overboard at the original sampling location. However, dispose of material in accordance with applicable regulations and any directives issued by the client. It may be required to place access material into DOT-approved 55-gallon drums (depending on level and type of contamination).
9. Decontaminate all sampling equipment, including internal components, prior to use, between sampling events, stations and depth intervals, and prior to demobilization in accordance with SOP-9, Equipment Decontamination.

STANDARD OPERATING PROCEDURES SOP-5:

SAMPLE LABELING

Scope and Application

This SOP describes the general Integral procedures for sample labeling. The project-specific sampling and analysis plan (SAP) should be consulted to determine the exact sample identifiers and sample labels are required for a given project. If they are not specified in the SAP, the designations listed below should be followed.

Supplies and Equipment

- Site logbook
- Chain-of-custody form(s)
- Sample labels.

Procedures

Environmental samples will be labeled using a unique designation system consisting of:

- Sample identification number
- Tag number
- Sample location identification.

The following describes each of the numbers.

Sample ID Number

The sample ID number is a unique number that is generally assigned six digits, including a two-digit media code and a four-digit number. The media code may be site-specific, but the Integral default codes are as follows:

- SS—Surface soil
- BH—Subsurface soil or rock (typically from borehole)
- GW—Groundwater
- SW—Surface water

- PW—Pore water
- BT—Biota or biological tissue

The exact sample ID numbering scheme may vary from project to project. Variances in the sample numbering scheme will be described in the field sampling plan for the field effort. Each sample will be assigned a unique sample number. Note that in cases where samples consist of multiple bottles from the same location, each bottle will be assigned the same sample number and time. Replicates from the same location, however, will be assigned a different sample number and time, and the sample numbers of related field replicates will not necessarily have any shared content. Each field split of a single sample will also have a different sample number and time. The sample number is recorded on the sample label, the chain-of-custody form, and the field logbook.

Sample Tag Number

A different tag number is attached to each sample container. If the amount of material (i.e., everything associated with a single sample number) is too large for a single container, each container will have the same sample number and a different sample tag. A sample will also be split between containers if a different preservation technique is used for each container (i.e., because different analyses will be conducted).

The sample tag number is a unique five- or six-digit number assigned to each sample label (or "tag") for multiple bottles per sample. Integral sample labels come with a pre-printed sample tag number. The purpose of the tag number is to provide a unique tracking number to a specific sample bottle. This allows for greater flexibility in tracking sample bottles and assists in field quality control when filling out documentation and shipping. Sample tags are not used by many other consultants, and there may be resistance from such firms during teaming situations. However, experience has shown that tags can be very valuable, both in the field and while processing data from field efforts.

Sample tag numbers will be recorded on the sample label (typically pre-printed), the chain-of-custody form, and the field logbook. Tag numbers are used by laboratories only to confirm that they have received all of the containers that were filled and shipped. Data are reported by sample number.

Sample Location ID

The sample location ID is a unique designation that identifies where the sample was collected. For sediment samples, this number is frequently the station ID (e.g., WB-10). The sample ID will also indicate if the sample is a field quality control sample (e.g., WB-10-DUP). The sample ID is recorded in the field logbook *only* and is not provided on the sample label or chain-of-custody form.

Sample Documentation

The SAP, or an appendix to the SAP, presents examples of how sample labeling information should be documented in the field logbook or borehole log. More or less information may be required on a site-specific basis.

STANDARD OPERATING PROCEDURE SOP-9:

EQUIPMENT DECONTAMINATION

Scope and Application

To prevent potential cross contamination of samples, all reusable sediment sampling and processing equipment will be decontaminated before each use. At the sample collection site, a decontamination area will be established in a clean location, upwind of actual sampling locations, if possible. This is where all sediment sampling and processing equipment will be cleaned. Decontaminated equipment will be stored away from areas that may cause recontamination. When handling decontamination chemicals, field personnel will follow all relevant procedures and will wear protective clothing as stipulated in the site-specific health and safety plan.

This SOP describes procedures for decontamination of sampling equipment, drilling equipment, and other tools that could come in contact with contaminated media (Ecology 2003, PSEP 1997).

Supplies and Equipment

- Plastic sheeting
- Steam cleaner and collection basin (if required)
- 55-gallon, DOT-approved drums (if required)
- Non-phosphate detergent (e.g., Alconox® or Liquinox®)
- Acid rinses (inorganic constituents), either reagent-grade diluted nitric or hydrochloric acid (if required)
- Solvent rinses (organic constituents), either pesticide-grade methanol, hexane, isopropanol or acetone (if required)
- Polyethylene or polypropylene tub (to collect solvent rinsate)
- Deionized or distilled water rinse available from retail stores. Note that distilled water generally contains low levels of organic contaminants and can not be used for field blanks (must receive reagent-grade from laboratory).
- Tap water rinse from local tap water.
- 5-gallon buckets, or other appropriate containers
- Scrub brushes

- Teflon™ squirt bottles
- Gloves (e.g., nitrile or polyethylene)
- Personal protective clothing (as specified in the site-specific health and safety plan)

Procedures

Drill Rig or Test Pit Sampling Equipment Decontamination Procedures

1. Decontaminate sampling equipment before use, between samples and stations, and upon completion of sampling operations.
2. Equipment used during drilling/test pit operations should be decontaminated in the Exclusion Zone prior to transport to the Support Zone (refer to site-specific HASP).
3. If the steam-cleaning location is in an area outside of the Exclusion Zone, remove loose sediment on the drill rig, augers, drill pipe, and rods, and other large equipment at the drill site, then move the equipment directly to the steam-cleaning decontamination area for more thorough cleaning.
4. To decontaminate a drill rig or backhoe, pressure wash with a steam cleaner using potable water rinse upon mobilization, between drilling locations, and upon demobilization. Cleaning water can generally be allowed to drain directly on the ground near the station (refer to the field sampling plan [FSP]).
5. To decontaminate auger, drill rods, and other downhole tools, pressure wash with a steam cleaner and potable water rinse upon mobilization, between drilling locations, and upon demobilization. All decontamination fluids are to be containerized for proper disposal.
6. To decontaminate split-spoon and hand-auger samplers, wash with laboratory-grade detergent/water solution, rinse with tap water and a final distilled water rinse. If the samplers were exposed to visibly contaminated sediments (e.g., creosote, diesel, etc), dry the sampler off with clean paper towels and carefully rinse the equipment with hexane from a squirt bottle, letting the excess solvent drain into a waste container (which may need to be equipped with a funnel). A hexane rinse should be followed by another distilled water rinse. To the extent possible, allow to air dry prior to sampling. If the split-spoon is not used immediately, wrap it in aluminum foil. All decontamination fluids are to be containerized for proper disposal.

Decontamination of Sampling Implements and Processing Materials

1. Decontaminate sampling implements (e.g., spoons and knives) and other processing materials such as mixing bowls and pans before use, between samples, and upon completion of sampling operations.
2. To decontaminate sampling spoons, mixing bowls, and other hand-held tools, wash with a scrub brush using a laboratory-grade detergent/water solution (Liquinox® or Alconox® solution), rinse with tap water, followed by distilled water or ASTM Type II reagent-grade water. As described above, if the sediment is visibly contaminated, a hexane rinse may be necessary. This is followed by another distilled water rinse. To the extent possible, allow to air dry. Once decontaminated, this equipment will be wrapped in aluminum foil to prevent contamination by airborne contaminants during transportation to the sampling site. Containerize all decontamination fluids for proper disposal.
3. To decontaminate sampling spoons used to collect volatile organics, wash the spoon with a scrub brush using a laboratory-grade detergent/water solution, and rinse with distilled water. Wrap the spoon in aluminum foil. The solvent rinse is eliminated in order to avoid interference with the analysis. Containerize all decontamination fluids for proper disposal.
4. If necessary, to decontaminate wash buckets, pressure wash with a steam cleaner using a laboratory-grade detergent/water solution and potable water rinse upon mobilization, between station locations, upon demobilization, or as needed during sampling operations.

After decontaminating all of the sampling equipment, the disposable gloves and used foil will be placed in garbage bags and disposed of in an appropriate solid waste landfill.

References

Ecology. 2003. Sediment sampling and analysis plan appendix. Guidance on the development of sediment sampling and analysis plans meeting the requirements of the sediment management standards (Chapter 173-204 WAC). Washington State Department of Ecology, Olympia, WA.

PSEP. 1997. Puget Sound Estuary Program: recommended guidelines for sampling marine sediment, water columns, and tissue in Puget Sound. Final report. Prepared for the Puget Sound Estuary Program, U.S. Environmental Protection Agency, Region 10, Office of Puget Sound, Seattle, WA, and Puget Sound Water Quality Authority, Olympia, WA.

STANDARD OPERATING PROCEDURE SOP-11: INVESTIGATION-DERIVED WASTE HANDLING

Scope and Application

This SOP presents the method to be used when handling investigation-derived wastes during field sampling activities.

Supplies and Equipment

- 55-gallon drums
- Paint markers
- Tools (to open and close drum)
- Drum labels.

Procedures

1. Containerize solid wastes by placing them in properly labeled, Department of Transportation (DOT)-approved, 55-gallon drums or other approved containers. Do not combine solid residues known to be from a contaminated area with other residues.
2. Label drums as "NON-CLASSIFIED WASTE MATERIAL: LABORATORY ANALYSIS IN PROGRESS". Include on the labels a drum number, the type of material, site address, accumulation date, and generator name and phone number.
3. Properly close, seal, and stage all filled or partially filled drums before demobilization.
4. Profile the drums based on the analytical results from corresponding borehole samples, or waste characterization samples collected from the drums. Once the drums are profiled, dispose of them in accordance with applicable regulations.
5. Maintain a drum inventory in the field logbook.

6. Sampling activities will generate personal protective equipment and miscellaneous debris that need to be disposed of. Remove gross contamination from these items, and place the items in plastic bags. Interim storage of these materials in plastic bags is acceptable. Dispose of the bags at an appropriate solid waste facility dumpster at the end of each day.

STANDARD OPERATING PROCEDURE SOP-12:

HYDROCARBON FIELD SCREENING FOR SOIL AND SEDIMENT

Scope and Application

This SOP presents the qualitative field screening methods for hydrocarbons in soil.

Equipment/Reagents Required

- Clean, stainless-steel or plastic pan
- Camera (if necessary)
- Ziploc® bags
- Photo-ionization detector (PID)

Procedures

Headspace Field Screening

1. Calibrate PID in accordance with the manufacturer's specifications.
2. Label Ziploc® bag with the sample number.
3. Place representative soil sample in Ziploc® bag until bag is approximately one-quarter full (if sample recovery is sufficient). Seal Ziploc® bag and homogenize sample.
4. Allow bag to sit at ambient temperature for approximately 10 minutes. Place PID wand into bag, being careful not to contact soil with PID probe. Also be careful not to let any ambient air in the bag as this may cause dilution.
5. Gently shake Ziploc® bag and record highest sustained reading in the field logbook or borehole log.

Visual Screening

Visual screening consists of inspecting the soil or sediment for the presence of stains indicative of residual petroleum hydrocarbons. Visual screening is generally more

effective in detecting the presence of heavier petroleum hydrocarbons, such as motor oil, or when hydrocarbon concentrations are high.

1. Visually inspect soil or sediment sample.
2. Look for indications of the presence of hydrocarbons, which typically include a mottled appearance or dark discoloration of the soil.
3. Record observations in logbook. Note: Visual observations do not definitively indicate the presence of hydrocarbons.

Sheen Testing

Sheen testing involves immersion of the soil or sediment sample in water and observing the water surface for signs of a sheen.

1. Place a representative soil or sediment sample into a clean, stainless-steel or plastic pan filled with deionized water with as little disturbance as possible.
2. Record observations in the logbook. Visual evidence of a sheen forming on the surface of the water is classified as follows:
    - **No sheen (NS)**—No visible sheen on the water surface.
    - **Colorless Sheen (CS**)—Light, nearly colorless sheen; spread is irregular, not rapid; film dissipates rapidly (**Note:** light colorless sheens can be confused with sheens produced by organic content). Note that this sheen may or may not indicate the presence hydrocarbons.
    - **Heavy Sheen (HS)—**Light to heavy colorful film with iridescence; stringy, spread is rapid; sheen flows off the sample; most or all of water surface is covered with sheen.

3.0 SOP B: TRIDENT PROBE GROUNDWATER DISCHARGE MAPPING AND TRANSITION ZONE WATER SAMPLING

The purpose of this SOP is to define and standardize the methods for groundwater discharge mapping and for collecting and processing Transition Zone water samples using the Trident Probe. The Trident Probe will be operated in accordance with the procedures described in *Coastal Contaminant Migration Monitoring: The Trident Probe and UltraSeep System* (SSC et al. 2003), which is included as Attachment 1 to this document. Select portions of these procedures are incorporated here, as appropriate.

Operation of the Trident Probe will be conducted by Coastal Monitoring Associates. Integral personnel will assist in the Transition Zone water sample collection and will be responsible for sample handling and field documentation.

3.1 SUMMARY OF METHOD

The Trident Probe is a point measurement system that evaluates the contrast in temperature and conductivity between surface water and Transition Zone water. Multiple point measurements are combined to develop a qualitative to semi-quantitative map of groundwater discharge zones. The Trident Probe itself is a simple, direct-push system equipped with temperature, conductivity, and water sampling probes. The Trident Probe will be lowered from a vessel via a push pole. Coupled to the mounting base that holds the temperature and water sampling probes is a submersible air hammer that can be used to assist driving the probes into the sediment.

Groundwater discharge mapping will be accomplished by deploying the Trident Probe at several points along transects oriented perpendicular to the shore within the pilot study investigation areas, as described in the FSP (Integral 2004a). Temperature and conductivity measurements and the location coordinates and riverbed depth (measured per SOP G) will be recorded at each station. The resultant data set will be evaluated in conjunction with the data from the TIR imagery results to identify active groundwater discharge zones and to select the stations for Transition Zone water sampling.

The Trident Probe will then be re-deployed to collect Transition Zone water samples using the water sampling probe. This probe is used to collect in-situ water samples for Transition Zone water characterization by applying suction and drawing the Transition Zone water to the surface. Once at the surface, the Transition Zone water will be processed and transferred to the appropriate pre-preserved sample vials.

3.2 SAMPLING VESSEL

A single sampling vessel will be required during the Trident discharge mapping and Transition Zone water sampling. It will have a deck large enough to accommodate three crewmembers and the captain. Deck space will also be sufficient to hold all required supplies and equipment for sampling and appropriate safety equipment. This vessel will also be equipped with navigational lights, anchors, and basic sonar.

3.3 SUPPLIES AND EQUIPMENT

There are five major pieces of equipment required to operate the Trident system: (1) the Trident Probe, (2) the communications/pneumatic cable, (3) Geoprobe®'s FC4000 field computer, (4) a laptop computer with the proper system requirements, and (5) a handheld GPS unit with an RS-232 interface. In many cases, a 12-V deep-cycle car battery and 750-watt power inverter will be required for portable power.

A full listing of the required equipment is provided in Table 1, including the additional equipment required for general support of the Transition Zone water sampling effort. Equipment and supplies include sampling equipment, utensils, sample containers, coolers, logbooks and forms, personal protection equipment, and personal gear. Protective wear (e.g., hard hats, gloves), as required for health and safety of field personnel, is as specified in the health and safety plan (HSP) (Integral 2004b).

3.4 PROCEDURES

3.4.1 Groundwater Discharge Mapping and Transition Zone Water Sampling Procedures

The approach to groundwater discharge mapping and Transition Zone water sampling with the Trident Probe is described in the FSP (Integral 2004a). The specific procedures for use of the Trident Probe for recording sediment temperature and conductivity and for collecting Transition Zone water samples are described in SSC et al. (2003), included as Attachment 1 to this document. The conductivity probe will be calibrated prior to deployment and at one point on each transect. Calibration information will be recorded in the logbook.

Station positioning will be accomplished per SOP G. At each station, the Trident Probe will be deployed from the vessel using a push pole system. The Trident will be moved progressively along each transects identified for the ARCO and Arkema sites (formerly ATOFINA) in the FSP, and the temperature and conductivity in the riverbed sediments will be recorded. These data will be considered in conjunction with the TIR data to identify zones of active groundwater discharge and to locate the Transition Zone water sampling stations. To the extent possible, the pilot study sampling stations will also be

collocated with Round 2 surface sediment sampling stations. At several of the temperature/ conductivity measurement locations, trial runs of Transition Zone water sampling will be conducted in order to assess the ability to recover the volumes of Transition Zone water required for chemical analysis.

The Trident Probe will employ the use of a peristaltic pump for the Transition Zone water sampling. If the Transition Zone water sampling trials indicate that sufficient volume of Transition Zone water will be yielded, a volume equivalent to 3 times the pore volume of the tubing/sampling probe will be purged at a low flow rate from the sampler prior to sample collection. Field parameters of pH, conductivity, and turbidity will be measured following purging and sample collection. This probe will be calibrated daily in accordance with the manufacturer's specifications, and the calibration will be checked twice daily. Calibration information will be recorded in the logbook.

After purging, the Transition Zone water will be pumped directly into the appropriate pre-preserved sample bottles. If filtered samples are also to be collected, the pump will then be stopped and a 0.45-µm cartridge filter attached to the pump discharge tubing. The pump will then be re-started and the discharge will be directed to the appropriate pre-preserved sample bottles. The two-person "clean hands – dirty hands" method (EPA 1996; SOP J) will be used, as appropriate, during this process.

Table 2 presents the analyses to be performed at each of three investigation areas during the pilot study. There is a potential that the sample volume may be limited (e.g., due to sediment texture or clogging of the sample probe). As such, Table 2 includes both target and minimum allowable sample volumes for each analysis to guide field personnel during sample collection. As noted above, the sample bottles for VOC analyses (if applicable) will be filled first and sealed with zero headspace. The remaining bottles will be filled in the following order: organics, metals, and conventional parameters.

SOP I describes the sample custody, labeling, and handling procedures that will be followed. All field activities will be documented per the procedures summarized in SOP H.

3.4.2 Decontamination Procedures

During discharge mapping, the entire Trident Probe assembly will be rinsed between temperature/conductivity measurement stations with river water. If the Probe contacts visibly contaminated sediment, it will be thoroughly washed using Alconox™ or other phosphate-free detergent and rinsed with river water before use at a new station. If a residual creosote or petroleum sheen remains on the sampling equipment or is difficult to remove using the standard decontamination procedures above, a final hexane rinse may be added.

In addition to the above decontamination protocols, during Transition Zone water sampling the sampling probe and associated tubing will be decontaminated prior to deployment at each sampling station. The peristaltic pump will be used to draw the decontamination solutions through all portions of the sampling probe and tubing that come in contact with sediment Transition Zone water. Tubing will be replaced prior to each deployment for sampling. The decontamination process will proceed according to the following protocol:

- Rinse with river water.
- Wash with brush and Alconox™ or other phosphate-free detergent.
- Double rinse with deionized water.
- Rinse with 0.1 N nitric acid.
- Rinse with deionized water.

To minimize sample contamination, gloves will be replaced or thoroughly washed using Alconox™ or other phosphate-free detergent and rinsed with distilled water before and after handling each sample, as appropriate. Rinse waters will be diluted with river water and discarded into the river.

3.5 FIELD QUALITY CONTROL PROCEDURES

Field quality control (QC) samples will consist of a field replicate at one sampling station at each of the three pilot study investigation areas. In addition, all volatile samples will be stored and shipped with a trip blank. Finally, an equipment rinsate blank will be collected following decontamination of the Trident sampling probe and tubing at each of the three pilot study investigation areas.

4.0 SOP C: ULTRASEEP GROUNDWATER DISCHARGE FLOW MEASUREMENT AND TRANSITION ZONE WATER SAMPLING

The purpose of this SOP is to define and standardize the methods for groundwater discharge flow measurement and Transition Zone water sample collection using the UltraSeep system. The UltraSeep system will be operated in accordance with the procedures described in *Coastal Contaminant Migration Monitoring: The Trident Probe and UltraSeep System* (SSC et al. 2003), which is included as Attachment 1 to this document. Select portions of these procedures are incorporated here, as appropriate.

Operation of the UltraSeep system will be conducted by Coastal Monitoring Associates, with oversight/assistance by Integral personnel. Integral personnel will process the Transition Zone water samples collected by the UltraSeep system and will be responsible for field documentation.

4.1 SUMMARY OF METHOD

The UltraSeep system is a seepage meter that incorporates continuous flow measurement with automated sample collection. The unit is deployed by divers and rests on the sediment surface. The UltraSeep system will be deployed at one of the three Transition Zone water sampling stations identified for each of the three pilot study investigation areas. The UltraSeep system will be programmed to collect continuous flow data and multiple samples from each of these stations over the course of 24 hours. At the end of the deployment period, divers will retrieve the UltraSeep system and associated samples. Coastal Monitoring Associates will perform all operational activities relating to the UltraSeep system, with oversight by Integral personnel. Once the Transition Zone water samples are at the surface, Integral personnel will process the Transition Zone water samples.

4.2 SAMPLING VESSEL

A single sampling vessel will be required for deployment and retrieval of the UltraSeep system. It will have a deck large enough to accommodate two divers, two crew members, and the captain. Deck space will also be sufficient to hold all required supplies and equipment for sampling and appropriate safety equipment. The vessel will also be equipped with navigational lights, anchors, and basic sonar.

4.3 SUPPLIES AND EQUIPMENT

The UltraSeep meter consists of a Teflon®-coated, stainless-steel, open-bottomed chamber, measuring 48 cm × 46 cm, to funnel the seepage water to an ultrasonic flow

meter. The flow sensor is connected to the high point of the funnel via 12-mm Teflon® tubing, allowing free flow of water between the funnel and the outside environment. A W.S. Ocean Systems (now EnviroTech) ESM data logger/controller unit monitors data from the flow meter. Based on the measured flow conditions, the ESM activates a water sampling system that can pump water to six sequential sampling bags mounted around the perimeter of the meter. The ESM also records data from conductivity, temperature, and pressure sensors mounted on the unit. All these components, along with a 12-V submersible battery housing, are mounted within a 74-cm-diameter by 79-cm-high cylindrical aluminum frame. Additional details and system specifications are presented in SSC et al. (2003).

The additional equipment required to support the deployment and use of the UltraSeep system is detailed in Table 3. Equipment and supplies include sampling equipment, utensils, sample containers, coolers, logbooks and forms, personal protection equipment, and personal gear. Protective wear (e.g., hard hats, gloves), as required for health and safety of field personnel, is as specified in the HSP (Integral 2004b).

4.4 PROCEDURES

4.4.1 Discharge Flow Measurement and Transition Zone Water Sampling Procedures

The general approach to discharge flow measurement and Transition Zone water sampling with the UltraSeep system is described in the FSP (Integral 2004a). The specific procedures for use of the UltraSeep are described in SSC et al. (2003), included as Attachment 1 to this document. This section provides an overview of the procedures that will be followed during the pilot study. Prior to each deployment, the conductivity probe will be calibrated against stock standard solutions. Calibration information will be recorded in the logbook.

Prior to deployment, the vessel will be positioned at the sampling station per the methods prescribed in SOP G. The UltraSeep system will be deployed by lowering the system to the bottom, either directly from a boat or by divers using a lift-bag. Once the unit is settled on the bottom, divers will check the seal. A period of 2 to 3 hours is generally allowed to ensure that any transient seepage response associated with the deployment activities has dissipated. The ESM unit is pre-programmed to initiate logging and control functions after this period. The seepage rate is then continuously monitored, and up to ten water samples are collected for chemical analysis.

At the end of the deployment, the meter will be recovered using either a lift line to the recovery boat, or by diver assistance. The meter data will then be downloaded and the Teflon® sample bags recovered. If VOCs are to be analyzed at the given sampling station, Transition Zone water will be poured directly from one of the sample bags to fill the VOA vials. A peristaltic pump equipped with silicon tubing will then be used to

pump water from the sample bags directly into the appropriate sample bottles for the remaining analyses to be performed at the sampling station. If filtered samples are also to be collected, the pump will then be stopped and a 0.45-µm cartridge filter attached to the pump discharge tubing. The pump will then be re-started and the discharge will be directed to the appropriate pre-preserved sample bottles. The two-person, clean hands – dirty hands method (EPA 1996; SOP J) will be used, as appropriate, during this sample processing. New tubing will be used for each sample station. Table 2 presents the analyses to be performed at each of three investigation areas during the pilot study. There is a potential that the sample volume may be limited (e.g., if the groundwater discharge rate is slow). As such, Table 2 includes both target and minimum allowable sample volumes for each analysis to guide field personnel during sample collection. As noted above, the sample bottles for VOC analyses (if applicable) will be filled first and sealed with zero headspace. The remaining bottles will be filled in the following order: organics, metals, and conventional parameters.

SOP I describes the sample custody, labeling, and handling procedures that will be followed. All field activities will be documented per the procedures summarized in SOP H.

4.4.2 Decontamination Procedures

The UltraSeep system will be decontaminated prior to and following deployment at each of the three sampling stations. The decontamination procedures are detailed in SSC et al. (2003), and are summarized below.

The solutions used for cleaning the UltraSeep system will differ according to the type of analysis performed. A 2% Alconox® solution is used in the cleaning process in preparation for sampling organic compounds. Nitric acid diluted to a concentration of 10% will also be used if metals are going to be measured. The last fluid used in the process will be DI water. New Teflon® sample bags will be used at each sampling station and will be attached to the DI-rinsed sample lines once the cleaning process is complete.

To minimize sample contamination, gloves will be replaced or thoroughly washed using Alconox™ or other phosphate-free detergent and rinsed with distilled water before and after handling each sample, as appropriate. Rinse waters will be diluted with river water and discarded into the river.

4.4.3 Field Quality Control Procedures

Due to the limited number of the UltraSeep systems in existence and limited vendor availability during the time planned for the pilot study, a field replicate will not be collected by this method. All volatile samples will be stored and shipped with a trip blank. A single equipment rinsate blank will be collected following decontamination of the UltraSeep system at one of the three sampling stations.

Attachment 2

Field Forms

integral consulting inc.

319 SW Washington St, Suite 1150
Portland, OR 97204

Boring Number: _____
Project Name: _____
Project Number: _____
Logged by: _____
Date: _____
Page of

SAMPLE INFORMATION										
Sample ID	Tag #	Time	Sample Depth	% Recovery	PID (ppm)	Sheen	Depth (Feet)	Symbol	Sediment/Soil Description (USCS group name, minor components, color, moisture, additional descriptions)
							5--		
							10--		
							15--		

Drilling Contractor: _____
Drilling Method: _____
Sampling Equipment: _____
Start/End Time: _____
Latitude: _____
Longitude: _____
Notes: _____

Location Sketch

CHAIN OF CUSTODY FORM

Project: _____

Samplers: _____

Integral Contact: _____

Phone _____

Ship to:

Lab Name _____

Address _____

_____

_____

Contact _____

Phone _____

integral consulting inc.

Sample No.	Tag #	Date	Time	Matrix	ANALYSES REQUESTED								Extra Container	Archive	Comments

Analysis Turn Time: **Normal** **Rush** **Rush Results Needed By:**

Shipped by: **Shipping Tracking No.**

Condition of Samples Upon Receipt: **Custody Seal Intact?**

Matrix Code:
GW - Groundwater
SL - Soil
SW - Surface water
SD -Sediment
Other:

Relinquished by: _____ **Date/Time:** _____ **Received by:** _____ **Date/Time:**_____
(signature) *(signature)*

Relinquished by: _____ **Date/Time:** _____ **Received by:** _____ **Date/Time:**_____
(signature) *(signature)*

Special Instructions:

Integral Consulting, Inc. **Core Description and Sample Information**

STATION:
REPLICATE:

PROJECT:_____

Field Log by:	Processing by:	Coring by:
Tide Level from MLLW: Depth to Mudline: Mudline Elev.:	Date: Time:	Total Drive Length: Recovered Length: Recovery Efficiency:

Note: All elevations, depths, and distances in feet.

Core Description - Core Tube Lengths **In-Situ Summary Log**

Tube Length	Sample No.	Visual Description	Photo Number	Interpreted Summary	Sample No.	Acquisition Notes
_1				_1		
_2				_2		
_3				_3		
_4				_4		
_5				_5		
_6				_6		
_7				_7		
_8				_8		
_9				_9		
_10				_10		
_11				_11		
_12				_12		
_13				_13		
_14				_14		
_15				_15		
_16				_16		
_17				_17		
_18				_18		

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length

Sample Test Information

Sample No./Tests	In-Situ Depth Int.

Notes:

FIELD CHANGE REQUEST (FCR) FORM

Project Name: _____ Project No.: _____
Client: _____ Request No.: FCR-_____

To: _____ Date: _____

Field Change Request Title: _____

Description:

_____
_____
_____
_____

Recommended Change:

_____
_____
_____

_____ _____ _____
Field Operations Lead (or designee) Signature Date

Approval:

_____ _____ _____
Project Manager Signature Date

Distribution:
LSS Project Coordinator
Integral Project Manager
Field Operations Lead
QA Officer
Project File
Other:

GROUNDWATER SAMPLE COLLECTION FORM

Well Number _____ Project Name:

Sample No. _____ Project Number:

Date Collector:

Well Information

Monument Condition ☐Good ☐Needs Repair_____

Well Cap Condition ☐Good ☐Locked ☐Replaced ☐Needs Replacement

Elevation Mark ☐ Yes ☐ Added ☐other

Well Diameter ☐ 2-inch ☐4-inch ☐6-inch ☐Other

☐Odor Comments _____

Purge Data

Total Well Depth _____ ft ☐ Clean Bottom ☐Muddy Bottom ☐Not Measured

Depth to Water _____ ft

Casing Volume _____ ft (H20) X _____ gpf = _____ X 3 = _____ gallons

3/4 " = 0.02 gpf 1"= 0.04 2" = 0.16 gpf 4"=0.65 gpf 6"=1.47 gpf

Purge Method

Pump Type: Tubing: Total volume purged _____

Sample Intake Depth _____ Purge Rate _____

Purge Start Time _____ Purge Stop Time _____ Sample Rate _____

Field Parameters

Time	Gallons	pH	Turbidity (NTU)	Temperature (C)	Conductivity (mS/cm)	D.O. (mg/L)	Comments

Sampling Device

Filter Type: Size:

Sample Containers Collection Time_____

Tag No.	Type		Preservative	Analytical Method	QA Remarks
	☐Amber	☐Poly (1 L)			
	☐Amber	☐Poly (250 mL)			
	☐Amber	☐Poly (500 mL)			
	☐Amber	☐Poly (500 mL)			
	☐Amber	☐Poly (500 mL)			
	☐Amber	☐Poly (250 mL)			
	☐Amber (40 mL vial)	☐Poly			
	☐Amber	☐Poly (500 mL)			
	☐Amber	☐Poly			

Samplers' Signature_____ Date _____

integral consulting inc.

"Rite in the Rain"®

ALL-WEATHER

ENVIRONMENTAL

No. 550F

Sample Label

Site: _____

Sample No.: _____

integral consulting inc.

Matrix: _____ Date: _____

Filtered (Y/N): _____ Time: _____
(if applicable)

Analysis: _____ Pres: _____
(optional)

Sampler: _____

Tag Number: 1813

Custody Seal

CUSTODY SEAL

integral consulting inc.

Date: _____ *Time:* _____

Sampler Signature: _____

Sample Summary Log

integral consulting inc.

Project:________________________________
Field Team Leader:________________________

319 SW Washington St., Suite 1150
Portland, Oregon 97206

Page ____of______

Sample Number	Sample Collection Date	Sample Delivery Date	Laboratory Sample Delivery Group	Laboratory Work Order	QA/QC Notes	Date Analyzed	Date Analytical Results Received

Table 6. Field Sample Collection Matrix for Groundwater Arkema

				Groundwater				Equipment Blank			
				DDx	VOCs			DDx	VOCs		
					3 Vials				3 Vials		
				250 mL AG	40 ml Vial with septum	40 ml Vial with septum	40 ml Vial with septum	250 mL AG	40 ml Vial with septum	40 ml Vial with septum	40 ml Vial with septum
				250 mL	40 ml	40 ml	40 ml	250 mL	40 ml	40 ml	40 ml
Station ID	Sample ID	Sample Number	Sample Type	≤6°C	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C	≤6°C	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
			Field Duplicate	Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
			Equipment rinsate blank	--	--	--	--	Tag #_____	Tag #_____	Tag #_____	Tag #_____

Notes:
AG = amber glass
DDx = 2,4'- and 4,4'-isomers of DDT, DDD, and DDE.
HPDE = high density polyethylene
VOCs = volatile organic compounds

Table 3. Field Sample Collection Matrix for Sediment Porewater Arkema

				Sediment Porewater				Equipment Blank			
				DOC	VOCs			DOC	VOCs		
					3 Vials				3 Vials		
				250 mL AG	40 ml Vial with septum	40 ml Vial with septum	40 ml Vial with septum	250 mL AG	40 ml Vial with septum	40 ml Vial with septum	40 ml Vial with septum
				250 mL	40 ml	40 ml	40 ml	250 mL	40 ml	40 ml	40 ml
Station ID	Sample ID	Sample Number	Sample Type	Refrigerated, H_2SO_4 to pH<2	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C	Refrigerated, H_2SO_4 to pH<2	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
			Field Duplicate	Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
			Equipment rinsate blank	--	--	--	--	Tag #_____	Tag #_____	Tag #_____	Tag #_____

Notes:
AG = amber glass
DOC = dissolved organic carbon
VOC = volatile organic compound

Table 5. Field Sample Collection Matrix for Soil Arkema

				Soil Chemistry				Equipment Blank		
				PCB Congeners	Dioxins/Furans	DDx	Asbestos	PCB Congeners	DDx	Dioxins/Furans
				250 mL WMG	250 mL WMG	250 mL WMG	250 mL WMG	1 L AG	250 mL AG	1 L AG
				100 g	100 g	100 g	100 g	1000 mL	250 mL	1000 mL
Station ID	Sample ID	Sample Number	Sample Type	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
			Field Duplicate	Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--
			Equipment rinsate blank	--	--	--	--	Tag #_____	Tag #_____	Tag #_____

Notes:
AG = amber glass
DDx = 2,4'- and 4,4'-isomers of DDT, DDD, and DDE.
WMG = wide mouth glass

Table 4. Field Sample Collection Matrix for Subsurface Sediment Arkema

				Subsurface Sediment Chemistry											
				Subsurface Sediment							NAPL Assessment				
				PCB Congeners	Dioxins/Furans	DDx	PAHs	Chlorobenzene			VOCs			NWTPH-Gx	NWTPH-Dx
				250 mL WMG	250 mL WMG	250 mL WMG	250 mL WMG	40 mL Vial with septum MeOH preserved	40 mL Vial with septum and stir bar	40 mL Vial with septum and stir bar	40 mL Vial with septum MeOH preserved	40 mL Vial with septum and stir bar	40 mL Vial with septum and stir bar	80 mL WMG with septa	250 mL WMG
				100 g	100 g	100 g	100 g	5 g	5 g	5 g	5 g	5 g	5 g	100 g	100 g
Station ID	Sample ID	Sample Number	Sample Type	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
			Field Duplicate	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
			Equipment rinsate blank	--	--	--	--	--	--	--	--	--	--	--	--

Notes:
AG = amber glass
DDx = 2,4'- and 4,4'-isomers of DDT, DDD, and DDE.
WMG = wide mouth glass
VOCs = volatile organic compounds

Table 4. Field Sample Collection Matrix for Subsurface Sediment Arkema

				Subsurface Sediment Chemistry						
				Geochronology	Additional Analytes					
				Cs 137/Pb 210	Pesticides	Herbicides	TAL Metals	VOCs		
				500 mL WMG	250 mL WMG	250 mL WMG	250 mL WMG	40 mL Vial with septum MeOH preserved	40 mL Vial with septum and stir bar	40 mL Vial with septum and stir bar
				100 g	100 g	100 g	100 g	5 g	5 g	5 g
Station ID	Sample ID	Sample Number	Sample Type	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
			Field Duplicate	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____
			Equipment rinsate blank	--	--	--	--	--	--	--

Notes:
AG = amber glass
DDx = 2,4'- and 4,4'-isomers of DDT, DDD, and DDE.
WMG = wide mouth glass
VOCs = volatile organic compounds

Table 4. Field Sample Collection Matrix for Subsurface Sediment Arkema

				Equipment Blank						
				Subsurface Sediment						
				PCB Congeners	DDx	Dioxins/Furans	PAHs	VOCs		
								3 Vials		
				1 L AG	250 mL AG	1 L AG	250 mL WMG	40 ml Vial with septum	40 ml Vial with septum	40 ml Vial with septum
				1000 mL	250 mL	1000 mL	100 g	40 mL	40 mL	40 mL
Station ID	Sample ID	Sample Number	Sample Type	≤6°C	≤6°C	≤6°C	≤6°C	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
				--	--	--	--	--	--	--
			Field Duplicate	--	--	--	--	--	--	--
			Equipment rinsate blank	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____	Tag #_____

Notes:
AG = amber glass
DDx = 2,4'- and 4,4'-isomers of DDT, DDD, and DDE.
WMG = wide mouth glass
VOCs = volatile organic compounds

Table 4. Field Sample Collection Matrix for Subsurface Sediment Arkema

				Equipment Blank							
				NAPL Assessment							Geochronology
				VOCs			NWTPH-Gx			NWTPH-Dx	Cs 137/Pb 210
				3 Vials			3 Vials				
				40 ml Vial with septum	40 ml Vial with septum	40 ml Vial with septum	40 ml Vial with septum	40 ml Vial with septum	40 ml Vial with septum	250 mL AG	2 x 1 L AG
				40 mL	40 mL	40 mL	40 mL	40 mL	40 mL	250 mL AG	1000 mL
Station ID	Sample ID	Sample Number	Sample Type	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C	≤6°C	≤6°C: HNO3 to pH < 2
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
				--	--	--	--	--	--	--	--
			Field Duplicate	--	--	--	--	--	--	--	--
			Equipment rinsate blank	Tag #________	Tag #________	Tag #________	Tag #________	Tag #________	Tag #________	Tag #________	Tag #________

Notes:
AG = amber glass
DDx = 2,4'- and 4,4'-isomers of DDT, DDD, and DDE.
WMG = wide mouth glass
VOCs = volatile organic compounds

Table 4. Field Sample Collection Matrix for Subsurface Sediment Arkema

Station ID	Sample ID	Sample Number	Sample Type	Equipment Blank					
				Additional Analytes					
				Pesticides	Herbicides	TAL Metals	VOCs		
							3 Vials		
				250 mL AG	1 L AG	250 mL HPDE	40 ml Vial with septum	40 ml Vial with septum	40 ml Vial with septum
				250 mL	1000 mL	250 mL	40 mL	40 mL	40 mL
				≤6°C	≤6°C	HNO3 to pH < 2	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C	No headspace; HCl to pH < 2; ≤6°C
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
				--	--	--	--	--	--
			Field Duplicate	--	--	--	--	--	--
			Equipment rinsate blank	Tag #________	Tag #________	Tag #________	Tag #________	Tag #________	Tag #________

Notes:
AG = amber glass
DDx = 2,4'- and 4,4'-isomers of DDT, DDD, and DDE.
WMG = wide mouth glass
VOCs = volatile organic compounds

Table 1. Field Sample Collection Matrix for Surface Sediment Arkema

				Surface Sediment Chemistry				Equipment Blank			
				PCB Congeners	DDx	Dioxins/Furans	PAHs	PCB Congeners	DDx	Dioxins/Furans	PAHs
				250 mL WMG	250 mL WMG	250 mL WMG	250 mL WMG	1 L AG	250 mL AG	1 L AG	250 mL AG
				100 g	100 g	100 g	100 g	1000 mL	250 mL	1000 mL	250 mL
Station ID	Sample ID	Sample Number	Sample Type	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--

Table 1. Field Sample Collection Matrix for Surface Sediment Arkema

				Surface Sediment Chemistry				Equipment Blank			
				PCB Congeners	DDx	Dioxins/Furans	PAHs	PCB Congeners	DDx	Dioxins/Furans	PAHs
				250 mL WMG	250 mL WMG	250 mL WMG	250 mL WMG	1 L AG	250 mL AG	1 L AG	250 mL AG
				100 g	100 g	100 g	100 g	1000 mL	250 mL	1000 mL	250 mL
Station ID	Sample ID	Sample Number	Sample Type	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
			Field Duplicate	Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--

Table 1. Field Sample Collection Matrix for Surface Sediment Arkema

				Surface Sediment Chemistry				Equipment Blank			
				PCB Congeners	DDx	Dioxins/Furans	PAHs	PCB Congeners	DDx	Dioxins/Furans	PAHs
				250 mL WMG	250 mL WMG	250 mL WMG	250 mL WMG	1 L AG	250 mL AG	1 L AG	250 mL AG
				100 g	100 g	100 g	100 g	1000 mL	250 mL	1000 mL	250 mL
Station ID	Sample ID	Sample Number	Sample Type	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C	≤6°C
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
			Field Duplicate	Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
				Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
			Field Duplicate	Tag #_____	Tag #_____	Tag #_____	Tag #_____	--	--	--	--
			Equipment rinsate blank	--	--	--	--	Tag #_____	Tag #_____	Tag #_____	Tag #_____

Notes:
AG = amber glass
DDx only = 2,4'- and 4,4'-isomers of DDT, DDD, and DDE.
PAH = polycyclic aromatic hydrocarbon
WMG = wide mouth glass

SURFACE SEDIMENT COLLECTION FORM

Project Name: _____ **Project #:** _____ pg ___of____

Date: _____ **Weather:** _____

Crew: _____

Sampling Method: _____

Station Positioning Tolerance:

Station: _____ **Time:** _____ **Attempt #:** _____ **Acceptable Grab:** ˜ Yes ˜ No

"On Bottom" Coordinates: _____

Estimated Distance from Target Station: _____ **Acceptable Distance:** ˜ Yes ˜ No

Bottom Depth: _____ **Penetration Depth:** _____ **Photo ID:** _____

Sample ID: _____ **discrete composite**

Type: ˜ cobble ˜ gravel ˜ sand [coarse / medium / fine] ˜ silt clay ˜ organic matter ˜ wood/shell fragments

Color: ˜ drab olive ˜ gray ˜ black ˜ brown **Apparent Redox Discontinuity Depth:** _____

Odor: ˜ none ˜ slight ˜ moderate ˜ strong ˜ sulfidic ˜ petroleum ˜ other

Comments/Description:

Station: _____ **Time:** _____ **Attempt #:** _____ **Acceptable Grab:** ˜ Yes ˜ No

"On Bottom" Coordinates: _____

Estimated Distance from Target Station: _____ **Acceptable Distance:** ˜ Yes ˜ No

Bottom Depth: _____ **Penetration Depth:** _____ **Photo ID:** _____

Sample ID: _____ **discrete composite**

Type: ˜ cobble ˜ gravel ˜ sand [coarse / medium / fine] ˜ silt clay ˜ organic matter ˜ wood/shell fragments

Color: ˜ drab olive ˜ gray ˜ black ˜ brown **Apparent Redox Discontinuity Depth:** _____

Odor: ˜ none ˜ slight ˜ moderate ˜ strong ˜ sulfidic ˜ petroleum ˜ other

Comments/Description:

integral consulting inc.

319 SW Washington St, Suite 1150
Portland, OR 97204

Test Pit Number: _____
Project Name: _____
Project Number _____
Logged by: _____
Date: _____

Page___ of ___

SAMPLE INFORMATION								DESCRIPTION
Sample ID	Time	PID	Sheen			Depth (Feet)	STRATA	USCS group name, color, grain size range, minor constituents, plasticity, odor, sheen, moisture content, texture, weathering, cementation, geologic interpretation, etc.
						2--		
						4--		
						6--		

ADDITIONAL NOTES / SKETCHES

EXCAVATING CONTRACTOR _____
EXCAVATION METHOD _____
SAMPLING EQUIPMENT _____
EXCAVATING STARTED _____ Ended _____
COORDINATES _____
SURFACE ELEVATION _____
DATUM _____

Location Sketch

Appendix B

Quality Assurance Project Plan

DRAFT
PRE-DESIGN INVESTIGATION WORK PLAN
ARKEMA PROJECT AREA

Appendix B
Quality Assurance Project Plan

Prepared for
Legacy Site Services LLC
665 Stockton Drive
Suite 110
Exton, PA 19341

Prepared by

integral consulting inc.
319 SW Washington St.
Suite 1150
Portland, OR 97204

DOF DALTON OLMSTED FUGLEVAND
1001 SW Klickitat Way
Suite 200B
Seattle, WA 98134

June 18, 2020

CONTENTS

LIST OF FIGURES ..... **v**

LIST OF TABLES ..... **v**

ACRONYMS AND ABBREVIATIONS ..... **vi**

TITLE AND APPROVAL SHEET ..... **viii**

DISTRIBUTION LIST ..... **x**

1 INTRODUCTION **1-1**

1.1 PROJECT AND TASK ORGANIZATION 1-1
1.1.1 EPA Organization and Responsibilities 1-2
1.1.2 Key Task Personnel 1-2
1.1.3 Analytical Laboratories 1-4
1.2 PROBLEM DEFINITION AND BACKGROUND 1-5
1.3 TASK DESCRIPTION 1-6
1.3.1 Field Tasks 1-7
1.3.2 Laboratory Analyses and Deliverables 1-9
1.3.3 Data Quality Evaluation 1-10
1.3.4 Data Management 1-10
1.3.5 Reports 1-10
1.3.6 Project Schedule 1-11
1.4 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA 1-11
1.4.1 The Data Quality Objective Process 1-11
1.4.2 Data Quality Indicators 1-12
1.5 SPECIAL TRAINING/CERTIFICATION 1-16
1.6 DOCUMENTS AND RECORDS 1-16
1.6.1 Field Documentation 1-17
1.6.2 Laboratory Documentation 1-18
1.6.3 Data Quality Documentation 1-19
1.6.4 Back Up and Maintain Database and Data Files 1-19

2 DATA GENERATION AND ACQUISITION **2-1**

2.1 SAMPLING PROCESS DESIGN 2-1
2.1.1 Sediment Chemistry 2-1
2.1.2 Surface Sediment Chemistry 2-1
2.1.3 Subsurface Sediment Chemistry 2-1

2.1.4 NAPL 2-2
2.1.5 Sediment Stability 2-2
2.1.6 Bank and Shoreline Soils 2-2
2.1.7 Groundwater Discharge and COC Flux 2-2
2.1.8 Porewater 2-2
2.1.9 Geotechnical Evaluation 2-2
2.2 SAMPLING METHODS 2-3
2.3 SAMPLE HANDLING AND CUSTODY 2-4
2.3.1 Field to Laboratory Sample Handling and Custody 2-4
2.3.2 Intralaboratory Sample Transfer 2-5
2.3.3 Archived Samples 2-5
2.4 ANALYTICAL METHODS 2-6
2.4.1 Surface Sediments 2-6
2.4.2 Subsurface Sediments 2-7
2.4.3 NAPL and COC Assessment 2-10
2.4.4 Soil Sampling 2-10
2.4.5 Groundwater, Transition Zone Water, and Porewater Sampling 2-12
2.4.6 Moisture Content 2-13
2.4.7 Analyses in Equipment Rinsate Blanks 2-13
2.5 QUALITY CONTROL 2-13
2.5.1 Field Quality Control Samples 2-13
2.5.2 Laboratory Quality Control 2-14
2.6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE 2-15
2.7 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY 2-15
2.8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES 2-15
2.9 NON-DIRECT MEASUREMENTS 2-16
2.10 DATA MANAGEMENT 2-17
2.10.1 Field Data 2-17
2.10.2 Laboratory Data 2-17
2.10.3 Backup and Maintenance of Database and Data Files 2-18
3 ASSESSMENT AND OVERSIGHT 3-1
3.1 ASSESSMENTS AND RESPONSE ACTIONS 3-1
3.2 REPORTS TO MANAGEMENT 3-2
4 DATA VALIDATION AND USABILITY 4-1
4.1 CRITERIA FOR DATA REVIEW, VERIFICATION, AND VALIDATION 4-1

4.1.1 Analytical Data 4-1
4.2 VERIFICATION AND VALIDATION METHODS 4-2
4.3 RECONCILIATION WITH USER REQUIREMENTS 4-3
5 REFERENCES 5-1
Attachment 1. Laboratory Quality Assurance Manuals
Attachment 2. Method Detection Limit Studies
Attachment 3. Assessment Checklists
Attachment 4. Laboratory Chain of Custody Forms
Attachment 5. Laboratory SOPs

LIST OF FIGURES

Figure B-1. Project Organization

LIST OF TABLES

Table B-1. Analysis Scheme for Arkema Project Area Pre-design Investigation

Table B-2. Project Team Contact Information

Table B-3. Laboratory Methods for Sediment and Soil Samples

Table B-4. Laboratory Methods for Groundwater and Equipment Blank Samples

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Table B-6. Analytes and Reporting Limits for Groundwater and Equipment Blank Samples

Table B-7. Laboratory Control Limits for Surrogate Recoveries in Sediment and Soil Samples

Table B-8. Laboratory Control Limits for Surrogate Recoveries in Groundwater and Equipment Blank Samples

Table B-9. Laboratory Control Limits for Matrix Spike and Laboratory Control Samples for Sediment and Soil Samples

Table B-10. Laboratory Control Limits for Matrix Spike and Laboratory Control Samples for Groundwater and Equipment Blank Samples

Table B-11. Summary of Samples and Analyses

Table B-12. Sample Containers and Preservation Requirements

Table B-13. Sample Size, Containers, and Holding Times for Geotechnical Sample Analysis

ACRONYMS AND ABBREVIATIONS

ASTM	ASTM International
CLP	Contract Laboratory Program
COC	contaminant of concern
DDx	total of 2,4'- and 4,4'-DDD, DDE, DDT
DOC	dissolved organic carbon
DOF	Dalton, Olmsted & Fuglevand
DRO	diesel range organics
DQO	data quality objective
EDD	electronic data deliverable
EDL	estimated detection limit
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
ESI	Environmental Standards, Inc.
FSP	field sampling plan
GC/ECD	gas chromatography/electron capture detector
GC/MS	gas chromatography/mass spectrometry
GRO	gasoline range organics
HAZWOPER	Hazardous Waste Operations and Emergency Response
HRGC/ HRMS	high resolution gas chromatography/high resolution mass spectrometry
Integral	Integral Consulting Inc.
LIMS	laboratory information management system
LSS	Legacy Site Services LLC, agent for Arkema Inc.
MDL	method detection limit
MRL	method reporting limit
MRO	motor oil range organics
NAPL	nonaqueous-phase liquid
PAH	polycyclic aromatic hydrocarbon
PARCC	precision, accuracy, representativeness, completeness, and comparability

PCB	polychlorinated biphenyl
PCDD/F	polychlorinated dibenzo-*p*-dioxin/furan
PTW	principal threat waste
QA/QC	quality assurance and quality control
QAPP	quality assurance project plan
RAL	remedial action level
RPD	relative percent difference
SOP	standard operating procedure
TAL	target analyte list
TPH	total petroleum hydrocarbons
VOC	volatile organic compound

TITLE AND APPROVAL SHEET

Quality Assurance Plan Approvals

U.S. EPA Project Coordinator:	Hunter Young	Date:	
U.S. EPA Project QA Manager	TBD	Date:	
Legacy Site Services Project Manager:	Mike Pinto	Date:	
Integral Project/QA Manager:	Eron Dodak	Date:	
Integral Lead Chemist:	Glenn Esler	Date:	
DOF Principal Engineer:	Rob Webb	Date:	
DOF Engineering Investigation Project/Quality Assurance Manager:	Tasya Gray	Date:	
Eurofins/TestAmerica Project Manager:	Nate Lewis	Date:	
Eurofins/TestAmerica Seattle Lab QA Manager:	Terri Torres	Date:	
Eurofins/TestAmerica West Sacramento Lab QA Manager:	Lisa Stafford	Date:	

Teledyne Project Manager	Rebecca Charles	Date:	
Teledyne QA Manager	Sharon Northcutt	Date:	
NW Geotech Project Manager	TBD	Date:	

DISTRIBUTION LIST

EPA Project Coordinator:	Hunter Young
EPA QA Manager:	TBD
Legacy Site Services Project Manager:	Mike Pinto
Integral Principal in Charge:	David Livermore
Integral Project/QA Manager:	Eron Dodak
Integral Lead Chemist:	Glenn Esler
Integral Field Team Leader:	Jane Sund
Integral Database Manager:	Tom Schulz
Dalton, Olmstead & Fuglevand (DOF) Principle Engineer:	Rob Webb
DOF Engineering Investigation Project/Quality Assurance Manager:	Tasya Gray
Eurofins/TA Seattle Project Manager:	Nate Lewis
Eurofins/TA Seattle QA Manager:	Terri Torres
Eurofins/TA West Sac Project Manager:	Nate Lewis
Eurofins/TA West Sac QA Manager:	Lisa Stafford
Teledyne Project Manager:	Rebecca Charles
Teledyne QA Manager:	Sharon Northcutt
Geotechnical Project Manager:	TBD

1 INTRODUCTION

This quality assurance project plan (QAPP) describes quality assurance and quality control (QA/QC) procedures that will be used to support data collection in a portion of the River Mile 7 West Project Area, which is part of the Portland Harbor Superfund Site in Portland, Oregon (Figure 1-1 of the work plan). The River Mile 7 West Project Area includes the Bayer Project Area (approximately river miles 6.5 to 6.9) in the downstream area and the Arkema Project Area (approximately river miles 6.9 to 7.6) in the upstream area. The Willbridge Cove Project Area is immediately upstream of the River Mile 7 West Project area (approximately river mile 7.6 to 8.1).

This pre-design investigation work plan has been developed for the Arkema Project Area. This QAPP is Appendix B to the work plan and has been prepared in accordance with U.S. Environmental Protection Agency (EPA) guidance for the preparation of QAPPs (USEPA 2002a).

This QAPP, along with the associated field sampling plan (FSP; Appendix A of the work plan), provides specific methodology and quality assurance procedures that will be followed by Integral Consulting Inc. (Integral), Dalton, Olmsted & Fuglevand (DOF), and their subcontractors during the pre-design investigation activities. Additional information about the sampling design and rationale is provided in the work plan.

EPA's seven-step data quality objective (DQO) process (USEPA 2006) was used to guide the requirements and design rationale for data collection activities presented in this QAPP and associated FSP. Summaries of the output from this DQO process are provided in Tables 3-2 to 3-7 of the work plan for subsurface sediment, riverbank soil, nonaqueous-phase liquid (NAPL) assessment, sediment stability, groundwater discharge study, and geotechnical assessment. Detailed discussions of the various study components are presented in subsequent sections of this QAPP and Section 3 of the work plan.

The field effort will include collection of subsurface sediment, riverbank soil, sediment porewater, transition zone water, and groundwater for various test parameters detailed in Table B-1. Additional information is provided in the work plan text and FSP (Appendix A of the work plan).

1.1 PROJECT AND TASK ORGANIZATION

This section presents the organizational structure for activities associated with the Arkema Project Area pre-design investigation, including project management and oversight, fieldwork, sample analysis, and data management. Integral and DOF are conducting this work under

contract with Legacy Site Services LLC (LSS), agent for Arkema Inc., with direction from EPA and its partners. The organizational structure for this project is illustrated in Figure B-1. Contact information is provided in Table B-2. Project and quality assurance responsibilities are described in detail in Section 6 of the work plan.

1.1.1 EPA Organization and Responsibilities

EPA will oversee activities associated with the Arkema Project Area pre-design investigation and will coordinate all Trustee, Tribe, and State input regarding the development of technical and decision documents. The project manager for EPA is Hunter Young. The EPA quality assurance manager will be assigned by EPA.

1.1.2 Key Task Personnel

Personnel involved in the Arkema Project Area pre-design investigation are listed below.

Principal-in-Charge—David Livermore (Integral), a registered geologist in Oregon, is the Integral principal-in-charge and will serve as the point of contact for LSS. He will be responsible for implementing and executing the technical, quality assurance, and administrative aspects of the pre-design investigation, including the overall management of the project team. Mr. Livermore will be responsible for the quality and timeliness of Integral documents.

Project/QA Manager—Eron Dodak (Integral), a registered geologist in Oregon, is the remedial design investigation project manager, and is responsible for conducting the pre-design investigation. He will work closely with the principal-in-charge and the lead chemist to ensure the objectives of the study are achieved. In the event that changes in the FSP or QAPP are needed, he will discuss proposed changes with LSS and EPA project managers or other designated EPA staff. Changes to the FSP and QAPP will not be made without prior approval from the EPA project manager unless conditions in the field or laboratory require immediate response.

Principle Engineer—Rob Webb (DOF), a professional engineer in Oregon, is the DOF principal-in-charge and will serve as the point of contact for LSS for all engineering matters. He will be responsible for implementing and executing the technical, quality assurance, and administrative aspects of the engineering investigations. Mr. Webb will be responsible for the quality and timeliness of DOF documents.

Project Geologist—Tasya Gray (DOF), a registered geologist in Oregon, is the engineering investigation project/quality assurance manager and is responsible for ensuring that the work plan components related to engineering design are implemented in accordance with applicable plans and guidelines.

Field Operations Manager—Jane Sund (Integral), a professional engineer in Oregon, is the field operations manager for the pre-design investigation. She will be responsible for the following activities:

- Oversee planning and coordination for all sampling efforts
- Oversee all aspects of sampling activities to ensure that the appropriate sampling, quality assurance, and documentation procedures are used.

Ms. Sund will work closely with the project manager and will be notified immediately if problems occur in the field. If changes to the FSP or QAPP are warranted, she will immediately notify the project manager.

Lead Chemist—Glenn Esler (Integral) will be the lead chemist for the pre-design investigation. He will be responsible for the following activities:

- Provide quality assurance support for the pre-design investigation
- Ensure that the QAPP and FSP contain all components necessary to meet EPA guidance (USEPA 2002a)
- Verify that the laboratories implement the requirements of the FSP and QAPP and address quality assurance issues related to laboratory analyses
- Coordinate the activities of the laboratories and track laboratory progress
- Direct the validation of the chemical data
- Communicate data quality issues to the data users
- Work with data users and EPA to address any data limitations.

Database Administrator—Tom Schulz (Integral) will have primary responsibility for data management and database maintenance and development. Mr. Schulz will be responsible for the following activities:

- Work with the field crew to ensure field data entries are correct and complete
- Work with the laboratories to ensure that data are delivered in the correct format for entry into the Environmental Quality Information System (EQuIS) database
- Work with data validators and the lead chemist to ensure correct and efficient entry of data qualifiers
- Take all necessary measures to develop and maintain the integrity and completeness of the database
- Provide various data summaries to data users in the required formats for interpretation and for importing into EPA's database.

1.1.3 Analytical Laboratories

Laboratory Project Manager—The laboratory project manager carries overall responsibility for the successful and timely completion of sample analyses for this project. The laboratory project manager will be responsible for the following tasks:

- Ensure that samples are received and logged in correctly, that the correct methods and modifications are used, and that data are reported within specified turnaround times
- Review analytical data to ensure that procedures were followed as required in this QAPP, the cited methods, and laboratory standard operating procedures (SOPs)
- Keep the quality assurance manager apprised of the schedule and status of sample analyses and data package preparation
- Notify the lead chemist if problems occur in sample receiving, analysis, or scheduling, or if control limits cannot be met
- Take appropriate corrective action as necessary
- Report data and supporting quality assurance information as specified in this QAPP.

Laboratory Quality Assurance Manager—The Laboratory QA manager is responsible for overseeing the quality assurance activities in the laboratory and ensuring the quality of the data for this project. Specific responsibilities include the following:

- Oversee and implement the laboratory's quality assurance program
- Maintain quality assurance records for each laboratory production unit
- Ensure that QA/QC procedures are implemented as required for each method and provide oversight of QA/QC practices and procedures
- Review and address or approve non-conformity and corrective action reports
- Coordinate response to any quality control issues that affect this project with the laboratory project manager.

1.1.3.1 Analytical Laboratories

Eurofins/TestAmerica and Teledyne Brown Engineering will be responsible for the sediment chemistry and radiochemistry analyses.

1.1.3.2 Geotechnical Laboratory

Northwest Geotech, Inc. will be responsible for all geotechnical analysis of sediments and soils.

1.2 PROBLEM DEFINITION AND BACKGROUND

The primary objective of the pre-design investigation is to collect additional sediment, riverbank soil, sediment porewater, transition zone water, and groundwater data to fill data gaps and inform remedial design of the Arkema Project Area, which is part of the Portland Harbor Superfund Site. The objectives of the pre-design investigation are to assess the following:

- **Sediment Chemistry:** Existing DDx[1] and polychlorinated dibenzo-*p*-dioxin/furan (PCDD/F) data for surface and subsurface sediment are insufficient to define the horizontal and vertical remedial extent for the focused contaminants of concern (COCs) in sufficient detail to prepare a remedial design. Historical data sets include relatively few subsurface measurements within the Arkema Project Area away from the Arkema docks, and the nature and extent of subsurface conditions in those areas is not well characterized. Additional surface and subsurface chemistry data are needed for remedial design to better define the areas of contaminated sediments in the Arkema Project Area.
- **NAPL and Chlorobenzene Principal Threat Waste (PTW)** : Chlorobenzene NAPL has been observed in the upland portion of the Arkema site in the former Acid Plant area. Based on extensive upland NAPL investigations and remediation activities, it appears that the upland chlorobenzene dense NAPL pinches out and does not make a connection to the river. If chlorobenzene NAPL is present, its identification and characterization in subsurface sediment is necessary for remedial design considerations. Chlorobenzene in groundwater at concentrations that cause sediment to exceed 320 µg/kg is considered not reliably contained PTW in the Record of Decision. Chlorobenzene concentrations in sediment and in groundwater beneath the riverbank area need to be evaluated to inform PTW determination and for other parts of remedial design.
- **Sediment Stability:** The current assessment of the depositional regime in the Arkema Project Area, which is based on available bathymetric data collected as part of the Portland Harbor remedial investigation and feasibility study and 2018 pre-design investigation, is inconclusive due to gaps in coverage for the nearshore area in this portion of the Portland Harbor site. Additional information may be needed based on the Phase 1 results to support consideration and incorporation of natural recovery into the remedial design
- **Bank and Shoreline Soils:** Riverbank soil chemistry data have identified areas that are potential erodible soil sources of focused COCs to the Willamette River. Based on the available data, there is uncertainty regarding the nature and extent of selected focused COCs exceeding remedial action levels (RALs) or PTW thresholds in riverbank soil. The remedy design will require surface and subsurface soil data that define the limits of the

[1] Total of 2,4'- and 4,4'-DDD, DDE, DDT

extent of COCs exceeding RALs in riverbank soil adjacent to the sediment portion of the Arkema Project Area.

- **Groundwater Discharge and COC Flux:** Arkema groundwater source control measures consisting of a groundwater barrier wall and a groundwater extraction and treatment system were installed in 2012–2013. Discharge of COCs in groundwater upgradient of the groundwater barrier wall has been controlled at the Arkema site for approximately 8 years; however, recent groundwater concentration measurements indicate that chlorobenzene and other chemicals are still present at elevated concentrations in groundwater downgradient of the groundwater barrier wall. Therefore, the potential for residual COCs in the area downgradient of the barrier wall to contribute to COC flux during and after sediment remediation is not currently known.
- **Geotechnical Evaluation:** Dredging performed on oversteepened or otherwise unstable slopes can result in slope failures and potential undermining of riverbanks and adjacent offshore and nearshore structures. Dredging in the vicinity of structures and pilings can reduce the amount of available soil to resist lateral loading and can potentially undermine relatively shallow piles. The geotechnical characteristics of the sediment will also be evaluated in conjunction with the structural analysis for assessing implementability limitations regarding dredging setbacks from remaining in-water structures. This evaluation will provide design level data that will identify remedial action implementability concerns associated with sediment and riverbank slope stability.

The rationale for sample collection is summarized in Section 3 and Tables 3-2 through 3-7 of the work plan. Sampling during this field effort will consist of sediment and riverbank soil sampling, sediment porewater, transition zone water sampling, and groundwater sampling. Integral and DOF will collect the samples and will prepare the samples for delivery to the laboratories. This QAPP addresses QA/QC activities, laboratory procedures, and data management procedures for surface and subsurface sediment samples, porewater, transition zone water, and groundwater samples, and riverbank soil samples. The analytical requirements and any additional QA/QC activities for any future sampling will be addressed in future QAPP addenda.

1.3 TASK DESCRIPTION

The tasks to be completed for the pre-design investigation include sample collection, laboratory analyses, data quality evaluation, data management, and report preparation. Summaries of these tasks and references to detailed descriptions are provided in this section.

1.3.1 Field Tasks

Tasks that will be completed in the field, including related documentation and QA/QC activities, are described in detail in the FSP (Appendix A of the work plan). The rationale for the field sampling is discussed in Section 3 and Tables 3-2 through 3-7 of the work plan. The COCs to be analyzed and the anticipated sampling schedule are discussed below. The following activities are addressed in Sections 4 through 6 of the FSP (Appendix A to the work plan):

- Subsurface utility clearance
- Horizontal and vertical control
- Surface sediment sampling
- Subsurface sediment sampling
- Riverbank soil sampling
- Groundwater discharge study
- Sediment porewater sampling
- Sample designation
- Sample handling procedures
- Field documentation and procedures
- Decontamination procedures
- Investigation-derived waste management.

1.3.1.1 Surface Sediment Chemistry Sampling

If needed for Phase 2, surface sediment (0–1 ft below mudline) samples for chemistry analyses will be collected using a vessel-deployed power grab or equivalent sediment sampler. Three subsamples will be collected within a 5-ft radius from each station and homogenized into a composite sample. Surface sediment samples will be analyzed for one or more of the following parameters:

- DDx
- Polychlorinated biphenyl (PCB) congeners
- PCDD/Fs
- Polycyclic aromatic hydrocarbons (PAHs).

1.3.1.2 Subsurface Sediment Chemistry Sampling

Phase 1 subsurface sediment sampling will consist of 94 sediment cores in the Arkema Project Area and 4 cores in the navigation channel to assess the vertical extent of focused COCs and other contaminants. Additional sediment chemistry sampling and analyses may be conducted during the second phase of design investigation based on the results of the first phase of investigation.

Subsurface sediment samples will be collected with a vibracorer. Select subsurface sediment samples will be analyzed for one or more of the following COCs:

- DDx
- PCB congeners
- PCDD/Fs
- PAHs
- Chlorobenzene
- Gasoline- and diesel-range petroleum hydrocarbons
- Volatile organic compounds (VOCs)
- Pesticides/herbicides
- Target analyte list (TAL) metals
- Sediment stability analytes (cesium-137 and lead-210, DDx).
- Total organic carbon.

1.3.1.3 Subsurface Sediment Geotechnical Sampling

Sediment borings will be advanced at seven locations to assess geotechnical parameters using a mud-rotary drill rig (or equivalent rig). Select sediment samples will be tested for the following parameters:

- Water content
- Grain size
- Total organic carbon
- Plasticity
- Sediment strength
- Bulk density.

1.3.1.4 Riverbank Soil Sampling

Soil borings will be advanced at 37 locations using a hand auger to a depth of 4 ft bgs. Soil samples will be collected at 1-ft intervals for chemical analysis or archive. The soil samples will be analyzed for the following COCs:

- DDx
- PCB congeners
- PCDD/Fs.

Shallow test pit explorations will be excavated using a track-mounted backhoe or excavator at six locations in the riverbank area to a depth of approximately 6 ft bgs. The soil samples will be analyzed for the following geotechnical parameters:

- Moisture content
- Grain size
- Atterberg limits
- Organic content.

1.3.1.5 Groundwater, Transition Zone Water, and Porewater Sampling

A total of nine groundwater samples from monitoring wells, four groundwater samples from piezometers, and eight transition zone water samples from UltraSeep meters are proposed for evaluation of COCs in groundwater along the flowpath from the top of the riverbank to the nearshore area of the Arkema site. The groundwater and transition zone water samples will be analyzed for the following:

- DDx
- VOCs.

Sediment porewater samples will be collected from three locations using a Trident Probe (or equivalent sampling device) at depths of approximately 1 ft, 2 ft, and 3 ft below mudline in support of sediment cap remedial design. The samples be analyzed for the following:

- Dissolved organic carbon (DOC)
- VOCs.

1.3.2 Laboratory Analyses and Deliverables

Chemical analyses of surface sediment, subsurface sediment, soil, groundwater, and associated field quality control samples will be completed by laboratories to be determined. Laboratories

and analytical methods are provided in Tables B-3 and B-4. Complete analyte lists and reporting limits (MRLs) are provided in Tables B-5 and B-6.

Analyses will be completed using SW-846 (USEPA 2014a), select ASTM International (ASTM) methods, laboratory SOPs, and other established methods as indicated in Tables B-3 and B-4. Full laboratory data reports will be provided electronically, and electronic data deliverables (EDDs) will be provided in spreadsheet format as required for importing into the database. A list of data deliverables from the laboratories is provided in Section 1.5.2

1.3.3 Data Quality Evaluation

Data quality evaluation includes the components of data verification and data validation (USEPA 2002b). Data verification involves verifying that correct procedures were followed and that control limits were met. Data validation involves evaluating the quality and usability of the data in the context of project objectives. Data verification will initially be completed by the laboratories that generate the data. Integral's field staff will verify data generated in the field, and each laboratory will verify data generated at the laboratory in accordance with its SOPs and quality assurance manual. The accuracy and completeness of the final database will be verified by Integral under the direction of the database administrator.

The review and validation of the data may be conducted by an independent third-party reviewer or Integral. Verification and validation procedures are described in Section 4.2 of this QAPP.

1.3.4 Data Management

Integral is responsible for data management for the pre-design investigation. The EQuIS database application is used as the final repository for all data related to the Arkema Project Area pre-design investigation and will be used to manage the field and laboratory data. Field data will by necessity be entered manually. Data will be provided electronically by the laboratories and imported directly into the database. Data management procedures are discussed in Section 2.10.

1.3.5 Reports

A field sampling and data report will be prepared by Integral after the sampling event and will be provided to EPA after laboratory analyses and the data quality review have been completed and the data are final. Reports are described in Section 3.2.

1.3.6 Project Schedule

The start date for field sampling will be determined following EPA approval of the work plan, which includes this QAPP. However, for illustrative purposes, it is anticipated that Phase 1 field sampling efforts will be conducted in fall 2020 and winter 2021. Sample analysis and data validation for all laboratory analyses are each expected to occur in winter and spring 2021. The field and reporting schedules are discussed further in Section 6 of the work plan.

1.4 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

DQOs were developed for the Arkema Project Area pre-design investigation using EPA's DQO process (USEPA 2006) to describe data and data quality needs for the project. DQOs are designed to ensure that the type, quality, and quantity of environmental data used in decision-making are appropriate for their intended application. Data quality indicators such as the PARCC (precision, accuracy, representativeness, completeness, and comparability) parameters (USEPA 2002a) and analytical sensitivity will be used to assess conformance of data with quality control criteria. DQOs and quality control criteria are described in this section.

1.4.1 The Data Quality Objective Process

The primary objective of the pre-design investigation is to collect additional sediment, sediment porewater, transition zone water, groundwater, and soil data to inform remedial design in the Arkema Project Area. The key objectives of the sediment investigation include the following:

- Sediment Chemistry: Determine concentrations for Portland Harbor focused COCs and other contaminants in the Arkema Project Area with sufficient horizontal and vertical resolution to refine the remedy footprint and support a cost-effective pre-remedial design.
- NAPL: Characterize NAPL, if observed, regardless of source, in subsurface sediment adjacent to the Arkema Project Area.
- Sediment Stability: Assess the sediment deposition rates in the area downstream of Dock 2.
- Bank and Shoreline Soils: Identify areas of the riverbank soil that exceed Portland Harbor RALs and PTW thresholds and have the potential to mobilize to the sediment portion of the Arkema Project Area through erosion or bank failure.
- Groundwater Discharge and COC Flux: Generate data that can be used to evaluate any residual COCs in groundwater downgradient of the barrier wall that could potentially contribute to post-remediation COC flux from the downgradient side of the groundwater barrier wall through the Willamette River sediments.

- Geotechnical Evaluation: Collect design level data that will provide physical and engineering sediment properties for use in design analyses.

Summaries of the outputs of the DQO process are provided in Tables 3-2 to 3-7 of the work plan. Details of the sample collection are presented in the FSP (Appendix A to the work plan) and Section 4 of the work plan.

The sediment chemistry data will be used primarily for screening against Portland Harbor RALs and PTW thresholds. Low-level reporting limits for selected analytes for sediment samples may be required for screening against Portland Harbor cleanup levels. The listed reporting limits reflect the use of method modifications (e.g., large volume injector, smaller extract volume) the laboratories plan to implement to achieve the corresponding project method detection limits (MDLs) and MRLs. The MRLs for sediment, soil, water, and equipment blank analyses are provided in Tables B-3 and B-4. Analytical sensitivity is discussed further in the following section.

1.4.2 Data Quality Indicators

The overall quality objective for the pre-design investigation is to develop and implement procedures that will ensure the collection of representative data of known and acceptable quality. The quality procedures and measurements that will be used for this project are based on SW-846 (USEPA 2014a), ASTM, and other established methods.

PARCC parameters are commonly used to assess the quality of environmental data.

1.4.2.1 Precision

Precision reflects the reproducibility between individual measurements of the same property. Precision will be evaluated using the results of matrix spike duplicates, laboratory duplicates, field splits, and field replicates. Precision is expressed in terms of the relative standard deviation for three or more measurements and the relative percent difference (RPD) for two measurements. The following equation is used to calculate the RPD between measurements:

$$RPD = \frac{|C_1 - C_2|}{(C_1 + C_2)/2} \times 100$$

Where:

RPD = Relative percent difference
C_1 = First measurement
C_2 = Second measurement

The relative standard deviation is the ratio of the standard deviation of three or more measurements to the average of the measurements, expressed as a percentage.

The analytical laboratory will have statistically based acceptability limits for RPDs established for each method of analysis and sample matrix. Laboratory-evaluated duplicates may include spike duplicates (for inorganics), and matrix spike duplicates or laboratory control sample duplicates (for organics). The laboratory will review the quality control samples to ensure that internal quality control data lie within the limits of acceptability. Any suspect trends will be investigated and corrective actions taken.

1.4.2.2 Accuracy

Accuracy (or bias) represents the degree to which a measured concentration conforms to the reference value. The results for matrix spikes, laboratory control samples, equipment blanks, and method blanks will be reviewed to evaluate bias of the data. The following calculation is used to determine percent recovery for a matrix spike sample:

$$\%R = \frac{M - U}{C} \times 100$$

Where:

%R = Percent recovery
M = Measured concentration in the spiked sample
U = Measured concentration in the unspiked sample
C = Concentration of the added spike

The following calculation is used to determine percent recovery for a laboratory control sample or reference material:

$$\%R = \frac{M}{C} \times 100$$

Where:

%R = Percent recovery
M = Measured concentration in the reference material
C = Established reference concentration

Results for field and method blanks can reflect systematic bias that results from contamination of samples during collection or analysis. Any analytes detected in field or method blanks will be evaluated as potential indicators of bias.

Laboratories will evaluate percent recovery data based on in-house statistically based control limits for each method of analysis and specific sample matrix. The laboratory will review the quality control samples and surrogate standard recoveries for each analysis to ensure that internal quality control data lie within the limits of acceptability. The laboratory will investigate any suspect trends and take appropriate corrective actions.

1.4.2.3 Representativeness

Representativeness is a qualitative QA/QC parameter. Representativeness is the degree to which data represent a characteristic of an environmental condition. In the field, representativeness will be addressed primarily in the sampling design by the selection of sampling sites and sample collection procedures.

Data generated by the laboratory must be representative of the laboratory database of accuracy and precision measurements for analytes in different matrices. Laboratory procedures for sample preparation will ensure that aliquots used for analysis are representative of the whole sample. Representativeness will be ensured by the proper handling and storage of samples and initiation of analysis within holding times.

1.4.2.4 Completeness

Completeness will be calculated as the ratio of usable data (i.e., unqualified data and *U*- or *J*-qualified data) to generated data, expressed as a percentage. Completeness will be calculated for each suite of analytes for each sample type and sampling event. The completeness goal for this project is 90 percent.

1.4.2.5 Comparability

Comparability is the qualitative similarity of one data set to another (i.e., the extent to which different data sets can be combined for use). Comparability will be addressed through the use of field and laboratory methods that are consistent with methods and procedures recommended by EPA and commonly used for pre-design studies.

Laboratory quality control results will be evaluated to provide supplementary information regarding overall quality of the data, performance of instruments and measurement systems, and sample-specific matrix effects.

Quality control samples and procedures are specified in each method protocol that will be used for this project. Methods are summarized in Table B-3 and B-4. All quality control requirements will be completed by each laboratory as described in the protocols, including the following (as applicable to each analysis):

- Instrument tuning

- Initial calibration
- Initial calibration verification
- Continuing calibration verification
- Calibration or instrument blanks
- Method blanks
- Laboratory control samples
- Internal standards
- Surrogate spikes
- Serial dilutions
- Matrix spikes
- Matrix spike duplicates or laboratory duplicates.

To alert the data user to possible bias or imprecision, data qualifiers will be applied to reported analyte concentrations when associated quality control samples or procedures do not meet control limits. Laboratory control limits for the methods that will be used for this pre-design investigation are provided in Tables B-7 through B-10 and in the laboratory quality assurance manuals (Attachment 1). The laboratory control limits presented in these tables are current as of the writing of this document. Control limits are periodically updated by the laboratory, and the control limits that are in effect at the laboratory at the time of analysis will be used for sample analysis and data validation. Data validation criteria and procedures are described in Sections 4.1 and 4.2 of this QAPP.

MRLs reflect the sensitivity of the analysis. Target MRLs for this study are summarized in Tables B-5 and B-6. Method modifications are described in Section 2.4. MDL studies are provided in Attachment 2.

Where applicable, MDLs have been determined for each analyte, as required by USEPA (2014a; Tables B-5 and B-6). MDLs are statistically derived and reflect the concentration at which an analyte can be detected in a clean matrix (e.g., sand or distilled water) with 99 percent confidence that a false positive result has not been reported. MRLs are established by the laboratories at levels above the MDLs for the project analytes. The MRL values are based on the laboratories' experience analyzing environmental samples and reflect the typical sensitivity obtained by the analytical system in environmental samples. The concentration of the lowest standard in the initial calibration curve for each analysis is at the level of the MRL. This allows reliable quantification of concentrations to the MRL in the absence of matrix interferences.

For all chemical analyses except high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS) analysis of PCB congeners and PCDD/Fs, analyte concentrations

for this investigation will be reported to the MDL. For HRMS methods, analyte concentrations will be reported to laboratory-established sample-specific estimated detection limits (EDLs). Analytes detected at concentrations between the MRL and the MDL (or EDL) will be reported with a *J* qualifier to indicate that the value is an estimate (i.e., the analyte concentration is below the calibration range). Non-detects will be reported at the MDL (or EDL). The MDL (or EDL) will be adjusted by each laboratory, as necessary, to reflect sample dilution or matrix interference. MDLs are updated periodically by the laboratories, and the MDLs that are in effect at the laboratory at the time of analysis will be used. The use of the MDL (or EDL) to report data for non-detects will be evaluated during data quality review.

1.5 SPECIAL TRAINING/CERTIFICATION

Integral has assembled a project team with the requisite experience and technical skills to successfully complete the Arkema Project Area pre-design investigation. All consultant team personnel involved in sample collection have extensive environmental sampling experience. Minimum training and certification requirements for laboratory personnel are described in the laboratory quality assurance manuals (Attachment 1 of this QAPP).

The Superfund Amendments and Reauthorization Act of 1986 required the Secretary of Labor to issue regulations providing health and safety standards and guidelines for workers engaged in hazardous waste operations. In response to this requirement, the U.S. Occupational Safety and Health Administration developed regulation 29 CFR§1910.120, the "Hazardous Waste Operations and Emergency Response" standard (HAZWOPER). This standard includes requirements for workers engaged in hazardous waste operations to complete a 40-hour training course and annual 8-hour refresher courses. The training provides employees with knowledge and skills that enable them to perform their jobs safely and with minimum risk to their personal health. All sampling personnel will have completed the 40-hour HAZWOPER training course and 8-hour refresher courses, as necessary. Documentation of course completion will be maintained in personnel files.

1.6 DOCUMENTS AND RECORDS

Records will be maintained documenting all activities and data related to sample collection and to laboratory analyses. Results of data verification and validation activities will also be documented. Procedures for documentation of these activities are described in this section.

The FSP, this QAPP, and the health and safety plan will be provided to every project participant listed in the Distribution List. Any revisions or amendments to any of these documents will also be provided to these individuals.

The project manager is responsible for distributing the most current copies of the project documents. The project manager will distribute electronic copies or hardcopies at his or her discretion.

1.6.1 Field Documentation

The following field records will be maintained throughout the duration of sampling activities:

- Field logbooks
- Photographic documentation
- Sample collection information forms
- Sample summary logs
- Sediment boring logs
- Sample labels
- Sample chain-of-custody forms
- Custody seals.

The content and use of this documentation is described in Section 6.2 of the FSP (Appendix A of the work plan). Field documentation related to sample collection will be maintained in the project file in Integral's Portland office. The laboratories will return original completed chain-of-custody forms to Integral. These will also be maintained in the project file.

The following reports will be completed, as necessary, to document an audit or a deviation from the FSP or the QAPP:

- Corrective action reports will be used, as necessary, to document any problems encountered during field activities and corrective actions taken.
- Field change request forms will be used, as necessary, to document the need for a procedural change or a station location change.
- System and performance audit reports will be used, as necessary, to document review or audit of field sampling activities. System or performance audits will be conducted if serious problems or nonconformances are encountered during sampling operations. If completed, these audits will be conducted by the Integral project/QA manager or designee. These audits may consist of onsite reviews of any phase of field activities. The field audit form is presented in Attachment 3.

The project/QA manager will ensure that the field team receives the final approved version of each FSP and this QAPP prior to the initiation of field activities.

1.6.2 Laboratory Documentation

All activities and results related to sample analysis will be documented at each laboratory. Internal laboratory documentation procedures are described in the laboratory quality assurance manuals (Attachment 1 to this QAPP).

1.6.2.1 Analytical Laboratory

The analytical laboratory will provide a data package for each sample delivery group or analysis batch that is comparable in content to a full Contract Laboratory Program (CLP) package. The format of the data may differ from CLP requirements. Each data package will contain all information required for a complete quality assurance review, including the following:

- A cover letter discussing analytical procedures and any difficulties that were encountered
- A case narrative referencing or describing the procedures used and discussing any analytical problems and deviations from SOPs and this QAPP
- Chain-of-custody and cooler receipt forms
- A summary of analyte concentrations (to two significant figures, unless otherwise justified), MRLs, and MDLs (or EDLs)
- Laboratory data qualifier codes appended to analyte concentrations, as appropriate, and a summary of code definitions
- Sample preparation and cleanup logs
- Instrument tuning check data
- Initial and continuing calibration data, including instrument printouts and quantification summaries, for all analytes
- Results for method and calibration blanks
- Results for all QA/QC checks, including but not limited to surrogate spikes, internal standards, laboratory control samples, matrix spike samples, matrix spike duplicate samples, and laboratory duplicate or triplicate samples provided on summary forms
- Instrument data quantification reports for all analyses and samples
- Florisil® check data and gel permeation chromatography calibration data
- Copies of all laboratory worksheets and standards preparation logs.

Data will be delivered in both hard-copy and electronic format to the Integral lead chemist, who will be responsible for oversight of data verification and validation and for archiving the final

data and data quality reports in the project file. A copy of the first data package for each sample type and method will be provided to the EPA quality assurance manager upon receipt from each laboratory. Integral will maintain data packages and EDDs for chemical analyses.

EDDs will be compatible with Integral's EQuIS database.

Laboratory data will be maintained by each laboratory for a period of at least 5 years. These data will include the original instrument data files, reduced and verified data stored in the laboratory information management system (LIMS), and final hard copy and EDDs. The laboratories will obtain approval from LSS prior to discarding these data.

1.6.3 Data Quality Documentation

Data validation reports prepared by the contracted validation firm will provided to the lead chemist. Results of the validation reports will be summarized in the summary report for the sampling event. Any limitations to the usability of the data will also be discussed in this report.

All electronic database entries provided by each laboratory will be verified against the validated data in the data package. All changes to the database will be documented in an electronic log file that automatically enters a current time stamp when opened and allows the data editor to enter notes about changes to the database. Any data tables prepared from the database for data users will include all qualifiers that were applied by the laboratories and during data validation, unless otherwise requested.

1.6.4 Back Up and Maintain Database and Data Files

All documents will stored as electronic files on a networked server. All data on the networked server will be stored on redundant, mirrored hard drives to protect against data loss due to hard drive failure. These drives will be mounted in a file server protected by an uninterruptible power supply that includes two diesel generators in the event of an extended power outage. The data from these drives, as well as any other data stored elsewhere on the network, will be backed up daily after work hours to a separate, corporate backup server to protect against data loss due to user error. This backup enables access to the most recently changed versions of all files. Overall, components that make up the data infrastructure (systems that store, backup, archive, etc.) and network systems will be monitored and maintained weekly to ensure that ongoing data storage and access needs are efficiently managed. Backup procedures will protect the data from system failure, accidental damage, catastrophic failures, and intrusion.

2 DATA GENERATION AND ACQUISITION

The following sections present the methodology for data generation and acquisition.

2.1 SAMPLING PROCESS DESIGN

This section presents the sampling design to complete the Arkema Project Area pre-design investigation (see Section 3 in the work plan). The design is based on Integral and DOF's understanding of historical data and professional judgment. Specific information related to sampling methods and sample handling procedures are addressed in the FSP (Appendix A to the work plan) and in Section 4 of the work plan.

The primary objective of the pre-design investigation is to collect additional sediment, sediment porewater, transition zone water, and groundwater, and soil data to inform remedial design in the Arkema Project Area. The complete sampling design (including station locations, types, and numbers of samples that will be collected; the rationale for collection; and the analyses that will be performed), as well as detailed sample collection and handling methods, are described in the work plan. A summary of samples and analyses is provided in Table B-11.

2.1.1 Sediment Chemistry

The following section present an overview of surface and subsurface sediment chemistry sampling.

2.1.2 Surface Sediment Chemistry

If needed for Phase 2, surface sediment (0–1 ft below mudline) samples for evaluation of focused COCs and other contaminants will be collected using a vessel-deployed power grab or equivalent sediment sampler. The number and locations of samples will be determined based on the results of the Phase 1 sampling.

2.1.3 Subsurface Sediment Chemistry

A total of 94 sediment cores are proposed for evaluation of focused COCs and other contaminants in the Arkema Project Area and 4 sediment cores in the navigation channel (Figures 3-1 and 3-2a-b of the work plan). Section 3 and Table 3-2 of the work plan provide a description of the proposed subsurface sediment sampling stations.

2.1.4 NAPL

A total of 12 sediment cores are proposed for the evaluation of potential NAPL and sheens in the Arkema Project Area (Figures 3-1 and 3-2a-b of the work plan). Section 3 and Table 3-4 of the work plan provide a description of the proposed NAPL sampling stations.

2.1.5 Sediment Stability

If needed for Phase 2, a limited number of sediment cores will be collected for evaluation of sediment stability parameters (cesium-137, lead-210, DDx). The number and locations of samples will be determined based on the results of the Phase 1 sampling. Section 3 and Table 3-5 of the work plan provide a description of the potential sediment stability sampling stations.

2.1.6 Bank and Shoreline Soils

A total of 39 soil borings are proposed for evaluation of focused COCs and other contaminants in bank and shoreline soils (Figures 3-1 and 3-2a-b of the work plan). Section 3 and Table 3-3 of the work plan provide a description of the proposed bank and shoreline soil sampling stations.

2.1.7 Groundwater Discharge and COC Flux

A total of nine groundwater samples from monitoring wells, four groundwater samples from piezometers, and eight transition zone water samples from UltraSeep meters are proposed for evaluation of COCs in groundwater along the flow path from the top of the riverbank to the nearshore area of the Arkema site (Figure 3-4 of the work plan). Section 3 and Table 3-6 of the work plan provide a description of the proposed groundwater discharge and COC flux sampling stations.

2.1.8 Porewater

Porewater sampling will be conducted at three locations in support of sediment cap design using a Trident Probe or similar device (Figure 3-5 of the work plan). The porewater samples will be collected from three depths and analyzed for dissolved organic carbon and VOCs.

2.1.9 Geotechnical Evaluation

Sediment borings will be advanced at seven locations to assess geotechnical parameters using a mud-rotary drill rig (or equivalent rig). In addition, six test pits will be excavated for the evaluation of geotechnical parameters. The sample locations are presented on Figure 3-7 of the work plan. Section 3 and Table 3-7 of the work plan provide a description of the proposed geotechnical sampling stations.

2.2 SAMPLING METHODS

Field sampling methods for the following are described in Sections 4 through 6 of the FSP (Appendix A to the work plan):

- Subsurface utility clearance
- Horizontal and vertical control
- Surface sediment sampling
- Subsurface sediment sampling
- Riverbank soil sampling
- Groundwater discharge study
- Sediment porewater sampling
- Sample designation
- Sample handling procedures
- Field documentation and procedures
- Decontamination procedures
- Investigation-derived waste management.

SOPs for each sampling method are provided in the FSP (Appendix A to the work plan).

In the event that unanticipated or changed circumstances occur in the field that require a major departure from the FSP, the change will be documented on a field change request form (see Attachment 2 to the FSP [Appendix A of the work plan]). The field operations manager will complete the field change request form. After approval from the Integral project/QA manager, EPA will be given the opportunity to review and approve the field change request. The field operations manager will then institute the necessary corrective actions, and ensure that the appropriate procedures are followed. In any other circumstances where sampling conditions are unanticipated, the appropriate sampling actions consistent with this task's objectives will be conducted. These changes will be noted in the field log. Any problems that cannot be easily resolved or that affect the final quality of the work product will be brought to the attention of the Integral and LSS project managers. EPA will be notified of any problems that may affect the final outcome of this task.

If any stations are determined to be inaccessible, the Integral field team leader, in consultation with EPA's oversight contractor, will locate at least two nearby alternate locations that meet the objectives of the sample station. The alternate locations will be provided verbally to the LSS and EPA project managers for their input and approval. Once a decision has been made for the

alternate location, the station will be moved and a field change request form will be drafted and submitted to EPA to document the station location change.

Additional information regarding corrective actions and related documentation is provided in Section 3.1.

2.3 SAMPLE HANDLING AND CUSTODY

The following sections present sampling handling and custody protocols.

2.3.1 Field to Laboratory Sample Handling and Custody

Detailed descriptions of procedures for sample identification, handling, documentation, custody, and ultimate disposal are presented in the FSP (Appendix A of the work plan).

From the time of collection, all samples and sediment cores will be stored on ice or refrigerated to a temperature ≤6°C prior to processing. Requirements for sample containers, sample preservation, and holding times are summarized in Tables B-12 and B-13.

Sample containers will be supplied by the laboratories. Commercially available pre-cleaned jars will be used, and each laboratory will maintain a record of certification from the suppliers. The bottle shipment documentation will include batch numbers for the bottles. With this documentation, bottles can be traced to the supplier, and bottle wash analysis results can be reviewed.

The field team coordinator, or the designated field sample custodian, will be responsible for sample tracking in the field. Samples will remain in Integral's custody until chain-of-custody forms and final sample inventory are completed in the field or at the field sample processing facility. Chain-of-custody forms will be used for samples that are in transit from the field site to the testing laboratories. The custodian will relinquish the samples to a designated analytical laboratory courier service or commercial transport company (e.g., Federal Express). Custody of samples in the field or at the field processing facility will be documented in the field logs.

Samples are considered to be in custody if they are 1) in the custodian's possession or view, 2) in a secured location (under lock) with restricted access, or 3) in a container that is secured with an official seal(s) such that the sample cannot be reached without breaking the seal(s). The principal documents used to identify samples and to document possession are chain-of-custody records, field logbooks, and field tracking forms. Chain-of-custody procedures will be used for all samples at all stages in the analytical or transfer process and for all data and data documentation whether in hard copy or electronic format. An example of a chain-of-custody form is provided in Attachment 4.

Sample packing and shipping procedures are detailed in the FSP (Appendix A to the work plan). Samples will be shipped to the laboratory in ice chests sealed with custody seals. Trip blanks will be included in all coolers containing samples for volatile analyses. Each ice chest will have three seals, one on the front of the chest and one on each side. The laboratory sample custodian will establish the integrity of the seals at the laboratory. The way bill of the carrier used to ship samples will provide additional custody and sample tracking information. The way bills will be maintained in the project file.

The sample custodian at each laboratory will accept custody and log samples into the LIMS. The sample custodian will check that the chain-of-custody forms were properly completed and signed, that a sample receipt form is completed for each cooler, and that samples are stored under the required temperature conditions. Each laboratory will deliver a copy of the chain-of-custody and sample receipt form to the lead chemist. Any breaks in the chain-of-custody or nonconformances will be noted and reported in writing to the lead chemist within 24 hours of receipt of samples.

Specific laboratory chain-of-custody procedures are described in the laboratory quality assurance manual for each of the designated laboratories (Attachment 1).

2.3.2 Intralaboratory Sample Transfer

The laboratory project manager will ensure that a sample-tracking record is maintained that follows each sample through all stages of laboratory processing. The sample-tracking record must contain, at a minimum, the names of individuals responsible for performing the analysis; dates of sample extraction, preparation, and analysis; and the type of analysis being performed.

2.3.3 Archived Samples

Archive samples will be collected for all of the sediment samples (i.e., surface sediment and sediment core samples). Up to 16 ounces of sediment will be collected for archiving for samples that are scheduled for analysis, as available. In addition, any sample remaining in the sample jars after aliquots are removed for analysis by the laboratory will be archived. For subsurface sediment samples that are not scheduled for analysis, 32 ounces will be collected for archiving.

All archive samples will be submitted to the laboratory and will be stored at -20±4°C. Sediment remaining after analysis will be archived by the laboratory that completed the analysis. The laboratory will maintain chain-of-custody documentation and proper storage conditions for the entire time that the samples are in their possession. The laboratory for this project will store the archive and excess samples for 12 months following completion of data validation. Archive samples will only be disposed of upon written authorization from LSS.

2.4 ANALYTICAL METHODS

Analytical methods to be used are consistent with requirements provided in *Test Methods for Evaluating Solid Wastes Physical/Chemical Methods* (SW-846; USEPA 2014a) and select ASTM methods, and other established and widely accepted protocols. For the analysis of sediment samples, modifications may be made to these methods, as necessary and technically feasible, to improve MRLs. Method modifications are not anticipated for the analysis of water samples or equipment blanks.

All surface sediment, subsurface sediment, soil, groundwater, transition zone water, and sediment porewater samples will be analyzed by a Eurofins/TestAmerica. If for any reason, any of these laboratories are not used after QAPP approval, EPA will be notified, and laboratory-specific quality assurance protocols for any new laboratory will be provided to EPA as an addendum to this QAPP.

LSS has requested the laboratories provide results within 20 business days of receipt of the samples at the laboratory.

The analytical method protocols include descriptions of quality control procedures, control limits, and requirements for corrective actions. The laboratories' SOPs for these analyses are provided in Attachment 5.

2.4.1 Surface Sediments

The methods described in this section apply to surface sediment samples, if needed based on the results from Phase 1 sampling. Table B-3 summarizes the analytical methods that will be used for the surface sediment samples. Surface sediments could be analyzed for one or more of the following parameters:

- DDx
- PCDD/Fs
- PCB congeners
- PAHs.

2.4.1.1 DDx

DDx will be extracted from sediment samples using sonication extraction procedures (EPA SW-846 Method 3550B) and analyzed by gas chromatography/electron capture detector (GC/ECD; EPA SW-846 Method 8081B). Sulfuric acid cleanup (EPA SW-846 3665A) and sulfur removal with tetrabutylammonium sulfite (EPA SW-846 Method 3660B modified) will be performed on the extract if necessary to achieve the MRL/MDLs specified in Table B-5.

Pesticide detections will be qualitatively confirmed using the instrument data for the gas chromatography/mass spectrometry (GC/MS) analysis when concentrations are 2 mg/kg or above. In addition, the laboratories will analyze Aroclor standards during the initial calibration or opening continuing calibration for organochlorine pesticides to evaluate the effects of Aroclor interferences on pesticide identification. The chromatograms and instrument data quantification reports for these Aroclor standards will be provided with each organochlorine pesticide data package.

2.4.1.2 PCDD/Fs

PCDD/Fs in sediment samples will be extracted with toluene in a Soxhlet extractor. Cleanup procedures will use silica, alumina, and sulfuric acid. Samples will be analyzed by HRGC/HRMS according to EPA Method 1613B (USEPA 1994).

2.4.1.3 PCB Congeners

For PCB congener analyses, samples will be extracted using Soxhlet procedures and analyzed by HRGC/HRMS according to EPA Method 1668C (USEPA 2010).

2.4.1.4 PAHs

For PAH analyses, samples will be extracted using Soxhlet procedures and analyzed by GC/MS according to EPA Method 8270D SIM (USEPA 2014a).

2.4.2 Subsurface Sediments

The methods described in this section apply to subsurface sediment samples. Table B-3 summarizes the analytical methods that will be used for the subsurface sediment samples. Select subsurface sediment samples will be analyzed for one or more of the following COCs:

- DDx
- PCDD/Fs
- PCB congeners
- PAHs
- Sediment stability analytes (cesium-137, lead-210, DDx)
- Pesticides/herbicides
- TAL metals
- VOCs and chlorobenzene
- Geotechnical parameters.

2.4.2.1 DDx

DDx will be extracted from sediment samples using sonication extraction procedures (EPA SW-846 Method 3550B) and analyzed by GC/ECD (EPA SW-846 Method 8081B). Sulfuric acid cleanup (EPA SW-846 Method 3665A) and sulfur removal with tetrabutylammonium sulfite (EPA SW-846 Method 3660B modified) will be performed on the extract if necessary to achieve the MRL/MDLs specified in Table B-5.

Pesticide detections will be qualitatively confirmed using the instrument data for the GC/MS analysis when concentrations are 2 mg/kg or above. In addition, the laboratories will analyze Aroclor standards during the initial calibration or opening continuing calibration for organochlorine pesticides to evaluate the effects of Aroclor interferences on pesticide identification. The chromatograms and instrument data quantification reports for these Aroclor standards will be provided with each organochlorine pesticide data package.

2.4.2.2 PCDD/Fs

PCDD/Fs in sediment samples will be extracted with toluene in a Soxhlet extractor. Cleanup procedures will use silica, alumina, and sulfuric acid extraction. Samples will be analyzed by HRGC/HRMS according to EPA 6 Method 1613B (EPA 1994).

2.4.2.3 PCB Congeners

For PCB congener analyses, samples will be extracted using Soxhlet procedures and analyzed by HRGC/HRMS according to EPA Method 1668C (USEPA 2010).

2.4.2.4 PAHs

For PAH analyses, samples will be extracted using Soxhlet procedures and analyzed by GC/MS according to EPA Method 8270D SIM (USEPA 2014a).

2.4.2.5 Cesium-137 and Lead-210

Subsurface samples may be analyzed for cesium-137 and lead-210 by Teledyne in Knoxville, Tennessee. Cesium-137 will be analyzed using gamma spectroscopy according to an internal Teledyne SOP (TBE-2007). Lead-210 will be analyzed using alpha spectroscopy according to an internal Teledyne SOP (TBE-2015).

2.4.2.6 VOCs and Chlorobenzene

Samples for VOC and chlorobenzene analyses will be extracted using purge and trap protocols (EPA SW-846 Method 5035) and analyzed by GC/MS (EPA SW-846 Method 8260C). The mass spectrometer will be operated in full-scan mode.

2.4.2.7 Pesticides

Organochlorine pesticides will be extracted from sediment samples using sonication extraction procedures (EPA SW-846 Method 3550B) and analyzed by GC/ECD (EPA SW-846 Method 8081B). Sulfuric acid cleanup (EPA SW-846 Method 3665A) and sulfur removal with tetrabutylammonium sulfite (EPA SW-846 Method 3660B modified) will be performed on the extract if necessary to achieve the MRL/MDLs specified in Table B-5.

2.4.2.8 Herbicides

Chlorinated herbicides will be extracted from sediment samples using sonication extraction procedures (EPA SW-846 Method 3550B) and analyzed by GC/MS (EPA SW-846 Method 8151A).

2.4.2.9 Metals

Twenty-three TAL metals will be extracted from sediment samples using sonication extraction procedures (EPA SW-846 Methods 3050B/7471A) and analyzed by inductively coupled plasma-mass spectrometry (EPA SW-846 Method 6020A), inductively coupled plasma-atomic emission spectroscopy (EPA SW-846 Method 6010C), and cold vapor atomic absorption spectroscopy (EPA SW-846 Method 7471A).

2.4.2.10 Geotechnical Parameters

Sediment samples may be analyzed for the following geotechnical parameters according to ASTM methods[2]:

- Water content (ASTM D-2216)
- Grain size (ASTM D-6913 and D-7928)
- Total organic carbon (ASTM D-2974 or SW-846-9060A Mod)
- Atterberg Limits (Plasticity, ASTM D-4318)
- Sediment strength (ASTM D-2850 and D-4767)
- Unit Weight (Bulk density ASTM D-7263.

[2] For ASTM methods without a specified date, the current edition will be used.

2.4.3 NAPL and COC Assessment

If there is field evidence of potential NAPL (via direct observation, fluorescence, or hydrophobic dye shake test), sediment samples will be collected and submitted to the laboratory and analyzed for the following:

- Total petroleum hydrocarbon (TPH)-diesel range organics (DRO)/motor oil range organics (MRO)
- TPH-gasoline range organics (GRO)
- VOCs
- Grain size (ASTM D-6913 and D-7928)
- TOC (ASTM D-2974 or SW-846-9060A Mod)
- Density
- Viscosity.

2.4.3.1 Total Petroleum Hydrocarbon

Samples for GRO, DRO, and MRO will be extracted using purge and trap or sonication and analyzed by gas chromatography/flame ionization detector (Ecology NWTPH-Gx and NWTPH-Dx).

2.4.3.2 VOCs

Sediment samples will be analyzed for physical and engineering parameters using ASTM methods listed in the FSP.

2.4.3.3 Geotechnical Parameters

Sediment samples will be analyzed for grain size, total organic carbon, density, and viscosity according to ASTM Methods D422, D4129, D1481, and D445, respectively.

2.4.4 Soil Sampling

The methods described in this section apply to soil samples. Table B-3 summarizes the analytical methods that will be used for the soil samples. Soil samples from hand auger boreholes will be analyzed for one or more of the following parameters:

- Asbestos
- DDx
- PCDD/Fs

- PCB congeners.

Soil samples from test pits may be analyzed for the following geotechnical parameters according to ASTM methods:

- Water content (ASTM D-2216)
- Grain size (ASTM D-6913 and D-7928)
- Total organic carbon (ASTM D-2974 or SW-846-9060A Mod)
- Atterberg Limits (Plasticity, ASTM D-4318).

2.4.4.1 Asbestos

Asbestos in soil samples will be analyzed according to California Resource Control Board Method 435. Soils will undergo size reduction prior to analysis using polarized light microscopy.

2.4.4.2 DDx

DDx will be extracted from soil samples using sonication extraction procedures (EPA SW-846 Method 3550B) and analyzed by GC/ECD (EPA SW-846 Method 8081B). Sulfuric acid cleanup (EPA SW-846 Method 3665A) and sulfur removal with tetrybutylammonium sulfite (EPA SW-846 Method 3660B modified) will be performed on the extract if necessary to achieve the MRL/MDLs specified in Table B-5.

Pesticide detections will be qualitatively confirmed using the instrument data for the GC/MS analysis when concentrations are 2 mg/kg or above. In addition, the laboratories will analyze Aroclor standards during the initial calibration or opening continuing calibration for organochlorine pesticides to evaluate the effects of Aroclor interferences on pesticide identification. The chromatograms and instrument data quantification reports for these Aroclor standards will be provided with each organochlorine pesticide data package.

2.4.4.3 PCDD/Fs

PCDD/Fs in soil samples will be extracted with toluene in a Soxhlet extractor. Cleanup procedures will use silica, alumina, and sulfuric acid. Samples will be analyzed by HRGC/HRMS according to EPA Method 1613B.

2.4.4.4 PCB Congeners

For PCB congener analyses, samples will be extracted using Soxhlet procedures and analyzed by HRGC/HRMS according to EPA Method 1668C (USEPA 2010).

2.4.4.5 Geotechnical Parameters

Test pit samples may be analyzed for moisture content, grain size, Atterberg limits, organic content, shear strength, and consolidation according to ASTM methods.

2.4.5 Groundwater, Transition Zone Water, and Porewater Sampling

The methods described in this section apply to the groundwater, transition zone water, and porewater samples. Table B-4 summarizes the analytical methods that will be used for the water samples. Groundwater, transition zone water, and porewater samples will be analyzed for one or more of the following parameters:

- DDx
- VOCs
- DOC.

2.4.5.1 DDx

DDx will be extracted from water samples using liquid-liquid extraction procedures (EPA SW-846 Method 3510C) and analyzed by GC/ECD (EPA SW-846 Method 8081B).

Pesticide detections will be qualitatively confirmed using the instrument data for the GC/MS analysis when concentrations are 2 mg/L or above. In addition, the laboratories will analyze Aroclor standards during the initial calibration or opening continuing calibration for organochlorine pesticides to evaluate the effects of Aroclor interferences on pesticide identification. The chromatograms and instrument data quantification reports for these Aroclor standards will be provided with each organochlorine pesticide data package.

2.4.5.2 VOCs

Samples for VOC analyses will be extracted using purge and trap protocols (EPA SW-846 Method 5035) and analyzed by GC/MS (EPA SW-846 Method 8260C). The mass spectrometer will be operated in full-scan mode.

2.4.5.3 Dissolved Organic Carbon

DOC in surface sediment porewater will be determined by persulfate oxidation and infrared detection according to EPA SW846-9060A (USEPA 2014a).

2.4.6 Moisture Content

All soil and sediment samples undergoing chemical analysis will be analyzed for percent moisture according to APHA SM Method 2540 G (APHA 2017). The chemical results for these soil and sediment samples will be reported on a dry weight basis.

2.4.7 Analyses in Equipment Rinsate Blanks

Field equipment blanks will be analyzed for chloride, DOC, organochlorine pesticides, chlorinated herbicides, metals, PAHs, PCB congeners, VOCs, PCDD/Fs, cesium-137, lead-210, and TPH using analytical methods as shown in Table B-4. Method modifications are not anticipated for the analysis of equipment blanks. For each analytical method, the analysis of equipment blank samples will be performed at the same laboratory location that analyzes the associated sediment samples.

2.5 QUALITY CONTROL

Quality control samples will be prepared in the field and at the laboratories to monitor the bias and precision of the sample collection and analysis procedures.

Laboratory quality control results will be evaluated to provide supplementary information regarding overall quality of the data, performance of instruments and measurement systems, and sample-specific matrix effects.

The analytical method protocols include descriptions of quality control procedures, control limits, and requirements for corrective actions. Laboratory control limits are provided in Tables B-7 to B-10. Control limits are updated periodically by the laboratories, and control limits that are in effect at the laboratory at the time of analysis will be used for sample analysis and data validation. Quality control procedures will be completed by the laboratory, as required in the protocols and the laboratory SOPs (see Attachment 5).

2.5.1 Field Quality Control Samples

Field quality control samples for this study will include field duplicates, equipment rinse blanks, trip blanks, and temperature blanks. The frequency of collection of field duplicates and equipment rinse blanks is summarized in Table B-11.

Field duplicates are generated by the field team by splitting the sediment sample into two aliquots for laboratory analysis. Data for field duplicates are used to evaluate sample handling and analysis procedures and used in the evaluation of the precision of the results.

Equipment rinse blanks are collected by pouring water over the sample homogenization equipment (i.e., for sediment samples). Equipment rinse blanks are used to monitor equipment decontamination procedures and to check for other sources of contamination.

Trip blanks are used to monitor for cross-contamination during sample shipment and storage. Trip blanks will be included in all coolers containing samples for volatile analyses. Trip blanks are used only for samples that will be analyzed for volatile constituents.

A temperature blank (a jar filled with water) is included with each cooler of samples. The laboratory sample custodian measures the temperature of the water in the jar to determine the temperature of the cooler upon receipt at the laboratory.

Procedures for preparing field quality control samples are provided in the FSP (Appendix A to the work plan). Validation criteria and procedures for field quality control samples are described in Sections 4.1 and 4.2.

2.5.2 Laboratory Quality Control

The following sections present laboratory quality control procedures.

2.5.2.1 Analytical Laboratory

Extensive and detailed requirements for laboratory quality control procedures are provided in the method protocols that will be used for this study (Tables B-3 and B-4). Every method protocol includes descriptions of quality control procedures, and many incorporate additional quality control requirements by reference to separate quality control chapters. Quality control requirements include control limits and, in many cases, requirements for corrective action. Quality control procedures will be completed by the laboratories, as required in each method protocol.

The frequency of analysis for laboratory control samples, matrix spike samples, matrix spike duplicates or laboratory duplicates, and method blanks will be one for every 20 samples or one per extraction batch, whichever is more frequent. Surrogate spikes and internal standards will be added to every field sample and quality control sample, as required by the method. Calibration procedures will be completed at the frequency specified in each method description. As required for EPA SW-846 methods (USEPA 2014a), performance-based control limits have been established by each laboratory. These and all other control limits specified in the method descriptions will be used by the laboratories to establish the acceptability of the data or the need for reanalysis of the samples. Control limits for surrogate compounds, laboratory control samples/laboratory control sample duplicates, and matrix spike/matrix spike duplicates are provided for all matrices in Tables B-7 through B-10.

Storage blanks for VOCs in sediment will be prepared and analyzed at the laboratory according to standard laboratory procedures. A pair of VOC blanks will be prepared for each cooler at the laboratory, but only one of the blanks will be shipped to the field. This blank will become a trip blank in a cooler of samples. The second blank will be retained at the laboratory and will become the storage blank when the cooler is received at the laboratory. A storage blank will be randomly selected for analysis on a weekly basis. In addition, the storage blank associated with a given cooler will be analyzed if results for the trip blank indicate that samples may be contaminated. Results for the storage blank will indicate whether contamination is related to field and shipping conditions or to laboratory storage conditions.

2.6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Analytical instrument testing, inspection, maintenance, setup, and calibration will be conducted by each laboratory in accordance with the requirements identified in the laboratory SOPs (Attachment 5 to this QAPP) and manufacturer instructions. Instrument maintenance and repair will be documented in maintenance logs or record books.

2.7 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Laboratory instruments will be properly calibrated, and the calibration will be verified with appropriate check standards and calibration blanks for each parameter before beginning each analysis. Instrument calibration procedures and schedules will conform to analytical protocol requirements and descriptions provided in the laboratories' quality assurance manuals (Attachment 1 to this QAPP) and SOPs (Attachment 5 to this QAPP).

All calibration standards will be obtained from either the EPA repository or a commercial vendor, and the laboratory will maintain traceability to the National Institute of Standards and Technology. Stock standards will be used to make intermediate standards and calibration standards. Special attention will be given to expiration dating, proper labeling, proper refrigeration, and prevention of contamination. Documentation relating to the receipt, mixing, and use of standards will be recorded in a laboratory logbook. All calibration and spiking standards will be checked against standards from another source.

2.8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

The quality of supplies and consumables used during sample collection and laboratory analysis can affect the quality of the project data. All equipment that comes into contact with the samples and extracts must be sufficiently clean to prevent detectable contamination, and the

analyte concentrations must be accurate in all standards used for calibration and quality control purposes.

During sample collection, solvents of appropriate, documented purity will be used for decontamination. Solvent containers will be dated and initialed when they are opened. The quality of laboratory water used for decontamination will be documented at the laboratory that provides that water. As discussed in Section 2.3.1, cleaned and documented sample containers will be provided by the laboratories. All containers will be visually inspected prior to use, and any suspect containers will be discarded.

Information on other supplies and consumables used are provided in the SOPs for each sampling method (Appendix A of the work plan) and in Section 4 of the work plan. Reagents of appropriate purity and suitably cleaned laboratory equipment will also be used for all stages of laboratory analyses. Details for acceptance requirements for supplies and consumables at the laboratories are provided in the laboratory SOPs (Attachment 5 of this QAPP) and quality assurance manuals (Attachment 1). All supplies will be obtained from reputable suppliers with appropriate documentation or certification. Supplies will be inspected to confirm that they meet use requirements, and certification records will be retained by Integral (i.e., for supplies used in the field) or the laboratories.

2.9 NON-DIRECT MEASUREMENTS

Historical data sets will be used to supplement the data acquired under the work plan. These include the following:

- 1997–2007 Lower Willamette Group remedial investigation surface sediment data
- 2004–2007 Lower Willamette Group remedial investigation benthic toxicity data
- 1997–2020 Arkema remedial investigation, risk assessment, and groundwater and stormwater source control measure data.
- 2009 Engineering evaluation and cost analysis investigation data
- 2009 Engineering evaluation and cost analysis archived PCB sediment data
- 2018 Pre-remedial design investigation.

Historical data combined with the newer data available for Portland Harbor and the Arkema Project Area will affect the design of the investigation. Identification of data gaps is addressed in Section 2.10 of the work plan.

Sampling conducted under this work plan is designed to be consistent with these historical sampling activities to facilitate the spatial and temporal trend analyses of the DQOs.

2.10 DATA MANAGEMENT

Data for the Arkema Project Area pre-design investigation will be generated in the field and at the laboratories. The final repository for all sample information will be an EQuIS database. Procedures to be used to transfer data from the point of generation to the EQuIS database are described in this section. The project database manager is responsible for all data management tasks.

2.10.1 Field Data

Daily field records (a combination of field logbooks and field data sheets) and navigational records will make up the main documentation for field activities. The records and procedures most applicable to field activities are summarized in Section 6.2.1 (field logbooks), Section 6.2.2 (photo documentation), and Section 6.2.3 (sample collection information form) of the FSP (Appendix A to the work plan).

Data that are generated during sample collection and sample preparation will be manually entered into the field logbook and core logs. Data from these sources will be entered into a Microsoft® Excel workbook template directly from the field logbook and core logs. These data include station location coordinates, station names, sampling dates, sample identification codes, and additional station and sample information (e.g., water depth, sample type, field split number). A second individual will review all entries for accuracy and completeness, and any errors will be corrected before the data are uploaded to the EQuIS database and approved for release to data users.

Chain-of-custody forms will be generated in the field at the time that samples are packaged for delivery to analytical laboratories.

2.10.2 Laboratory Data

A wide variety of manually entered and electronic instrument data are generated at the laboratories. Data are manually entered into:

- Standard logbooks
- Storage temperature logs
- Balance calibration log
- Instrument logs
- Sample preparation and analysis worksheets
- Maintenance logs
- Individual laboratory notebooks

- Results tables for conventional analyses (i.e., grain-size distribution, total solids, and DOC).

The LIMS is the central data management tool for each laboratory. All manual data entry into the LIMS is proofed at the laboratory. All data collected from each laboratory instrument, either manually or electronically, are reviewed and confirmed by analysts before reporting. The LIMS is used for every aspect of sample processing, including sample log-in and tracking, instrument data storage and processing, generation of data reports for sample and quality control results, and preparation of EDDs.

Laboratory data will be entered directly into the EQuIS database from the EDD. A database printout will be used to verify database entries against the hard-copy laboratory data packages.

2.10.3 Backup and Maintenance of Database and Data Files

The project database will be stored on a networked server. All data on the networked server will be stored on redundant, mirrored hard drives to protect against data loss due to hard drive failure. These drives will be mounted in a file server protected by an uninterruptible power supply that includes two diesel generators in the event of an extended power outage. The data from these drives, as well as any other data stored elsewhere on the network, will be backed up daily after work hours to a separate, corporate backup server to protect against data loss due to user error. This backup enables access to the most recently changed versions of all files. Overall, components that make up the data infrastructure (systems that store, backup, archive, etc.) and network systems will be monitored and maintained weekly to ensure that ongoing data storage and access needs are efficiently managed. Backup procedures will protect the data from system failure, accidental damage, catastrophic failures, and intrusion.

3 ASSESSMENT AND OVERSIGHT

This task will rely on the knowledge and expertise of the technical team, as described in the work plan. The field team and laboratories will stay in close verbal contact with the project/QA manager and the lead chemist during all phases of this task. This level of communication will serve to keep the management team appraised of activities and events, and will allow for informal but continuous task oversight. Few scheduled assessment activities are planned for this task because the scope of the sampling and analysis effort and the size of the team are relatively small.

3.1 ASSESSMENTS AND RESPONSE ACTIONS

Assessment activities will include readiness reviews prior to sampling and prior to release of the final data to the data users, and internal review while work is in progress. An informal technical systems audit may be conducted if problems are encountered during any phase of this project.

Readiness reviews are conducted to ensure that all necessary preparations have been made for efficient and effective completion of each critical phase of project work. The first readiness review will be conducted prior to field sampling. The field team leader will verify that all field equipment is ready for transfer to the site. The field team leader will also verify that the field team and subcontractors have been scheduled and briefed and that the contracts for the subcontractors have been signed by both parties. Any deficiencies noted during this readiness review will be corrected prior to initiation of sampling activities.

The second readiness review will be completed before final data are released for use. The database manager will verify that all results have been received from the laboratories, data validation and data quality assessment have been completed for all of the data, and data qualifiers have been entered into the database and verified. Any deficiencies noted during this review will be corrected by the database manager, the Integral project/QA manager, or their designee. Data will not be released for final use until all data have been verified and validated. No report will be prepared in conjunction with the readiness reviews. However, the project/QA manager and data users will be notified when the data are ready for use.

Technical review of intermediate and final work products generated for this project will be completed throughout the course of all sampling, laboratory, data validation, data management, and data interpretation activities to ensure that every phase of work is accurate and complete and follows the quality assurance procedures outlined in this QAPP. Any problems that are encountered will be resolved between the reviewer and the person completing the work. Any problems that cannot be easily resolved or that affect the final

quality of the work product will be brought to the attention of the Integral and LSS project managers. EPA will be notified of any problems that may affect the final outcome of the project.

The laboratories have implemented a review system that serves as a formal surveillance mechanism for all laboratory activities. Each phase of work is reviewed by a supervisor before it is approved for release. Details are provided in the laboratory quality assurance plans (Attachment 1).

Technical system audits may be conducted at the discretion of the project/QA manager. If completed, these audits will be conducted by the Integral project/QA manager or designee or by the laboratory QA managers. These audits may consist of onsite reviews of any phase of field or laboratory activities or data management. Integral audit checklists and the NELAC Quality Systems Checklist (Attachment 3 of this QAPP) will be used as guides for any technical system audits. Results of any audits will be provided in the field sampling and data report.

Any project team member who discovers or suspects a nonconformance is responsible for reporting the nonconformance to the project/QA manager, the Integral lead chemist, or the laboratory project or quality assurance manager, as applicable. The project/QA manager will ensure that no additional work dependent on the nonconforming activity is performed until a confirmed nonconformance is corrected.

3.2 REPORTS TO MANAGEMENT

A field sampling and data report will be prepared under the direction of the Integral project/QA manager and submitted to EPA following completion of sample collection, laboratory analysis, and data validation activities. The field sampling and data report will summarize field sampling activities, including sampling locations (maps), requested sample analyses, and sample collection methods, and will provide a discussion of any deviations from the FSP and QAPP, and a discussion of the data quality.

Data packages and EDDs will be prepared by the laboratory upon completion of analyses for each sample delivery group. The case narrative will include a description of any problems encountered, control limit exceedances, and a description and rationale for any deviations from protocol. Copies of corrective action reports generated at the laboratory will also be included with the data package.

A data validation report will be prepared for each data package by Integral or the data validation firm Environmental Standards, Inc. (ESI) of Valley Forge, Pennsylvania. These reports and the validated data will be provided to the lead chemist when validation is completed for each package. A summary of any significant data quality issues will be provided to EPA with the field sampling and data report.

4 DATA VALIDATION AND USABILITY

Data generated in the field and at the laboratories will be verified and validated according to criteria and procedures described in this section. Data quality and usability will be evaluated, and a discussion will be included in the applicable site characterization summary report for each sampling event.

4.1 CRITERIA FOR DATA REVIEW, VERIFICATION, AND VALIDATION

Field and laboratory data for this project will undergo a formal verification and validation process. All entries into the database will be verified. All errors found during the verification of field data, laboratory data, and the database will be corrected prior to release of the final data.

4.1.1 Analytical Data

Data verification and validation will be conducted in accordance with *Guidance on Environmental Data Verification and Validation* (USEPA 2002b). Data verification and validation for organic compounds and metals will be completed according to methods described in the EPA guidance for data review (USEPA 1995, 2009, 2014b, 2017a,b). Performance-based control limits established by the laboratory and control limits provided in the method protocols will be used to evaluate data quality and determine the need for data qualification. Current laboratory control limits for surrogate compounds, laboratory control samples and duplicates, and matrix spikes and duplicates are provided in Tables B-7 through B-10. Control limits are updated periodically by the laboratories, and the control limits that are in affect at the laboratory at the time of analysis will be used for data validation.

No guidelines are available for validation of data for conventional analyses. These data will be validated using procedures described in the functional guidelines for inorganic methods data review (USEPA 2017b), as applicable.

Results for field duplicates will be evaluated against a target control limit of 50 RPD. Data will not be qualified as estimated if this control limit is exceeded, but RPD results will be tabulated, and any exceedances will be discussed in the applicable quality assurance report. Equipment rinse blanks will be evaluated and data qualifiers will be applied in the same manner as method blanks, as described in the applicable EPA guidance documents for data review (USEPA 2014b, 2017a,b).

Data will be rejected if control limits for acceptance of data are not met, as described in USEPA (1995, 2009, 2014b, 2017a,b).

The review and validation of the analytical data will be conducted by Integral and ESI.

Data will be validated by sample delivery group. All quality assurance data from each sample delivery group will be reviewed. Any items that were out of compliance with the methods will be noted.

All discrepancies and requests for additional information will be discussed with the laboratory prior to issuing the formal data validation report. All contacts with the laboratory will be documented. Procedures used during data review and findings made during data validation will be documented. A validation report will be prepared; that report will summarize quality control results and possible data limitations. All data will be accessible, but only validated data (including replicate and reduced data) will be released for general use.

4.2 VERIFICATION AND VALIDATION METHODS

Field data will be verified during preparation of samples and chain-of-custody forms. Field data and chain-of-custody forms will be reviewed by the field team leader on a daily basis. After field data are entered into the project database, 100 percent verification of the entries will be completed by a second party to ensure the accuracy and completeness of the database. Any discrepancies will be resolved before the final database is released for use.

Procedures for verification and validation of laboratory data and field quality control samples will be completed as described in the following EPA guidance documents for data validation:

- *Guidance on Environmental Data Verification and Validation* (USEPA 2002b)
- *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use* (USEPA 2009)
- *USEPA Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review* (USEPA 2017b)
- *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Methods Data Review* (USEPA 2017b)
- *EPA Region 10 Data Validation Guidelines for Polychlorinated Dibenzo-p-dioxin and Polychlorinated Dibenzofuran Data (PCDD/PCDF) using Method 1613B, and SW836 Method 8290* (USEPA 2014b)
- EPA Region 10 SOP for the Validation of Method 1668 Toxic, Dioxin-like, PCB Data (USEPA 1995).

Control limits that will be used to qualify data are described in Section 4.1, above. The following is a summary of the verification and validation that will be conducted:

- ESI will perform 10 percent EPA Stage 4 and 90 percent EPA Stage 2b validation on the surface sediment (if needed based on Phase 1 results), sediment porewater, transition

zone water, and groundwater data. In addition, ESI will perform 10 percent EPA Stage 4 and 90 percent EPA Stage 2b validation on data from two subsurface sediment samples from each vibracore station and two soil samples from each hand auger soil borehole that are below RALs and PTW thresholds. Integral will perform EPA Stage 2a data validation on all other subsurface sediment and soil data.

- ESI will review all pesticide chromatograms to evaluate any interference effects from PCBs.
- Geotechnical and sediment stability sample data will not be validated.

MRL goals for this project will be determined prior to initiation of field activities. Reporting limits for non-detects will be compared to the reporting limit goals to evaluate method sensitivity for each sample. Any exceedance of actual MRLs over the target MRLs will be discussed in the field sampling and data report.

In addition to verification of field and laboratory data and information, data qualifier entries into the database will be verified. Any discrepancies will be resolved before the final database is released for use. The accuracy and completeness of the database will be verified at the laboratory and again as part of data validation. All entries to the database from the laboratory EDDs will be checked against the hard copy data packages.

4.3 RECONCILIATION WITH USER REQUIREMENTS

The data users, including EPA, in cooperation with Integral project management staff and the lead chemist, will determine whether field and analytical data sets meet the requirements necessary for decision making. The results of measurements will be compared to the DQO requirements set forth in this QAPP.

Data generated by this program will be used to inform remedial design in the Arkema Project Area. The DQOs will be considered to be satisfied if the data are sufficient to evaluate conditions in the Arkema Project Area.

The goal of data validation is to determine the quality of each data point and to identify data points that do not meet the project criteria. Nonconforming data may be qualified as undetected, estimated, or rejected as unusable during data validation if criteria for data quality are not met. Rejected data will not be used for any purpose. An explanation of the rejected data will be included in the field sampling and data report.

Data qualified as estimated will be used for all intended purposes (Section 1.2) and will be appropriately qualified in the final project database. These data may be less precise or less accurate than unqualified data. Data that do not meet the data users' needs will be identified and appropriately noted in the project database so the decision-makers are aware of its limitation.

5 REFERENCES

APHA. 2017. APHA SM 2540G. America Public Health Association Standard Method Solids. Standard methods for the examination of water and wastewater. American Public Health Association, American Water Works Association, and Water Environment Federation.

Barton, J. 2002. Ammonia and amphipod toxicity testing. DMMP Clarification Paper. 2002 Sediment Management Annual Review Meeting. Available at: www.nws.usace.army.mil/publicmenu/DOCUMENTS/AmphAmmoniaClar20021.pdf.

Dean, K.E., R.M. Palachek, J.M. Noel, R. Warbritton, J. Aufderheide, and J. Wireman. 2004. Development of Freshwater Water Quality Criteria for Perchlorate. Environmental Toxicology and Chemistry, Volume 23, No. 6, pp. 1441-1451.

Integral. 2003. Phase II Stage 1 & 2 In-River Groundwater and Sediment Investigation Report. Prepared for ATOFINA Chemicals, Inc. Integral Consulting Inc., Portland, OR.

USEPA. 1988. Ambient Water Quality Criteria for Chloride: 1988. United States Environmental Protection Agency, Office of Water, Office of Science and Technology (4304T). EPA-440/5-88/001. February 1988.

USEPA. 1994. Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 1995. EPA Region 10 SOP for the Validation of Method 1668 Toxic, Dioxin-like, PCB Data. U.S. Environmental Protection Agency, Region 10, Environmental Services Division, Seattle, WA.

USEPA. 2000. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates. Second Edition. EPA 600/R-99/064. U.S. Environmental Protection Agency, Duluth, MN.

USEPA. 2002a. Guidance for Quality Assurance Project Plans. EPA QA/G-5. EPA/240/R-02/009. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

USEPA. 2002b. Guidance on Environmental Data Verification and Validation. EPA AQ/G-8. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

USEPA. 2002c. National Recommended Water Quality Criteria: 2002. EPA-822-R-02-047. United States Environmental Protection Agency, Office of Water, Office of Science and Technology (4304T). November 2002.

USEPA. 2006. Guidance on Systematic Planning Using the Data Quality Objective Process. EPA QA/G-4. EPA/240/B-06/001. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

USEPA. 2009. Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use. USEPA-540-R-08-005. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

USEPA. 2010. Method 1668C. Chlorinated Biphenyl Congeners in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS. EPA-820-R-10-005. April 2010. U.S. Environmental Protection Agency, Washington, DC.

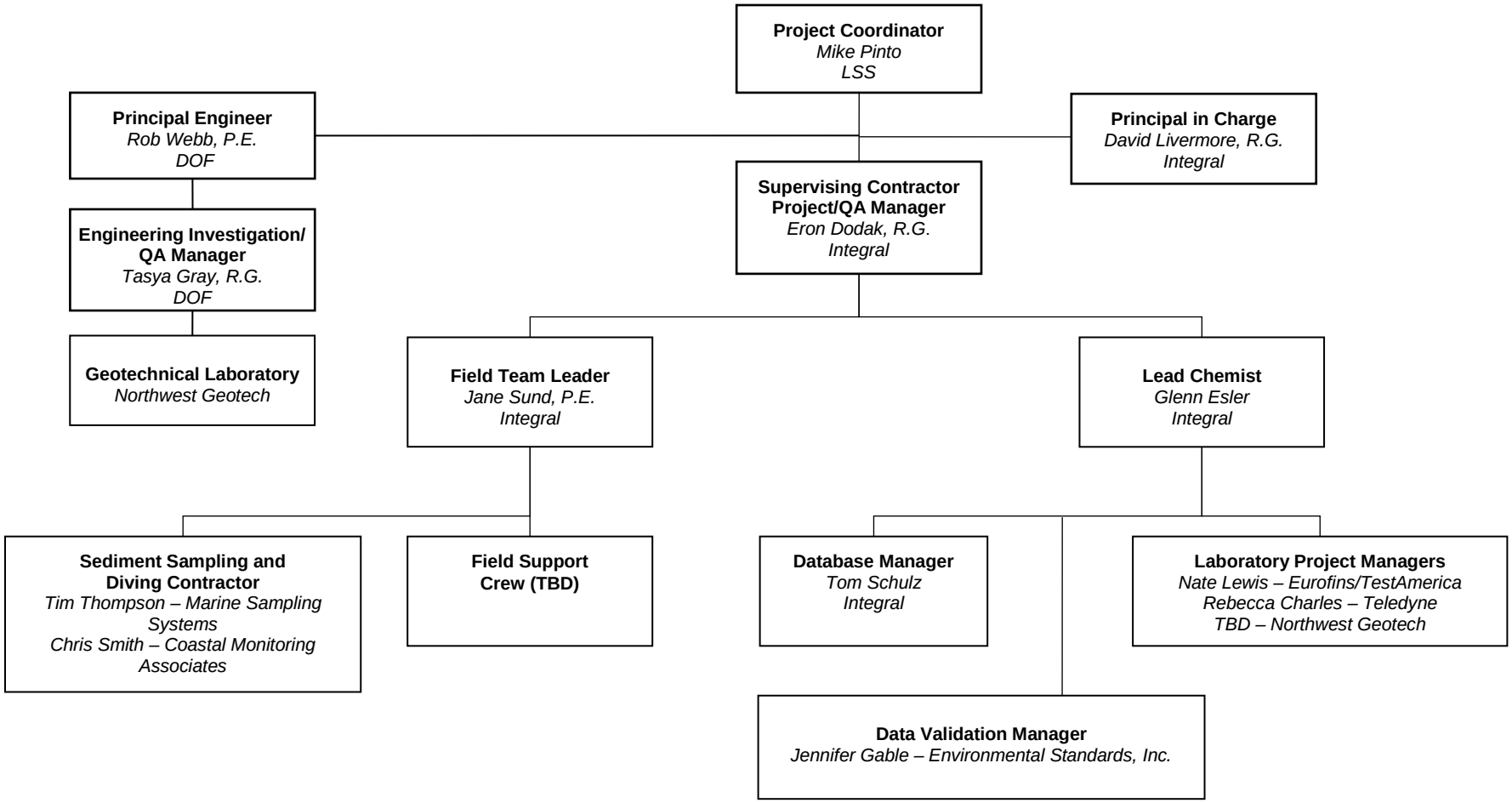
USEPA. 2014a. SW-846 On-line, Test Methods for Evaluating Solid Waste - Physical/Chemical Methods. Available at http://www.epa.gov/epaoswer/hazwaste/test/main.htm. U.S. Environmental Protection Agency, Washington, DC.

USEPA. 2014b. EPA Region 10 Data Validation Guidelines for Polychlorinated Dibenzo-p-dioxin and Polychlorinated Dibenzofuran Data (PCDD/PCDF) using Method 1613B, and SW836 Method 8290. EPA-910-R-14-003. U.S. Environmental Protection Agency, Region 10, Office of Environmental Assessment, Seattle, WA.

USEPA. 2017a. USEPA Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review. USEPA-540-R-2017-002. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation, Washington, DC.

USEPA. 2017b. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Methods Data Review. USEPA-540-R-2017-001. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation, Washington, DC.

Figures



DRAFT

Figure B-1
Project Organization

Tables

Table B-1. Analysis Scheme for Arkema Project Area Pre-design Investigation

Test Characteristics	Sample Matrix	Analysis
Sediment Quality	Surface Sediments (if needed for Phase 2)	Organochlorine pesticides (DDx only) PCDD/Fs PCB congeners PAHs
	Subsurface Sediments	Organochlorine pesticides (DDx only) PCDD/Fs PCB congeners PAHs Chlorobenzene
	Additional Analytes	Organochlorine pesticides Chlorinated herbicides VOCs TAL metals
	Sediment Stability (if needed for Phase 2)	Cesium 137 Lead 210 Organochlorine pesticides (DDx only)
	NAPL Assessment	TPH- DRO/MRO TPH-GRO VOCs Grain size TOC Density (NAPL) Viscosity (NAPL)
	Geotechnical	Water content, grain size,TOC, plasticity, sediment strength, bulk density
Soils	Soils	Asbestos Organochlorine pesticides (DDx only) PCDD/Fs PCB congeners
	Geotechnical	Moisture content, grain size analysis, Atterberg Limits, organic content, shear strength, and consolidation testing
Groundwater, Transition Zone Water, Sediment Porewater	Groundwater	Organochlorine pesticides (DDx only) VOCs
	Transition Zone Water (UltraSeep Meters)	Organochlorine pesticides (DDx only) VOCs
	Sediment Porewater (Trident Probe)	DOC VOCs

Table B-1. Analysis Scheme for Arkema Project Area Pre-design Investigation

Test Characteristics	Sample Matrix	Analysis

Notes:
DDx = total of 2,4'- and 4,4'-DDD, DDE, and DDT
DOC = dissolved organic carbon
DRO = diesel range organics
GRO = gasoline range organics
MRO = mineral oil range organics
NAPL = nonaqueous-phase liquid
PAH = polycyclic aromatic hydrocargon
PCB = polychlorinated biphenyl
PCDD/F = polychlorinated dibenzo-*p*-dioxin/furan
SVOC = semivolatile organic compound
TAL = target analyte list
TOC = total organic carbon
TPH = total petroleum hydrocarbons
VOC = volatile organic compound

Table B-2. Project Team Contact Information

Name	Project Role	Phone	Fax	Email
Legacy Site Services				
Mike Pinto	Project Coordinator	484 875-3465	610 363-1498	michael.pinto@total.com
EPA Region 10				
Hunter Young	Project Coordinator	503-326-5020	--	Young.Hunter@epa.gov
TBD	Quality Assurance Manager	TBD	TBD	TBD
Integral Consulting Inc.				
David Livermore	Principal-in-Charge	503-943-3613	503-284-5755	dlivermore@integral-corp.com
Glenn Esler	Lead Chemist	503-943-3617	503-284-5755	gesler@integral-corp.com
Eron Dodak	Project Manager/QA Manager	503-943-3614	503-284-5755	edodak@integral-corp.com
Dalton, Olmsted & Fuglevand				
Rob Webb	Principal Engineer	360-908-1386	--	rwebb@dofnw.com
Tasya Gray	:ngineering Investigation Project/Quality Assurance Manage	206-502-1120	--	ngray@dofnw.com
Eurofins/TestAmerica Seattle				
Nate Lewis	Arkema Project Area Pre-design Investigation Work Plan	253-248-4975	253-922-5047	Nathan.lewis@testamericainc.com
Terri Torrres	Laboratory QA Manager	253-248-4968	253-922-5047	Terri.Torres@testamericainc.com
Eurofins/TestAmerica West Sacramento				
Nate Lewis	Laboratory Project Manager	253-248-4975	253-922-5047	Nathan.lewis@testamericainc.com
Lisa Stafford	Laboratory QA Manager	916-374-4308	--	Lisa.stafford@testamericainc.com
Teledyne				
Rebecca Charles	Laboratory Project Manager	865-934-0379	865-934-0396	rebecca.charles@tbe.com
Sharon Northcutt	Laboratory QA Officer	865 934-0374	865-934-0396	Sharon.Northcutt@teledyne.com
NW Geotech				
TBD	Laboratory Project Manager			
TBD	Laboratory QA Manager			

Notes:
EPA = U.S. Environmental Protection Agency
QA = quality assurance
TBD = to be determined

Table B-3. Laboratory Methods for Sediment and Soil Samples

Analyte	Sample Type	Laboratory	Sample Preparation		Quantitative Analysis	
			Protocol	Procedure	Protocol	Procedure
Sediment and Soil Quality Characteristics						
Physical and Engineering Characteristics						
Water Content	Subsurface sediments	NW Geotech	--	--	TBD	TBD
Plasticity	Subsurface sediments	NW Geotech	--	--	TBD	TBD
Bulk Density	Subsurface sediments	NW Geotech	--	--	TBD	TBD
Density (NAPL)	Subsurface sediments	NW Geotech	--	--	TBD	TBD
Total Organic Carbon	Subsurface sediments	NW Geotech	--	--	TBD	TBD
Sediment Strength	Subsurface sediments	NW Geotech	--	--	TBD	TBD
Viscosity (NAPL)	Subsurface sediments	NW Geotech	--	--	TBD	TBD
Grain Size	Subsurface sediments Soils	NW Geotech	--	--	TBD	TBD
Moisture Content	Soils	NW Geotech	--	--	TBD	TBD
Atterberg Limits	Soils	NW Geotech	--	--	TBD	TBD
Organic Content	Soils	NW Geotech	--	--	TBD	TBD
Shear Strength	Soils	NW Geotech	--	--	TBD	TBD
Consolidation Testing	Soils	NW Geotech	--	--	TBD	TBD
Conventional Analyses						
Total Solids	Surface sediments Subsurface sediments Soils	Eurofins/TestAmerica	--	Oven drying	APHA SM 2540G	Gravimetric
Organic Analyses						
Organochlorine Pesticides	Surface sediments Subsurface sediments Soils	Eurofins/TestAmerica	EPA SW846-3550B	Sonication	EPA SW846-8081B	Dual column GC/ECD
			EPA SW846-3640A	Gel permeation chromatography [a]	--	--
			EPA SW846-3660B	Sulfur cleanup (mod to use tertbutylammonium sulfite)	--	--
			EPA SW846-3620B	Florisil® cleanup [a]	--	--
PAHs	Surface sediments	Eurofins/TestAmerica	EPA SW846-3546	Microwave extraction	EPA SW-846 8270D SIM	GC/MS
PCB Congeners	Surface sediments Subsurface sediments Soils	Eurofins/TestAmerica	EPA 1668C	Soxhlet extraction	EPA 1668C	HRGC/HRMS
VOCs	Subsurface sediments	Eurofins/TestAmerica	EPA SW846-5035A	Purge & Trap	EPA SW846-8260C	GC/MS
Chlorobenzene	Subsurface sediments	Eurofins/TestAmerica	EPA SW846-5035A	Purge & Trap	EPA SW846-8260C	GC/MS

Table B-3. Laboratory Methods for Sediment and Soil Samples

			Sample Preparation		Quantitative Analysis	
Analyte	Sample Type	Laboratory	Protocol	Procedure	Protocol	Procedure
PCDD/Fs	Surface sediments Subsurface sediments Soils	Eurofins/TestAmerica	EPA 1613B	Soxhlet extraction	EPA 1613B	HRGC/HRMS
			EPA 3665A	Sulfuric acid extraction	--	--
			EPA 3630C	Acid/base silica column [a]	--	--
			EPA 3610B	Alumina column [a]	--	--
			EPA SW846-3640A	Gel permeation chromatography [a]		
Asbestos	Soils	Eurofins/TestAmerica	CARB 435	Sample size reduction	CARB 435	PLM
Chlorinated Herbicides	Subsurface sediments	Eurofins/TestAmerica	EPA SW846-8151A	Sonication/Derivatization	EPA SW846-8151A	GC/MS
TAL Metals	Subsurface sediments	Eurofins/TestAmerica	EPA SW-846-3050B/7471A	Acid Digestion	EPA SW-846-6020A/ 6010C/7471A	ICPMS/ICPAES/CVAA
TPH- DRO/MRO	Subsurface sediments	Eurofins/TestAmerica	EPA SW846-3546	Microwave extraction	NWTPH-Dx	GC/FID
TPH-GRO	Subsurface sediments	Eurofins/TestAmerica	EPA SW846-5035A	Purge & Trap	NWTPH-Gx	GC/FID
Cesium 137	Subsurface sediments	Teledyne	--	--	TBE-2007	Gamma Spectroscopy
Lead 210	Subsurface sediments	Teledyne	TBE-2015	Acid Leaching	TBE-2015	Anion Exchange

Notes:
[a] Cleanup procedures will be performed as necessary to achieve the method reporting limits and method detection limits listed in Table B-5.

-- = not applicable
APHA SM = American Public Health Association Standard Methods
CARB = California Air Resources Board
DDx = total of 2,4'- and 4,4'-DDD, DDE, and DDT
DRO = diesel range organics
EPA = U.S. Environmental Protection Agency
GC/ECD = gas chromatography/electron capture detection
GC/FID = gas chromatography/flame ionization detector
GC/MS = gas chromatography/mass spectrometry
GRO = gasoline range organics
HRGC/HRMS = high resolution gas chromatography/mass spectrometry
ICPMS/CVAA = inductively coupled plasma mass spectrometry/cold vapor atomic absorption spectrometry
Nautilus = Nautilus Environmental
MRO = mineral oil range organics
PCB = polychlorinated biphenyl
PCDD/F = polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran
PLM = polarized light microscopy
SVOC = semivolatile organic compound
TOC = total organic carbon
TPH = total petroleum hydrocarbons
VOC = volatile organic compound

Table B-4. Laboratory Methods for Groundwater and Equipment Blank Samples

		Sample Preparation		Quantitative Analysis	
Analyte	Laboratory	Protocol	Procedure	Protocol	Procedure
Aqueous					
Organochlorine Pesticide	Eurofins/TestAmerica	EPA SW846-3510C	Separatory funnel extraction	EPA SW846-8081B	Dual column GC/ECD
PAHs	Eurofins/TestAmerica	EPA SW846-3510C	Separatory funnel extraction	EPA SW-846 8270D SIM	GC/MS
PCB Congeners	Eurofins/TestAmerica	EPA 1668C	Separatory funnel extraction	EPA 1668C	HRGC/HRMS
VOCs	Eurofins/TestAmerica	EPA SW846-5030B	Purge and trap	EPA SW846-8260C	GC/MS
PCDD/Fs	Eurofins/TestAmerica	EPA 1613B	Separatory funnel extraction	EPA 1613B	HRGC/HRMS
TPH- DRO/MRO	Eurofins/TestAmerica	NWTPH-Dx	Separatory funnel extraction	NWTPH-Dx	GC/FID
TPH-GRO	Eurofins/TestAmerica	NWTPH-Gx	Purge and trap	NWTPH-Gx	GC/FID
Cesium 137	Teledyne	TBE-2007	Acid digestion	TBE-2007	Gamma Spectroscopy
Lead 210	Teledyne	TBE-2015	Acid Leaching	TBE-2015	Anion exchange
Chlorinated Herbicides	Eurofins/TestAmerica	EPA SW846 8151A	Solid phase extraction/Derivatization	EPA SW846 8151A	GC/MS
TAL Metals	Eurofins/TestAmerica	EPA SW-846-3010A/7470	Acid digestion	EPA SW-846-6010C/6020A/7470A	ICP/ICPMS/CVAA
Sediment Transition Zone Water (UltraSeep Meter)					
Organochlorine Pesticide	Eurofins/TestAmerica	EPA SW846-3510C	Separatory funnel extraction	EPA SW846-8081B	Dual column GC/ECD
VOCs	Eurofins/TestAmerica	EPA SW846-5030B	Purge and trap	EPA SW846-8260C	GC/MS
Sediment Porewater (Trident Probe)					
VOCs	Eurofins/TestAmerica	EPA SW846-5030B	Purge and trap	EPA SW846-8260C	GC/MS
DOC	Eurofins/TestAmerica	APHA SM 5310B	Persulfate oxidation	APHA SM 5310B	Infrared detector

Notes:
DOC = dissolved organic carbon
DRO = diesel range organics
EPA = U.S. Environmental Protection Agency
GC/ECD = gas chromatography/electron capture detection
GC/FID = gas chromatography/flame ion detection
GC/MS = gas chromatography/mass spectrometry

Table B-4. Laboratory Methods for Groundwater and Equipment Blank Samples

Analyte	Laboratory	Sample Preparation		Quantitative Analysis	
		Protocol	Procedure	Protocol	Procedure

GRO = gasoline range organics
HRGC/HRMS = high resolution gas chromatography/mass spectrometry
ICPMS/CVAA = inductively coupled plasma mass spectrometry/cold vapor atomic absorption spectrometry
MRO = mineral oil range organics
PCB = polychlorinated biphenyl
PCDD/F = polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran
RCRA = Resource Conservation and Recovery Act
SVOC = semivolatile organic compound
TOC = total organic carbon
TPH = total petroleum hydrocarbons
VOC = volatile organic compound

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
Surface Sediments					
Organochlorine Pesticides (µg/kg dry weight)					
Standard List					
2,4'-DDD	53-19-0	EPA SW846-8081B	Eurofins/TestAmerica	1.1	0.5
2,4'-DDE	3424-82-6	EPA SW846-8081B	Eurofins/TestAmerica	0.91	0.5
2,4'-DDT	789-02-6	EPA SW846-8081B	Eurofins/TestAmerica	1.9	0.5
4,4'-DDD	72-54-8	EPA SW846-8081B	Eurofins/TestAmerica	0.39	0.2
4,4'-DDE	72-55-9	EPA SW846-8081B	Eurofins/TestAmerica	0.53	0.2
4,4'-DDT	50-29-3	EPA SW846-8081B	Eurofins/TestAmerica	0.39	0.2
Polycyclic Aromatic Hydrocarbons (µg/kg dry weight)					
Naphthalene	91-20-3	SW-846 8270D SIM	Eurofins/TestAmerica	1.62	5
2-Methylnaphthalene	91-57-6	SW-846 8270D SIM	Eurofins/TestAmerica	2.05	5
1-Methylnaphthalene	90-12-0	SW-846 8270D SIM	Eurofins/TestAmerica	0.63	5
Acenaphthylene	208-96-8	SW-846 8270D SIM	Eurofins/TestAmerica	0.5	5
Acenaphthene	83-32-9	SW-846 8270D SIM	Eurofins/TestAmerica	0.6	5
Fluorene	86-73-7	SW-846 8270D SIM	Eurofins/TestAmerica	0.5	5
Phenanthrene	85-01-8	SW-846 8270D SIM	Eurofins/TestAmerica	1.63	5
Anthracene	120-12-7	SW-846 8270D SIM	Eurofins/TestAmerica	0.6	5
Fluoranthene	206-44-0	SW-846 8270D SIM	Eurofins/TestAmerica	1.4	5
Pyrene	129-00-0	SW-846 8270D SIM	Eurofins/TestAmerica	0.97	5
Benzo[a]anthracene	56-55-3	SW-846 8270D SIM	Eurofins/TestAmerica	0.76	5
Chrysene	218-01-9	SW-846 8270D SIM	Eurofins/TestAmerica	1.5	5
Benzo[b]fluoranthene	205-99-2	SW-846 8270D SIM	Eurofins/TestAmerica	0.59	5
Benzo[k]fluoranthene	207-08-9	SW-846 8270D SIM	Eurofins/TestAmerica	0.6	5
Benzo[a]pyrene	50-32-8	SW-846 8270D SIM	Eurofins/TestAmerica	0.84	5
Indeno[1,2,3-cd]pyrene	193-39-5	SW-846 8270D SIM	Eurofins/TestAmerica	0.6	5
Dibenz(a,h)anthracene	53-70-3	SW-846 8270D SIM	Eurofins/TestAmerica	0.72	5

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
Benzo[g,h,i]perylene	191-24-2	SW-846 8270D SIM	Eurofins/TestAmerica	0.5	5
Chlorinated Dioxins and Furans (pg/g dry weight)					
2,3,7,8-TCDD	1746-01-6	EPA 8290	Eurofins/TestAmerica	1	0.4
2,3,7,8-TCDF	51207-31-9	EPA 8290	Eurofins/TestAmerica	1	0.4
1,2,3,7,8-PeCDD	40321-76-4	EPA 8290	Eurofins/TestAmerica	5	0.75
1,2,3,7,8-PeCDF	57117-41-6	EPA 8290	Eurofins/TestAmerica	5	0.75
2,3,4,7,8-PeCDF	57117-31-4	EPA 8290	Eurofins/TestAmerica	5	0.75
1,2,3,4,7,8-HxCDD	39227-28-6	EPA 8290	Eurofins/TestAmerica	5	2
1,2,3,6,7,8-HxCDD	57653-85-7	EPA 8290	Eurofins/TestAmerica	5	2
1,2,3,7,8,9-HxCDD	19408-74-3	EPA 8290	Eurofins/TestAmerica	5	2
1,2,3,4,7,8-HxCDF	70648-26-9	EPA 8290	Eurofins/TestAmerica	5	0.75
1,2,3,6,7,8-HxCDF	57117-44-9	EPA 8290	Eurofins/TestAmerica	5	1
1,2,3,7,8,9-HxCDF	72918-21-9	EPA 8290	Eurofins/TestAmerica	5	1
2,3,4,6,7,8-HxCDF	60851-34-5	EPA 8290	Eurofins/TestAmerica	5	0.75
1,2,3,4,6,7,8-HpCDD	35822-46-9	EPA 8290	Eurofins/TestAmerica	5	1
1,2,3,4,6,7,8-HpCDF	67562-39-4	EPA 8290	Eurofins/TestAmerica	5	1
1,2,3,4,7,8,9-HpCDF	55673-89-7	EPA 8290	Eurofins/TestAmerica	5	2
OCDD	3268-87-9	EPA 8290	Eurofins/TestAmerica	10	4
OCDF	39001-02-0	EPA 8290	Eurofins/TestAmerica	10	4
Total tetrachlorinated dioxins	41903-57-5	EPA 8290	Eurofins/TestAmerica	-	-
Total pentachlorinated dioxins	36088-22-9	EPA 8290	Eurofins/TestAmerica	-	-
Total hexachlorinated dioxins	34465-46-8	EPA 8290	Eurofins/TestAmerica	-	-
Total heptachlorinated dioxins	37871-00-4	EPA 8290	Eurofins/TestAmerica	-	-
Total tetrachlorinated furans	30402-14-3	EPA 8290	Eurofins/TestAmerica	-	-
Total pentachlorinated furans	30402-15-4	EPA 8290	Eurofins/TestAmerica	-	-
Total hexachlorinated furans	55684-94-1	EPA 8290	Eurofins/TestAmerica	-	-
Total heptachlorinated furans	38998-75-3	EPA 8290	Eurofins/TestAmerica	-	-

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB Congeners (pg/g dry weight)					
PCB-1	2051-60-7	EPA 1668C	Eurofins/TestAmerica	0.64	20
PCB-2	2051-61-8	EPA 1668C	Eurofins/TestAmerica	0.85	20
PCB-3	2051-62-9	EPA 1668C	Eurofins/TestAmerica	1.58	20
PCB-4	13029-08-8	EPA 1668C	Eurofins/TestAmerica	1.38	20
PCB-5	16605-91-7	EPA 1668C	Eurofins/TestAmerica	1.45	20
PCB-6	25569-80-6	EPA 1668C	Eurofins/TestAmerica	1.12	20
PCB-7	33284-50-3	EPA 1668C	Eurofins/TestAmerica	2.02	20
PCB-8	34883-43-7	EPA 1668C	Eurofins/TestAmerica	0.79	20
PCB-9	34883-39-1	EPA 1668C	Eurofins/TestAmerica	0.78	20
PCB-10	33146-45-1	EPA 1668C	Eurofins/TestAmerica	1.3	20
PCB-11	2050-67-1	EPA 1668C	Eurofins/TestAmerica	8.59	20
PCB-12/13	STL01797	EPA 1668C	Eurofins/TestAmerica	2.45	40
PCB-14	34883-41-5	EPA 1668C	Eurofins/TestAmerica	1.15	20
PCB-15	2050-68-2	EPA 1668C	Eurofins/TestAmerica	1.27	20
PCB-16	38444-78-9	EPA 1668C	Eurofins/TestAmerica	0.77	20
PCB-17	37680-66-3	EPA 1668C	Eurofins/TestAmerica	0.56	20
PCB-18/30	STL01798	EPA 1668C	Eurofins/TestAmerica	1.46	40
PCB-19	38444-73-4	EPA 1668C	Eurofins/TestAmerica	0.6	20
PCB-20/28	STL01799	EPA 1668C	Eurofins/TestAmerica	1.89	40
PCB-21/33	STL01800	EPA 1668C	Eurofins/TestAmerica	0.63	40
PCB-22	38444-85-8	EPA 1668C	Eurofins/TestAmerica	0.78	20
PCB-23	55720-44-0	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-24	55702-45-9	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-25	55712-37-3	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-26/29	STL01801	EPA 1668C	Eurofins/TestAmerica	0.74	40
PCB-27	38444-76-7	EPA 1668C	Eurofins/TestAmerica	0.26	20
PCB-31	16606-02-3	EPA 1668C	Eurofins/TestAmerica	1.95	20
PCB-32	38444-77-8	EPA 1668C	Eurofins/TestAmerica	0.62	20

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-34	37680-68-5	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-35	37680-69-6	EPA 1668C	Eurofins/TestAmerica	0.45	20
PCB-36	38444-87-0	EPA 1668C	Eurofins/TestAmerica	0.19	20
PCB-37	38444-90-5	EPA 1668C	Eurofins/TestAmerica	0.39	20
PCB-38	53555-66-1	EPA 1668C	Eurofins/TestAmerica	0.38	20
PCB-39	38444-88-1	EPA 1668C	Eurofins/TestAmerica	0.33	20
PCB-40/71	STL01802	EPA 1668C	Eurofins/TestAmerica	0.79	40
PCB-41	52663-59-9	EPA 1668C	Eurofins/TestAmerica	0.79	20
PCB-42	36559-22-5	EPA 1668C	Eurofins/TestAmerica	0.46	20
PCB-43	70362-46-8	EPA 1668C	Eurofins/TestAmerica	0.28	20
PCB-44/47/65	STL01803	EPA 1668C	Eurofins/TestAmerica	1.68	60
PCB-45	70362-45-7	EPA 1668C	Eurofins/TestAmerica	0.49	20
PCB-46	41464-47-5	EPA 1668C	Eurofins/TestAmerica	0.13	20
PCB-48	70362-47-9	EPA 1668C	Eurofins/TestAmerica	0.48	20
PCB-49/69	STL01805	EPA 1668C	Eurofins/TestAmerica	0.84	40
PCB-50/53	STL01806	EPA 1668C	Eurofins/TestAmerica	0.7	40
PCB-51	68194-04-7	EPA 1668C	Eurofins/TestAmerica	0.49	20
PCB-52	35693-99-3	EPA 1668C	Eurofins/TestAmerica	1.8	20
PCB-54	15968-05-5	EPA 1668C	Eurofins/TestAmerica	0.18	20
PCB-55	74338-24-2	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-56	41464-43-1	EPA 1668C	Eurofins/TestAmerica	0.48	20
PCB-57	70424-67-8	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-58	41464-49-7	EPA 1668C	Eurofins/TestAmerica	0.19	20
PCB-59/62/75	STL01807	EPA 1668C	Eurofins/TestAmerica	0.69	60
PCB-60	33025-41-1	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-61/70/74/76	STL01808	EPA 1668C	Eurofins/TestAmerica	2.03	80
PCB-63	74472-34-7	EPA 1668C	Eurofins/TestAmerica	0.23	20
PCB-64	52663-58-8	EPA 1668C	Eurofins/TestAmerica	0.67	20
PCB-66	32598-10-0	EPA 1668C	Eurofins/TestAmerica	0.89	20

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-67	73575-53-8	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-68	73575-52-7	EPA 1668C	Eurofins/TestAmerica	0.28	20
PCB-72	41464-42-0	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-73	74338-23-1	EPA 1668C	Eurofins/TestAmerica	0.38	20
PCB-77 - WHO 12	32598-13-3	EPA 1668C	Eurofins/TestAmerica	0.25	2
PCB-78	70362-49-1	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-79	41464-48-6	EPA 1668C	Eurofins/TestAmerica	0.32	20
PCB-80	33284-52-5	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB 81 - WHO 12	70362-50-4	EPA 1668C	Eurofins/TestAmerica	0.24	2
PCB-82	52663-62-4	EPA 1668C	Eurofins/TestAmerica	0.12	20
PCB-83	60145-20-2	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-84	52663-60-2	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-85/116/117	STL01810	EPA 1668C	Eurofins/TestAmerica	0.87	60
PCB-86/87/97/108/119/125	STL01811	EPA 1668C	Eurofins/TestAmerica	1.09	120
PCB-88/91	STL01812	EPA 1668C	Eurofins/TestAmerica	0.47	40
PCB-89	73575-57-2	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-90/101/113	STL01813	EPA 1668C	Eurofins/TestAmerica	0.43	60
PCB-92	52663-61-3	EPA 1668C	Eurofins/TestAmerica	0.21	20
PCB-93/100	STL01814	EPA 1668C	Eurofins/TestAmerica	0.54	40
PCB-107/124	STL01815	EPA 1668C	Eurofins/TestAmerica	0.16	40
PCB-94	73575-55-0	EPA 1668C	Eurofins/TestAmerica	0.3	20
PCB-95	38379-99-6	EPA 1668C	Eurofins/TestAmerica	0.53	20
PCB-96	73575-54-9	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-98/102	STL01843	EPA 1668C	Eurofins/TestAmerica	0.54	40
PCB-99	38380-01-7	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-103	60145-21-3	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-104	56558-16-8	EPA 1668C	Eurofins/TestAmerica	0.26	20
PCB 105 - WHO 12	32598-14-4	EPA 1668C	Eurofins/TestAmerica	0.45	2
PCB-106	70424-69-0	EPA 1668C	Eurofins/TestAmerica	0.39	20

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-110/115	STL01826	EPA 1668C	Eurofins/TestAmerica	0.87	40
PCB-109	74472-35-8	EPA 1668C	Eurofins/TestAmerica	0.34	20
PCB-111	39635-32-0	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-112	74472-36-9	EPA 1668C	Eurofins/TestAmerica	0.31	20
PCB 114 - WHO 12	74472-37-0	EPA 1668C	Eurofins/TestAmerica	0.34	2
PCB-118	31508-00-6	EPA 1668C	Eurofins/TestAmerica	0.51	2
PCB-120	68194-12-7	EPA 1668C	Eurofins/TestAmerica	0.19	20
PCB-121	56558-18-0	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB-122	76842-07-4	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB 123 - WHO 12	65510-44-3	EPA 1668C	Eurofins/TestAmerica	0.44	2
PCB 126 - WHO 12	57465-28-8	EPA 1668C	Eurofins/TestAmerica	0.37	2
PCB-127	39635-33-1	EPA 1668C	Eurofins/TestAmerica	0.23	20
PCB-128/166	STL01816	EPA 1668C	Eurofins/TestAmerica	0.26	40
PCB-129/138/163	STL01817	EPA 1668C	Eurofins/TestAmerica	1.11	60
PCB-130	52663-66-8	EPA 1668C	Eurofins/TestAmerica	0.25	20
PCB-131	61798-70-7	EPA 1668C	Eurofins/TestAmerica	0.11	20
PCB-132	38380-05-1	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-133	35694-04-3	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-134/143	STL01818	EPA 1668C	Eurofins/TestAmerica	0.34	40
PCB-135/151	STL01819	EPA 1668C	Eurofins/TestAmerica	0.21	40
PCB-136	38411-22-2	EPA 1668C	Eurofins/TestAmerica	0.15	20
PCB-137	35694-06-5	EPA 1668C	Eurofins/TestAmerica	0.42	20
PCB-139/140	STL01820	EPA 1668C	Eurofins/TestAmerica	0.19	40
PCB-141	52712-04-6	EPA 1668C	Eurofins/TestAmerica	0.34	20
PCB-142	41411-61-4	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-144	68194-14-9	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-145	74472-40-5	EPA 1668C	Eurofins/TestAmerica	0.17	20
PCB-146	51908-16-8	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB-147/149	STL01821	EPA 1668C	Eurofins/TestAmerica	0.42	40

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-148	74472-41-6	EPA 1668C	Eurofins/TestAmerica	0.15	20
PCB-150	68194-08-1	EPA 1668C	Eurofins/TestAmerica	0.23	20
PCB-152	68194-09-2	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-153/168	STL01822	EPA 1668C	Eurofins/TestAmerica	0.5	40
PCB-154	60145-22-4	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB-155	33979-03-2	EPA 1668C	Eurofins/TestAmerica	0.21	20
PCB-156/157 -WHO 12	STL01792	EPA 1668C	Eurofins/TestAmerica	0.76	4
PCB-158	74472-42-7	EPA 1668C	Eurofins/TestAmerica	0.25	20
PCB-159	39635-35-3	EPA 1668C	Eurofins/TestAmerica	0.32	20
PCB-160	41411-62-5	EPA 1668C	Eurofins/TestAmerica	0.61	20
PCB-161	74472-43-8	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-162	39635-34-2	EPA 1668C	Eurofins/TestAmerica	0.25	20
PCB-164	74472-45-0	EPA 1668C	Eurofins/TestAmerica	0.43	20
PCB-165	74472-46-1	EPA 1668C	Eurofins/TestAmerica	0.24	20
PCB 167 - WHO 12	52663-72-6	EPA 1668C	Eurofins/TestAmerica	0.31	2
PCB-169	32774-16-6	EPA 1668C	Eurofins/TestAmerica	0.31	2
PCB-170	35065-30-6	EPA 1668C	Eurofins/TestAmerica	0.31	20
PCB-171/173	STL01823	EPA 1668C	Eurofins/TestAmerica	0.35	40
PCB-172	52663-74-8	EPA 1668C	Eurofins/TestAmerica	0.32	20
PCB-174	38411-25-5	EPA 1668C	Eurofins/TestAmerica	0.55	20
PCB-175	40186-70-7	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-176	52663-65-7	EPA 1668C	Eurofins/TestAmerica	0.17	20
PCB-177	52663-70-4	EPA 1668C	Eurofins/TestAmerica	0.42	20
PCB-178	52663-67-9	EPA 1668C	Eurofins/TestAmerica	0.17	20
PCB-179	52663-64-6	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-180/193	STL01824	EPA 1668C	Eurofins/TestAmerica	0.58	40
PCB-181	74472-47-2	EPA 1668C	Eurofins/TestAmerica	0.15	20
PCB-182	60145-23-5	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-183	52663-69-1	EPA 1668C	Eurofins/TestAmerica	0.32	20

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-184	74472-48-3	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB-185	52712-05-7	EPA 1668C	Eurofins/TestAmerica	0.41	20
PCB-186	74472-49-4	EPA 1668C	Eurofins/TestAmerica	0.23	20
PCB-187	52663-68-0	EPA 1668C	Eurofins/TestAmerica	0.24	20
PCB-188	74487-85-7	EPA 1668C	Eurofins/TestAmerica	0.23	20
PCB 189 - WHO 12	39635-31-9	EPA 1668C	Eurofins/TestAmerica	0.46	2
PCB-190	41411-64-7	EPA 1668C	Eurofins/TestAmerica	0.33	20
PCB-191	74472-50-7	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-192	74472-51-8	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-194	35694-08-7	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-195	52663-78-2	EPA 1668C	Eurofins/TestAmerica	0.33	20
PCB-196	42740-50-1	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-197	33091-17-7	EPA 1668C	Eurofins/TestAmerica	0.31	20
PCB-198/199	STL01825	EPA 1668C	Eurofins/TestAmerica	0.35	40
PCB-200	52663-73-7	EPA 1668C	Eurofins/TestAmerica	0.26	20
PCB-201	40186-71-8	EPA 1668C	Eurofins/TestAmerica	0.15	20
PCB-202	2136-99-4	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-203	52663-76-0	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-204	74472-52-9	EPA 1668C	Eurofins/TestAmerica	0.12	20
PCB-205	74472-53-0	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-206	40186-72-9	EPA 1668C	Eurofins/TestAmerica	0.45	20
PCB-207	52663-79-3	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-208	52663-77-1	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-209	2051-24-3	EPA 1668C	Eurofins/TestAmerica	0.62	20

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
Subsurface Sediments					
Radiochemistry (pCi/g)					
Cesium-137	--	TBE-2007	Teledyne	NA	0.1
Lead-210	--	TBE-2015	Teledyne	NA	0.2
Organochlorine Pesticides (µg/kg dry weight)					
2,4'-DDD	53-19-0	EPA SW846-8081B	Eurofins/TestAmerica	1.1	0.5
2,4'-DDE	3424-82-6	EPA SW846-8081B	Eurofins/TestAmerica	0.91	0.5
2,4'-DDT	789-02-6	EPA SW846-8081B	Eurofins/TestAmerica	1.9	0.5
4,4'-DDD	72-54-8	EPA SW846-8081B	Eurofins/TestAmerica	0.39	0.2
4,4'-DDE	72-55-9	EPA SW846-8081B	Eurofins/TestAmerica	0.53	0.2
4,4'-DDT	50-29-3	EPA SW846-8081B	Eurofins/TestAmerica	0.39	0.2
Aldrin	309-00-2	EPA SW846-8081B	Eurofins/TestAmerica	0.32	0.3
alpha-BHC	319-84-6	EPA SW846-8081B	Eurofins/TestAmerica	0.32	0.2
cis-Chlordane	5103-71-9	EPA SW846-8081B	Eurofins/TestAmerica	1.25	0.3
beta-BHC	319-85-7	EPA SW846-8081B	Eurofins/TestAmerica	0.29	0.5
delta-BHC	319-86-8	EPA SW846-8081B	Eurofins/TestAmerica	0.7	0.3
Dieldrin	60-57-1	EPA SW846-8081B	Eurofins/TestAmerica	0.41	0.2
Endosulfan I	959-98-8	EPA SW846-8081B	Eurofins/TestAmerica	0.43	0.2
Endosulfan II	33213-65-9	EPA SW846-8081B	Eurofins/TestAmerica	0.4	0.2
Endosulfan sulfate	1031-07-8	EPA SW846-8081B	Eurofins/TestAmerica	0.32	0.2
Endrin	72-20-8	EPA SW846-8081B	Eurofins/TestAmerica	0.78	0.2
Endrin aldehyde	7421-93-4	EPA SW846-8081B	Eurofins/TestAmerica	3	2
Endrin ketone	53494-70-5	EPA SW846-8081B	Eurofins/TestAmerica	0.77	0.2
gamma-BHC (Lindane)	58-89-9	EPA SW846-8081B	Eurofins/TestAmerica	0.21	0.2
trans-Chlordane	5103-74-2	EPA SW846-8081B	Eurofins/TestAmerica	1.25	0.3
Heptachlor	76-44-8	EPA SW846-8081B	Eurofins/TestAmerica	0.89	0.3
Heptachlor epoxide	1024-57-3	EPA SW846-8081B	Eurofins/TestAmerica	0.74	0.3
Methoxychlor	72-43-5	EPA SW846-8081B	Eurofins/TestAmerica	0.36	1
Toxaphene	8001-35-2	EPA SW846-8081B	Eurofins/TestAmerica	32	10
Volatile Organic Compounds (µg/kg dry weight)					
1,1,1,2-Tetrachloroethane	630-20-6	EPA SW846-8260C	Eurofins/TestAmerica	0.59	3
1,1,1-Trichloroethane	71-55-6	EPA SW846-8260C	Eurofins/TestAmerica	0.3	2

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
1,1,2,2-Tetrachloroethane	79-34-5	EPA SW846-8260C	Eurofins/TestAmerica	0.9	4
1,1,2-Trichloroethane	79-00-5	EPA SW846-8260C	Eurofins/TestAmerica	0.25	2
1,1-Dichloroethane	75-34-3	EPA SW846-8260C	Eurofins/TestAmerica	0.19	1
1,1-Dichloroethene	75-35-4	EPA SW846-8260C	Eurofins/TestAmerica	1.1	5
1,1-Dichloropropene	563-58-6	EPA SW846-8260C	Eurofins/TestAmerica	0.3	2
1,2,3-Trichlorobenzene	87-61-6	EPA SW846-8260C	Eurofins/TestAmerica	0.6	3
1,2,3-Trichloropropane	96-18-4	EPA SW846-8260C	Eurofins/TestAmerica	1	5
1,2,4-Trichlorobenzene	120-82-1	EPA SW846-8260C	Eurofins/TestAmerica	0.42	2
1,2,4-Trimethylbenzene	95-63-6	EPA SW846-8260C	Eurofins/TestAmerica	1.2	5
1,2-Dibromo-3-Chloropropane	96-12-8	EPA SW846-8260C	Eurofins/TestAmerica	1.6	10
1,2-Dibromoethane	106-93-4	EPA SW846-8260C	Eurofins/TestAmerica	0.2	1
1,2-Dichlorobenzene	95-50-1	EPA SW846-8260C	Eurofins/TestAmerica	1.3	10
1,2-Dichloroethane	107-06-2	EPA SW846-8260C	Eurofins/TestAmerica	0.2	1
1,2-Dichloropropane	78-87-5	EPA SW846-8260C	Eurofins/TestAmerica	0.4	2
1,3,5-Trimethylbenzene	108-67-8	EPA SW846-8260C	Eurofins/TestAmerica	0.81	5
1,3-Dichlorobenzene	541-73-1	EPA SW846-8260C	Eurofins/TestAmerica	1.1	5
1,3-Dichloropropane	142-28-9	EPA SW846-8260C	Eurofins/TestAmerica	0.23	2
1,4-Dichlorobenzene	106-46-7	EPA SW846-8260C	Eurofins/TestAmerica	0.98	5
2,2-Dichloropropane	594-20-7	EPA SW846-8260C	Eurofins/TestAmerica	0.33	5
2-Chlorotoluene	95-49-8	EPA SW846-8260C	Eurofins/TestAmerica	0.93	5
4-Chlorotoluene	106-43-4	EPA SW846-8260C	Eurofins/TestAmerica	1	5
4-Isopropyltoluene	99-87-6	EPA SW846-8260C	Eurofins/TestAmerica	0.4	2
Benzene	71-43-2	EPA SW846-8260C	Eurofins/TestAmerica	0.39	2
Bromobenzene	108-86-1	EPA SW846-8260C	Eurofins/TestAmerica	1	10
Bromochloromethane	74-97-5	EPA SW846-8260C	Eurofins/TestAmerica	0.25	2
Bromodichloromethane	75-27-4	EPA SW846-8260C	Eurofins/TestAmerica	0.18	1
Bromoform	75-25-2	EPA SW846-8260C	Eurofins/TestAmerica	0.84	5
Bromomethane	74-83-9	EPA SW846-8260C	Eurofins/TestAmerica	0.21	1
Carbon tetrachloride	56-23-5	EPA SW846-8260C	Eurofins/TestAmerica	0.3	2

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
Chlorobenzene	108-90-7	EPA SW846-8260C	Eurofins/TestAmerica	0.25	2
Chloroethane	75-00-3	EPA SW846-8260C	Eurofins/TestAmerica	0.75	10
Chloroform	67-66-3	EPA SW846-8260C	Eurofins/TestAmerica	0.3	2
Chloromethane	74-87-3	EPA SW846-8260C	Eurofins/TestAmerica	0.93	5
cis-1,2-Dichloroethene	156-59-2	EPA SW846-8260C	Eurofins/TestAmerica	0.6	3
cis-1,3-Dichloropropene	10061-01-5	EPA SW846-8260C	Eurofins/TestAmerica	0.2	1
Dibromochloromethane	124-48-1	EPA SW846-8260C	Eurofins/TestAmerica	0.27	1.5
Dibromomethane	74-95-3	EPA SW846-8260C	Eurofins/TestAmerica	0.17	1
Dichlorodifluoromethane	75-71-8	EPA SW846-8260C	Eurofins/TestAmerica	0.49	2
Ethylbenzene	100-41-4	EPA SW846-8260C	Eurofins/TestAmerica	0.41	2
Hexachlorobutadiene	87-68-3	EPA SW846-8260C	Eurofins/TestAmerica	0.6	3
Isopropylbenzene	98-82-8	EPA SW846-8260C	Eurofins/TestAmerica	0.46	2
Methyl tert-butyl ether	1634-04-4	EPA SW846-8260C	Eurofins/TestAmerica	0.3	2
Methylene Chloride	75-09-2	EPA SW846-8260C	Eurofins/TestAmerica	9.9	40
m-Xylene & p-Xylene	179601-23-1	EPA SW846-8260C	Eurofins/TestAmerica	0.56	10
Naphthalene	91-20-3	EPA SW846-8260C	Eurofins/TestAmerica	1.8	10
n-Butylbenzene	104-51-8	EPA SW846-8260C	Eurofins/TestAmerica	0.63	3
N-Propylbenzene	103-65-1	EPA SW846-8260C	Eurofins/TestAmerica	0.76	5
o-Xylene	95-47-6	EPA SW846-8260C	Eurofins/TestAmerica	0.92	5
sec-Butylbenzene	135-98-8	EPA SW846-8260C	Eurofins/TestAmerica	0.67	3
Styrene	100-42-5	EPA SW846-8260C	Eurofins/TestAmerica	0.74	3
t-Butylbenzene	98-06-6	EPA SW846-8260C	Eurofins/TestAmerica	0.66	3
Tetrachloroethene	127-18-4	EPA SW846-8260C	Eurofins/TestAmerica	0.4	2
Toluene	108-88-3	EPA SW846-8260C	Eurofins/TestAmerica	1.3	10
trans-1,2-Dichloroethene	156-60-5	EPA SW846-8260C	Eurofins/TestAmerica	0.4	2
trans-1,3-Dichloropropene	10061-02-6	EPA SW846-8260C	Eurofins/TestAmerica	0.6	10
Trichloroethene	79-01-6	EPA SW846-8260C	Eurofins/TestAmerica	0.3	2
Trichlorofluoromethane	75-69-4	EPA SW846-8260C	Eurofins/TestAmerica	0.3	2
Vinyl chloride	75-01-4	EPA SW846-8260C	Eurofins/TestAmerica	0.3	2

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
Chlorinated Dioxins and Furans (pg/g dry weight)					
2,3,7,8-TCDD	1746-01-6	EPA 8290	Eurofins/TestAmerica	1	0.4
2,3,7,8-TCDF	51207-31-9	EPA 8290	Eurofins/TestAmerica	1	0.4
1,2,3,7,8-PeCDD	40321-76-4	EPA 8290	Eurofins/TestAmerica	5	0.75
1,2,3,7,8-PeCDF	57117-41-6	EPA 8290	Eurofins/TestAmerica	5	0.75
2,3,4,7,8-PeCDF	57117-31-4	EPA 8290	Eurofins/TestAmerica	5	0.75
1,2,3,4,7,8-HxCDD	39227-28-6	EPA 8290	Eurofins/TestAmerica	5	2
1,2,3,6,7,8-HxCDD	57653-85-7	EPA 8290	Eurofins/TestAmerica	5	2
1,2,3,7,8,9-HxCDD	19408-74-3	EPA 8290	Eurofins/TestAmerica	5	2
1,2,3,4,7,8-HxCDF	70648-26-9	EPA 8290	Eurofins/TestAmerica	5	0.75
1,2,3,6,7,8-HxCDF	57117-44-9	EPA 8290	Eurofins/TestAmerica	5	1
1,2,3,7,8,9-HxCDF	72918-21-9	EPA 8290	Eurofins/TestAmerica	5	1
2,3,4,6,7,8-HxCDF	60851-34-5	EPA 8290	Eurofins/TestAmerica	5	0.75
1,2,3,4,6,7,8-HpCDD	35822-46-9	EPA 8290	Eurofins/TestAmerica	5	1
1,2,3,4,6,7,8-HpCDF	67562-39-4	EPA 8290	Eurofins/TestAmerica	5	1
1,2,3,4,7,8,9-HpCDF	55673-89-7	EPA 8290	Eurofins/TestAmerica	5	2
OCDD	3268-87-9	EPA 8290	Eurofins/TestAmerica	10	4
OCDF	39001-02-0	EPA 8290	Eurofins/TestAmerica	10	4
Total tetrachlorinated dioxins	41903-57-5	EPA 8290	Eurofins/TestAmerica	-	-
Total pentachlorinated dioxins	36088-22-9	EPA 8290	Eurofins/TestAmerica	-	-
Total hexachlorinated dioxins	34465-46-8	EPA 8290	Eurofins/TestAmerica	-	-
Total heptachlorinated dioxins	37871-00-4	EPA 8290	Eurofins/TestAmerica	-	-
Total tetrachlorinated furans	30402-14-3	EPA 8290	Eurofins/TestAmerica	-	-
Total pentachlorinated furans	30402-15-4	EPA 8290	Eurofins/TestAmerica	-	-
Total hexachlorinated furans	55684-94-1	EPA 8290	Eurofins/TestAmerica	-	-
Total heptachlorinated furans	38998-75-3	EPA 8290	Eurofins/TestAmerica	-	-
PCB Congeners (pg/g dry weight)					
PCB-1	2051-60-7	EPA 1668C	Eurofins/TestAmerica	0.64	20

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-2	2051-61-8	EPA 1668C	Eurofins/TestAmerica	0.85	20
PCB-3	2051-62-9	EPA 1668C	Eurofins/TestAmerica	1.58	20
PCB-4	13029-08-8	EPA 1668C	Eurofins/TestAmerica	1.38	20
PCB-5	16605-91-7	EPA 1668C	Eurofins/TestAmerica	1.45	20
PCB-6	25569-80-6	EPA 1668C	Eurofins/TestAmerica	1.12	20
PCB-7	33284-50-3	EPA 1668C	Eurofins/TestAmerica	2.02	20
PCB-8	34883-43-7	EPA 1668C	Eurofins/TestAmerica	0.79	20
PCB-9	34883-39-1	EPA 1668C	Eurofins/TestAmerica	0.78	20
PCB-10	33146-45-1	EPA 1668C	Eurofins/TestAmerica	1.3	20
PCB-11	2050-67-1	EPA 1668C	Eurofins/TestAmerica	8.59	20
PCB-12/13	STL01797	EPA 1668C	Eurofins/TestAmerica	2.45	40
PCB-14	34883-41-5	EPA 1668C	Eurofins/TestAmerica	1.15	20
PCB-15	2050-68-2	EPA 1668C	Eurofins/TestAmerica	1.27	20
PCB-16	38444-78-9	EPA 1668C	Eurofins/TestAmerica	0.77	20
PCB-17	37680-66-3	EPA 1668C	Eurofins/TestAmerica	0.56	20
PCB-18/30	STL01798	EPA 1668C	Eurofins/TestAmerica	1.46	40
PCB-19	38444-73-4	EPA 1668C	Eurofins/TestAmerica	0.6	20
PCB-20/28	STL01799	EPA 1668C	Eurofins/TestAmerica	1.89	40
PCB-21/33	STL01800	EPA 1668C	Eurofins/TestAmerica	0.63	40
PCB-22	38444-85-8	EPA 1668C	Eurofins/TestAmerica	0.78	20
PCB-23	55720-44-0	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-24	55702-45-9	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-25	55712-37-3	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-26/29	STL01801	EPA 1668C	Eurofins/TestAmerica	0.74	40
PCB-27	38444-76-7	EPA 1668C	Eurofins/TestAmerica	0.26	20
PCB-31	16606-02-3	EPA 1668C	Eurofins/TestAmerica	1.95	20
PCB-32	38444-77-8	EPA 1668C	Eurofins/TestAmerica	0.62	20
PCB-34	37680-68-5	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-35	37680-69-6	EPA 1668C	Eurofins/TestAmerica	0.45	20

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-36	38444-87-0	EPA 1668C	Eurofins/TestAmerica	0.19	20
PCB-37	38444-90-5	EPA 1668C	Eurofins/TestAmerica	0.39	20
PCB-38	53555-66-1	EPA 1668C	Eurofins/TestAmerica	0.38	20
PCB-39	38444-88-1	EPA 1668C	Eurofins/TestAmerica	0.33	20
PCB-40/71	STL01802	EPA 1668C	Eurofins/TestAmerica	0.79	40
PCB-41	52663-59-9	EPA 1668C	Eurofins/TestAmerica	0.79	20
PCB-42	36559-22-5	EPA 1668C	Eurofins/TestAmerica	0.46	20
PCB-43	70362-46-8	EPA 1668C	Eurofins/TestAmerica	0.28	20
PCB-44/47/65	STL01803	EPA 1668C	Eurofins/TestAmerica	1.68	60
PCB-45	70362-45-7	EPA 1668C	Eurofins/TestAmerica	0.49	20
PCB-46	41464-47-5	EPA 1668C	Eurofins/TestAmerica	0.13	20
PCB-48	70362-47-9	EPA 1668C	Eurofins/TestAmerica	0.48	20
PCB-49/69	STL01805	EPA 1668C	Eurofins/TestAmerica	0.84	40
PCB-50/53	STL01806	EPA 1668C	Eurofins/TestAmerica	0.7	40
PCB-51	68194-04-7	EPA 1668C	Eurofins/TestAmerica	0.49	20
PCB-52	35693-99-3	EPA 1668C	Eurofins/TestAmerica	1.8	20
PCB-54	15968-05-5	EPA 1668C	Eurofins/TestAmerica	0.18	20
PCB-55	74338-24-2	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-56	41464-43-1	EPA 1668C	Eurofins/TestAmerica	0.48	20
PCB-57	70424-67-8	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-58	41464-49-7	EPA 1668C	Eurofins/TestAmerica	0.19	20
PCB-59/62/75	STL01807	EPA 1668C	Eurofins/TestAmerica	0.69	60
PCB-60	33025-41-1	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-61/70/74/76	STL01808	EPA 1668C	Eurofins/TestAmerica	2.03	80
PCB-63	74472-34-7	EPA 1668C	Eurofins/TestAmerica	0.23	20
PCB-64	52663-58-8	EPA 1668C	Eurofins/TestAmerica	0.67	20
PCB-66	32598-10-0	EPA 1668C	Eurofins/TestAmerica	0.89	20
PCB-67	73575-53-8	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-68	73575-52-7	EPA 1668C	Eurofins/TestAmerica	0.28	20

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-72	41464-42-0	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-73	74338-23-1	EPA 1668C	Eurofins/TestAmerica	0.38	20
PCB-77 - WHO 12	32598-13-3	EPA 1668C	Eurofins/TestAmerica	0.25	2
PCB-78	70362-49-1	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-79	41464-48-6	EPA 1668C	Eurofins/TestAmerica	0.32	20
PCB-80	33284-52-5	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB 81 - WHO 12	70362-50-4	EPA 1668C	Eurofins/TestAmerica	0.24	2
PCB-82	52663-62-4	EPA 1668C	Eurofins/TestAmerica	0.12	20
PCB-83	60145-20-2	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-84	52663-60-2	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-85/116/117	STL01810	EPA 1668C	Eurofins/TestAmerica	0.87	60
PCB-86/87/97/108/119/125	STL01811	EPA 1668C	Eurofins/TestAmerica	1.09	120
PCB-88/91	STL01812	EPA 1668C	Eurofins/TestAmerica	0.47	40
PCB-89	73575-57-2	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-90/101/113	STL01813	EPA 1668C	Eurofins/TestAmerica	0.43	60
PCB-92	52663-61-3	EPA 1668C	Eurofins/TestAmerica	0.21	20
PCB-93/100	STL01814	EPA 1668C	Eurofins/TestAmerica	0.54	40
PCB-107/124	STL01815	EPA 1668C	Eurofins/TestAmerica	0.16	40
PCB-94	73575-55-0	EPA 1668C	Eurofins/TestAmerica	0.3	20
PCB-95	38379-99-6	EPA 1668C	Eurofins/TestAmerica	0.53	20
PCB-96	73575-54-9	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-98/102	STL01843	EPA 1668C	Eurofins/TestAmerica	0.54	40
PCB-99	38380-01-7	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-103	60145-21-3	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-104	56558-16-8	EPA 1668C	Eurofins/TestAmerica	0.26	20
PCB 105 - WHO 12	32598-14-4	EPA 1668C	Eurofins/TestAmerica	0.45	2
PCB-106	70424-69-0	EPA 1668C	Eurofins/TestAmerica	0.39	20
PCB-110/115	STL01826	EPA 1668C	Eurofins/TestAmerica	0.87	40
PCB-109	74472-35-8	EPA 1668C	Eurofins/TestAmerica	0.34	20

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-111	39635-32-0	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-112	74472-36-9	EPA 1668C	Eurofins/TestAmerica	0.31	20
PCB 114 - WHO 12	74472-37-0	EPA 1668C	Eurofins/TestAmerica	0.34	2
PCB-118	31508-00-6	EPA 1668C	Eurofins/TestAmerica	0.51	2
PCB-120	68194-12-7	EPA 1668C	Eurofins/TestAmerica	0.19	20
PCB-121	56558-18-0	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB-122	76842-07-4	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB 123 - WHO 12	65510-44-3	EPA 1668C	Eurofins/TestAmerica	0.44	2
PCB 126 - WHO 12	57465-28-8	EPA 1668C	Eurofins/TestAmerica	0.37	2
PCB-127	39635-33-1	EPA 1668C	Eurofins/TestAmerica	0.23	20
PCB-128/166	STL01816	EPA 1668C	Eurofins/TestAmerica	0.26	40
PCB-129/138/163	STL01817	EPA 1668C	Eurofins/TestAmerica	1.11	60
PCB-130	52663-66-8	EPA 1668C	Eurofins/TestAmerica	0.25	20
PCB-131	61798-70-7	EPA 1668C	Eurofins/TestAmerica	0.11	20
PCB-132	38380-05-1	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-133	35694-04-3	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-134/143	STL01818	EPA 1668C	Eurofins/TestAmerica	0.34	40
PCB-135/151	STL01819	EPA 1668C	Eurofins/TestAmerica	0.21	40
PCB-136	38411-22-2	EPA 1668C	Eurofins/TestAmerica	0.15	20
PCB-137	35694-06-5	EPA 1668C	Eurofins/TestAmerica	0.42	20
PCB-139/140	STL01820	EPA 1668C	Eurofins/TestAmerica	0.19	40
PCB-141	52712-04-6	EPA 1668C	Eurofins/TestAmerica	0.34	20
PCB-142	41411-61-4	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-144	68194-14-9	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-145	74472-40-5	EPA 1668C	Eurofins/TestAmerica	0.17	20
PCB-146	51908-16-8	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB-147/149	STL01821	EPA 1668C	Eurofins/TestAmerica	0.42	40
PCB-148	74472-41-6	EPA 1668C	Eurofins/TestAmerica	0.15	20
PCB-150	68194-08-1	EPA 1668C	Eurofins/TestAmerica	0.23	20

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-152	68194-09-2	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-153/168	STL01822	EPA 1668C	Eurofins/TestAmerica	0.5	40
PCB-154	60145-22-4	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB-155	33979-03-2	EPA 1668C	Eurofins/TestAmerica	0.21	20
PCB-156/157 -WHO 12	STL01792	EPA 1668C	Eurofins/TestAmerica	0.76	4
PCB-158	74472-42-7	EPA 1668C	Eurofins/TestAmerica	0.25	20
PCB-159	39635-35-3	EPA 1668C	Eurofins/TestAmerica	0.32	20
PCB-160	41411-62-5	EPA 1668C	Eurofins/TestAmerica	0.61	20
PCB-161	74472-43-8	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-162	39635-34-2	EPA 1668C	Eurofins/TestAmerica	0.25	20
PCB-164	74472-45-0	EPA 1668C	Eurofins/TestAmerica	0.43	20
PCB-165	74472-46-1	EPA 1668C	Eurofins/TestAmerica	0.24	20
PCB 167 - WHO 12	52663-72-6	EPA 1668C	Eurofins/TestAmerica	0.31	2
PCB-169	32774-16-6	EPA 1668C	Eurofins/TestAmerica	0.31	2
PCB-170	35065-30-6	EPA 1668C	Eurofins/TestAmerica	0.31	20
PCB-171/173	STL01823	EPA 1668C	Eurofins/TestAmerica	0.35	40
PCB-172	52663-74-8	EPA 1668C	Eurofins/TestAmerica	0.32	20
PCB-174	38411-25-5	EPA 1668C	Eurofins/TestAmerica	0.55	20
PCB-175	40186-70-7	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-176	52663-65-7	EPA 1668C	Eurofins/TestAmerica	0.17	20
PCB-177	52663-70-4	EPA 1668C	Eurofins/TestAmerica	0.42	20
PCB-178	52663-67-9	EPA 1668C	Eurofins/TestAmerica	0.17	20
PCB-179	52663-64-6	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-180/193	STL01824	EPA 1668C	Eurofins/TestAmerica	0.58	40
PCB-181	74472-47-2	EPA 1668C	Eurofins/TestAmerica	0.15	20
PCB-182	60145-23-5	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-183	52663-69-1	EPA 1668C	Eurofins/TestAmerica	0.32	20
PCB-184	74472-48-3	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB-185	52712-05-7	EPA 1668C	Eurofins/TestAmerica	0.41	20

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-186	74472-49-4	EPA 1668C	Eurofins/TestAmerica	0.23	20
PCB-187	52663-68-0	EPA 1668C	Eurofins/TestAmerica	0.24	20
PCB-188	74487-85-7	EPA 1668C	Eurofins/TestAmerica	0.23	20
PCB 189 - WHO 12	39635-31-9	EPA 1668C	Eurofins/TestAmerica	0.46	2
PCB-190	41411-64-7	EPA 1668C	Eurofins/TestAmerica	0.33	20
PCB-191	74472-50-7	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-192	74472-51-8	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-194	35694-08-7	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-195	52663-78-2	EPA 1668C	Eurofins/TestAmerica	0.33	20
PCB-196	42740-50-1	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-197	33091-17-7	EPA 1668C	Eurofins/TestAmerica	0.31	20
PCB-198/199	STL01825	EPA 1668C	Eurofins/TestAmerica	0.35	40
PCB-200	52663-73-7	EPA 1668C	Eurofins/TestAmerica	0.26	20
PCB-201	40186-71-8	EPA 1668C	Eurofins/TestAmerica	0.15	20
PCB-202	2136-99-4	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-203	52663-76-0	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-204	74472-52-9	EPA 1668C	Eurofins/TestAmerica	0.12	20
PCB-205	74472-53-0	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-206	40186-72-9	EPA 1668C	Eurofins/TestAmerica	0.45	20
PCB-207	52663-79-3	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-208	52663-77-1	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-209	2051-24-3	EPA 1668C	Eurofins/TestAmerica	0.62	20
Chlorinated Herbicides (µg/kg dry weight)					
2,4,5-T	93-76-5	EPA SW846-8151A	Eurofins/TestAmerica	38.2	90
2,4-D	94-75-7	EPA SW846-8151A	Eurofins/TestAmerica	39.3	90
2,4-DB	94-82-6	EPA SW846-8151A	Eurofins/TestAmerica	21.3	90
4-Nitrophenol	100-02-7	EPA SW846-8151A	Eurofins/TestAmerica	31.9	90
Dicamba	1918-00-9	EPA SW846-8151A	Eurofins/TestAmerica	20.6	90

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
Dichlorprop	120-36-5	EPA SW846-8151A	Eurofins/TestAmerica	20.6	90
Dinoseb	88-85-7	EPA SW846-8151A	Eurofins/TestAmerica	53.2	160
MCPA	94-74-6	EPA SW846-8151A	Eurofins/TestAmerica	20.6	90
Mecoprop	93-65-2	EPA SW846-8151A	Eurofins/TestAmerica	20.6	90
Pentachlorophenol	87-86-5	EPA SW846-8151A	Eurofins/TestAmerica	44.5	160
Silvex (2,4,5-TP)	93-72-1	EPA SW846-8151A	Eurofins/TestAmerica	22.1	90
TAL Metals (mg/kg dry weight)					
Aluminum	7429-90-5	EPA SW846-6020A	Eurofins/TestAmerica	6.6	30
Antimony	7440-36-0	EPA SW846-6020A	Eurofins/TestAmerica	0.068	0.5
Arsenic	7440-38-2	EPA SW846-6020A	Eurofins/TestAmerica	0.1	0.5
Barium	7440-39-3	EPA SW846-6020A	Eurofins/TestAmerica	0.228	1
Beryllium	7440-41-7	EPA SW846-6020A	Eurofins/TestAmerica	0.048	0.2
Cadmium	7440-43-9	EPA SW846-6020A	Eurofins/TestAmerica	0.077	0.8
Chromium	7440-47-3	EPA SW846-6020A	Eurofins/TestAmerica	0.063	1
Cobalt	7440-48-4	EPA SW846-6020A	Eurofins/TestAmerica	0.01	0.2
Copper	7440-50-8	EPA SW846-6020A	Eurofins/TestAmerica	0.22	1
Iron	7439-89-6	EPA SW846-6020A	Eurofins/TestAmerica	11.5	40
Lead	7439-92-1	EPA SW846-6020A	Eurofins/TestAmerica	0.048	0.5
Manganese	7439-96-5	EPA SW846-6020A	Eurofins/TestAmerica	0.453	1.5
Nickel	7440-02-0	EPA SW846-6020A	Eurofins/TestAmerica	0.193	0.5
Selenium	7782-49-2	EPA SW846-6020A	Eurofins/TestAmerica	0.286	1.5
Silver	7440-22-4	EPA SW846-6020A	Eurofins/TestAmerica	0.02	0.2
Thallium	7440-28-0	EPA SW846-6020A	Eurofins/TestAmerica	0.055	0.4
Vanadium	7440-62-2	EPA SW846-6020A	Eurofins/TestAmerica	0.272	2
Zinc	7440-66-6	EPA SW846-6020A	Eurofins/TestAmerica	1.61	5.5
Calcium	7440-70-2	EPA SW846-6010C	Eurofins/TestAmerica	10	55
Magnesium	7439-95-4	EPA SW846-6010C	Eurofins/TestAmerica	7.92	55
Potassium	7440-09-7	EPA SW846-6010C	Eurofins/TestAmerica	6.81	165

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
Sodium	7440-23-5	EPA SW846-6010C	Eurofins/TestAmerica	18.8	100
Mercury	7439-97-6	EPA SW846-7471A	Eurofins/TestAmerica	0.009	0.03
NWTPH (mg/kg dry weight)					
Diesel Range Organics (C10-C24)	-	NWTPH-Dx	Eurofins/TestAmerica	12.3	50
Motor Oil Range Organics (>C24-C36)	-	NWTPH-Dx	Eurofins/TestAmerica	17.5	50
Gasoline Range Organics	-	NWTPH-Gx	Eurofins/TestAmerica	2.3	5
Soils					
Organochlorine Pesticides (µg/kg dry weight)					
2,4'-DDD	53-19-0	EPA SW846-8081B	Eurofins/TestAmerica	1.1	0.5
2,4'-DDE	3424-82-6	EPA SW846-8081B	Eurofins/TestAmerica	0.91	0.5
2,4'-DDT	789-02-6	EPA SW846-8081B	Eurofins/TestAmerica	1.9	0.5
4,4'-DDD	72-54-8	EPA SW846-8081B	Eurofins/TestAmerica	0.39	0.2
4,4'-DDE	72-55-9	EPA SW846-8081B	Eurofins/TestAmerica	0.53	0.2
4,4'-DDT	50-29-3	EPA SW846-8081B	Eurofins/TestAmerica	0.39	0.2
Chlorinated Dioxins and Furans (pg/g dry weight)					
2,3,7,8-TCDD	1746-01-6	EPA 8290	Eurofins/TestAmerica	1	0.4
2,3,7,8-TCDF	51207-31-9	EPA 8290	Eurofins/TestAmerica	1	0.4
1,2,3,7,8-PeCDD	40321-76-4	EPA 8290	Eurofins/TestAmerica	5	0.75
1,2,3,7,8-PeCDF	57117-41-6	EPA 8290	Eurofins/TestAmerica	5	0.75
2,3,4,7,8-PeCDF	57117-31-4	EPA 8290	Eurofins/TestAmerica	5	0.75
1,2,3,4,7,8-HxCDD	39227-28-6	EPA 8290	Eurofins/TestAmerica	5	2
1,2,3,6,7,8-HxCDD	57653-85-7	EPA 8290	Eurofins/TestAmerica	5	2
1,2,3,7,8,9-HxCDD	19408-74-3	EPA 8290	Eurofins/TestAmerica	5	2
1,2,3,4,7,8-HxCDF	70648-26-9	EPA 8290	Eurofins/TestAmerica	5	0.75
1,2,3,6,7,8-HxCDF	57117-44-9	EPA 8290	Eurofins/TestAmerica	5	1
1,2,3,7,8,9-HxCDF	72918-21-9	EPA 8290	Eurofins/TestAmerica	5	1
2,3,4,6,7,8-HxCDF	60851-34-5	EPA 8290	Eurofins/TestAmerica	5	0.75

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
1,2,3,4,6,7,8-HpCDD	35822-46-9	EPA 8290	Eurofins/TestAmerica	5	1
1,2,3,4,6,7,8-HpCDF	67562-39-4	EPA 8290	Eurofins/TestAmerica	5	1
1,2,3,4,7,8,9-HpCDF	55673-89-7	EPA 8290	Eurofins/TestAmerica	5	2
OCDD	3268-87-9	EPA 8290	Eurofins/TestAmerica	10	4
OCDF	39001-02-0	EPA 8290	Eurofins/TestAmerica	10	4
Total tetrachlorinated dioxins	41903-57-5	EPA 8290	Eurofins/TestAmerica	-	-
Total pentachlorinated dioxins	36088-22-9	EPA 8290	Eurofins/TestAmerica	-	-
Total hexachlorinated dioxins	34465-46-8	EPA 8290	Eurofins/TestAmerica	-	-
Total heptachlorinated dioxins	37871-00-4	EPA 8290	Eurofins/TestAmerica	-	-
Total tetrachlorinated furans	30402-14-3	EPA 8290	Eurofins/TestAmerica	-	-
Total pentachlorinated furans	30402-15-4	EPA 8290	Eurofins/TestAmerica	-	-
Total hexachlorinated furans	55684-94-1	EPA 8290	Eurofins/TestAmerica	-	-
Total heptachlorinated furans	38998-75-3	EPA 8290	Eurofins/TestAmerica	-	-
PCB Congeners (pg/g dry weight)					
PCB-1	2051-60-7	EPA 1668C	Eurofins/TestAmerica	0.64	20
PCB-2	2051-61-8	EPA 1668C	Eurofins/TestAmerica	0.85	20
PCB-3	2051-62-9	EPA 1668C	Eurofins/TestAmerica	1.58	20
PCB-4	13029-08-8	EPA 1668C	Eurofins/TestAmerica	1.38	20
PCB-5	16605-91-7	EPA 1668C	Eurofins/TestAmerica	1.45	20
PCB-6	25569-80-6	EPA 1668C	Eurofins/TestAmerica	1.12	20
PCB-7	33284-50-3	EPA 1668C	Eurofins/TestAmerica	2.02	20
PCB-8	34883-43-7	EPA 1668C	Eurofins/TestAmerica	0.79	20
PCB-9	34883-39-1	EPA 1668C	Eurofins/TestAmerica	0.78	20
PCB-10	33146-45-1	EPA 1668C	Eurofins/TestAmerica	1.3	20
PCB-11	2050-67-1	EPA 1668C	Eurofins/TestAmerica	8.59	20
PCB-12/13	STL01797	EPA 1668C	Eurofins/TestAmerica	2.45	40
PCB-14	34883-41-5	EPA 1668C	Eurofins/TestAmerica	1.15	20
PCB-15	2050-68-2	EPA 1668C	Eurofins/TestAmerica	1.27	20

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-16	38444-78-9	EPA 1668C	Eurofins/TestAmerica	0.77	20
PCB-17	37680-66-3	EPA 1668C	Eurofins/TestAmerica	0.56	20
PCB-18/30	STL01798	EPA 1668C	Eurofins/TestAmerica	1.46	40
PCB-19	38444-73-4	EPA 1668C	Eurofins/TestAmerica	0.6	20
PCB-20/28	STL01799	EPA 1668C	Eurofins/TestAmerica	1.89	40
PCB-21/33	STL01800	EPA 1668C	Eurofins/TestAmerica	0.63	40
PCB-22	38444-85-8	EPA 1668C	Eurofins/TestAmerica	0.78	20
PCB-23	55720-44-0	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-24	55702-45-9	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-25	55712-37-3	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-26/29	STL01801	EPA 1668C	Eurofins/TestAmerica	0.74	40
PCB-27	38444-76-7	EPA 1668C	Eurofins/TestAmerica	0.26	20
PCB-31	16606-02-3	EPA 1668C	Eurofins/TestAmerica	1.95	20
PCB-32	38444-77-8	EPA 1668C	Eurofins/TestAmerica	0.62	20
PCB-34	37680-68-5	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-35	37680-69-6	EPA 1668C	Eurofins/TestAmerica	0.45	20
PCB-36	38444-87-0	EPA 1668C	Eurofins/TestAmerica	0.19	20
PCB-37	38444-90-5	EPA 1668C	Eurofins/TestAmerica	0.39	20
PCB-38	53555-66-1	EPA 1668C	Eurofins/TestAmerica	0.38	20
PCB-39	38444-88-1	EPA 1668C	Eurofins/TestAmerica	0.33	20
PCB-40/71	STL01802	EPA 1668C	Eurofins/TestAmerica	0.79	40
PCB-41	52663-59-9	EPA 1668C	Eurofins/TestAmerica	0.79	20
PCB-42	36559-22-5	EPA 1668C	Eurofins/TestAmerica	0.46	20
PCB-43	70362-46-8	EPA 1668C	Eurofins/TestAmerica	0.28	20
PCB-44/47/65	STL01803	EPA 1668C	Eurofins/TestAmerica	1.68	60
PCB-45	70362-45-7	EPA 1668C	Eurofins/TestAmerica	0.49	20
PCB-46	41464-47-5	EPA 1668C	Eurofins/TestAmerica	0.13	20
PCB-48	70362-47-9	EPA 1668C	Eurofins/TestAmerica	0.48	20
PCB-49/69	STL01805	EPA 1668C	Eurofins/TestAmerica	0.84	40

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-50/53	STL01806	EPA 1668C	Eurofins/TestAmerica	0.7	40
PCB-51	68194-04-7	EPA 1668C	Eurofins/TestAmerica	0.49	20
PCB-52	35693-99-3	EPA 1668C	Eurofins/TestAmerica	1.8	20
PCB-54	15968-05-5	EPA 1668C	Eurofins/TestAmerica	0.18	20
PCB-55	74338-24-2	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-56	41464-43-1	EPA 1668C	Eurofins/TestAmerica	0.48	20
PCB-57	70424-67-8	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-58	41464-49-7	EPA 1668C	Eurofins/TestAmerica	0.19	20
PCB-59/62/75	STL01807	EPA 1668C	Eurofins/TestAmerica	0.69	60
PCB-60	33025-41-1	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-61/70/74/76	STL01808	EPA 1668C	Eurofins/TestAmerica	2.03	80
PCB-63	74472-34-7	EPA 1668C	Eurofins/TestAmerica	0.23	20
PCB-64	52663-58-8	EPA 1668C	Eurofins/TestAmerica	0.67	20
PCB-66	32598-10-0	EPA 1668C	Eurofins/TestAmerica	0.89	20
PCB-67	73575-53-8	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-68	73575-52-7	EPA 1668C	Eurofins/TestAmerica	0.28	20
PCB-72	41464-42-0	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-73	74338-23-1	EPA 1668C	Eurofins/TestAmerica	0.38	20
PCB-77 - WHO 12	32598-13-3	EPA 1668C	Eurofins/TestAmerica	0.25	2
PCB-78	70362-49-1	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-79	41464-48-6	EPA 1668C	Eurofins/TestAmerica	0.32	20
PCB-80	33284-52-5	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB 81 - WHO 12	70362-50-4	EPA 1668C	Eurofins/TestAmerica	0.24	2
PCB-82	52663-62-4	EPA 1668C	Eurofins/TestAmerica	0.12	20
PCB-83	60145-20-2	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-84	52663-60-2	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-85/116/117	STL01810	EPA 1668C	Eurofins/TestAmerica	0.87	60
PCB-86/87/97/108/119/125	STL01811	EPA 1668C	Eurofins/TestAmerica	1.09	120
PCB-88/91	STL01812	EPA 1668C	Eurofins/TestAmerica	0.47	40

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-89	73575-57-2	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-90/101/113	STL01813	EPA 1668C	Eurofins/TestAmerica	0.43	60
PCB-92	52663-61-3	EPA 1668C	Eurofins/TestAmerica	0.21	20
PCB-93/100	STL01814	EPA 1668C	Eurofins/TestAmerica	0.54	40
PCB-107/124	STL01815	EPA 1668C	Eurofins/TestAmerica	0.16	40
PCB-94	73575-55-0	EPA 1668C	Eurofins/TestAmerica	0.3	20
PCB-95	38379-99-6	EPA 1668C	Eurofins/TestAmerica	0.53	20
PCB-96	73575-54-9	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-98/102	STL01843	EPA 1668C	Eurofins/TestAmerica	0.54	40
PCB-99	38380-01-7	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-103	60145-21-3	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-104	56558-16-8	EPA 1668C	Eurofins/TestAmerica	0.26	20
PCB 105 - WHO 12	32598-14-4	EPA 1668C	Eurofins/TestAmerica	0.45	2
PCB-106	70424-69-0	EPA 1668C	Eurofins/TestAmerica	0.39	20
PCB-110/115	STL01826	EPA 1668C	Eurofins/TestAmerica	0.87	40
PCB-109	74472-35-8	EPA 1668C	Eurofins/TestAmerica	0.34	20
PCB-111	39635-32-0	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-112	74472-36-9	EPA 1668C	Eurofins/TestAmerica	0.31	20
PCB 114 - WHO 12	74472-37-0	EPA 1668C	Eurofins/TestAmerica	0.34	2
PCB-118	31508-00-6	EPA 1668C	Eurofins/TestAmerica	0.51	2
PCB-120	68194-12-7	EPA 1668C	Eurofins/TestAmerica	0.19	20
PCB-121	56558-18-0	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB-122	76842-07-4	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB 123 - WHO 12	65510-44-3	EPA 1668C	Eurofins/TestAmerica	0.44	2
PCB 126 - WHO 12	57465-28-8	EPA 1668C	Eurofins/TestAmerica	0.37	2
PCB-127	39635-33-1	EPA 1668C	Eurofins/TestAmerica	0.23	20
PCB-128/166	STL01816	EPA 1668C	Eurofins/TestAmerica	0.26	40
PCB-129/138/163	STL01817	EPA 1668C	Eurofins/TestAmerica	1.11	60
PCB-130	52663-66-8	EPA 1668C	Eurofins/TestAmerica	0.25	20

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-131	61798-70-7	EPA 1668C	Eurofins/TestAmerica	0.11	20
PCB-132	38380-05-1	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-133	35694-04-3	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-134/143	STL01818	EPA 1668C	Eurofins/TestAmerica	0.34	40
PCB-135/151	STL01819	EPA 1668C	Eurofins/TestAmerica	0.21	40
PCB-136	38411-22-2	EPA 1668C	Eurofins/TestAmerica	0.15	20
PCB-137	35694-06-5	EPA 1668C	Eurofins/TestAmerica	0.42	20
PCB-139/140	STL01820	EPA 1668C	Eurofins/TestAmerica	0.19	40
PCB-141	52712-04-6	EPA 1668C	Eurofins/TestAmerica	0.34	20
PCB-142	41411-61-4	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-144	68194-14-9	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-145	74472-40-5	EPA 1668C	Eurofins/TestAmerica	0.17	20
PCB-146	51908-16-8	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB-147/149	STL01821	EPA 1668C	Eurofins/TestAmerica	0.42	40
PCB-148	74472-41-6	EPA 1668C	Eurofins/TestAmerica	0.15	20
PCB-150	68194-08-1	EPA 1668C	Eurofins/TestAmerica	0.23	20
PCB-152	68194-09-2	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-153/168	STL01822	EPA 1668C	Eurofins/TestAmerica	0.5	40
PCB-154	60145-22-4	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB-155	33979-03-2	EPA 1668C	Eurofins/TestAmerica	0.21	20
PCB-156/157 -WHO 12	STL01792	EPA 1668C	Eurofins/TestAmerica	0.76	4
PCB-158	74472-42-7	EPA 1668C	Eurofins/TestAmerica	0.25	20
PCB-159	39635-35-3	EPA 1668C	Eurofins/TestAmerica	0.32	20
PCB-160	41411-62-5	EPA 1668C	Eurofins/TestAmerica	0.61	20
PCB-161	74472-43-8	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-162	39635-34-2	EPA 1668C	Eurofins/TestAmerica	0.25	20
PCB-164	74472-45-0	EPA 1668C	Eurofins/TestAmerica	0.43	20
PCB-165	74472-46-1	EPA 1668C	Eurofins/TestAmerica	0.24	20
PCB 167 - WHO 12	52663-72-6	EPA 1668C	Eurofins/TestAmerica	0.31	2

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-169	32774-16-6	EPA 1668C	Eurofins/TestAmerica	0.31	2
PCB-170	35065-30-6	EPA 1668C	Eurofins/TestAmerica	0.31	20
PCB-171/173	STL01823	EPA 1668C	Eurofins/TestAmerica	0.35	40
PCB-172	52663-74-8	EPA 1668C	Eurofins/TestAmerica	0.32	20
PCB-174	38411-25-5	EPA 1668C	Eurofins/TestAmerica	0.55	20
PCB-175	40186-70-7	EPA 1668C	Eurofins/TestAmerica	0.2	20
PCB-176	52663-65-7	EPA 1668C	Eurofins/TestAmerica	0.17	20
PCB-177	52663-70-4	EPA 1668C	Eurofins/TestAmerica	0.42	20
PCB-178	52663-67-9	EPA 1668C	Eurofins/TestAmerica	0.17	20
PCB-179	52663-64-6	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-180/193	STL01824	EPA 1668C	Eurofins/TestAmerica	0.58	40
PCB-181	74472-47-2	EPA 1668C	Eurofins/TestAmerica	0.15	20
PCB-182	60145-23-5	EPA 1668C	Eurofins/TestAmerica	0.22	20
PCB-183	52663-69-1	EPA 1668C	Eurofins/TestAmerica	0.32	20
PCB-184	74472-48-3	EPA 1668C	Eurofins/TestAmerica	0.14	20
PCB-185	52712-05-7	EPA 1668C	Eurofins/TestAmerica	0.41	20
PCB-186	74472-49-4	EPA 1668C	Eurofins/TestAmerica	0.23	20
PCB-187	52663-68-0	EPA 1668C	Eurofins/TestAmerica	0.24	20
PCB-188	74487-85-7	EPA 1668C	Eurofins/TestAmerica	0.23	20
PCB 189 - WHO 12	39635-31-9	EPA 1668C	Eurofins/TestAmerica	0.46	2
PCB-190	41411-64-7	EPA 1668C	Eurofins/TestAmerica	0.33	20
PCB-191	74472-50-7	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-192	74472-51-8	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-194	35694-08-7	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-195	52663-78-2	EPA 1668C	Eurofins/TestAmerica	0.33	20
PCB-196	42740-50-1	EPA 1668C	Eurofins/TestAmerica	0.29	20
PCB-197	33091-17-7	EPA 1668C	Eurofins/TestAmerica	0.31	20
PCB-198/199	STL01825	EPA 1668C	Eurofins/TestAmerica	0.35	40
PCB-200	52663-73-7	EPA 1668C	Eurofins/TestAmerica	0.26	20

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-201	40186-71-8	EPA 1668C	Eurofins/TestAmerica	0.15	20
PCB-202	2136-99-4	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-203	52663-76-0	EPA 1668C	Eurofins/TestAmerica	0.35	20
PCB-204	74472-52-9	EPA 1668C	Eurofins/TestAmerica	0.12	20
PCB-205	74472-53-0	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-206	40186-72-9	EPA 1668C	Eurofins/TestAmerica	0.45	20
PCB-207	52663-79-3	EPA 1668C	Eurofins/TestAmerica	0.27	20
PCB-208	52663-77-1	EPA 1668C	Eurofins/TestAmerica	0.16	20
PCB-209	2051-24-3	EPA 1668C	Eurofins/TestAmerica	0.62	20
Sediment Porewater					
Dissolved Organic Carbon (mg/L)	7440-44-0	EPA SW846-9060A	Eurofins/TestAmerica	0.38	1.5
Volatile Organic Compounds (µg/L)					
1,1,1,2-Tetrachloroethane	630-20-6	EPA SW846-8260C	Eurofins/TestAmerica	0.027	0.07
1,1,1-Trichloroethane	71-55-6	EPA SW846-8260C	Eurofins/TestAmerica	0.025	0.07
1,1,2,2-Tetrachloroethane	79-34-5	EPA SW846-8260C	Eurofins/TestAmerica	0.056	0.15
1,1,2-Trichloroethane	79-00-5	EPA SW846-8260C	Eurofins/TestAmerica	0.07	0.15
1,1-Dichloroethane	75-34-3	EPA SW846-8260C	Eurofins/TestAmerica	0.025	0.07
1,1-Dichloroethene	75-35-4	EPA SW846-8260C	Eurofins/TestAmerica	0.035	0.07
1,1-Dichloropropene	563-58-6	EPA SW846-8260C	Eurofins/TestAmerica	0.036	0.07
1,2,3-Trichlorobenzene	87-61-6	EPA SW846-8260C	Eurofins/TestAmerica	0.149	0.35
1,2,3-Trichloropropane	96-18-4	EPA SW846-8260C	Eurofins/TestAmerica	0.05	0.15
1,2,4-Trichlorobenzene	120-82-1	EPA SW846-8260C	Eurofins/TestAmerica	0.172	0.35
1,2,4-Trimethylbenzene	95-63-6	EPA SW846-8260C	Eurofins/TestAmerica	0.072	0.15
1,2-Dibromo-3-Chloropropane	96-12-8	EPA SW846-8260C	Eurofins/TestAmerica	0.44	1
1,2-Dichlorobenzene	95-50-1	EPA SW846-8260C	Eurofins/TestAmerica	0.024	0.07
1,2-Dichloroethane	107-06-2	EPA SW846-8260C	Eurofins/TestAmerica	0.043	0.15
1,2-Dichloropropane	78-87-5	EPA SW846-8260C	Eurofins/TestAmerica	0.06	0.15
1,3,5-Trimethylbenzene	108-67-8	EPA SW846-8260C	Eurofins/TestAmerica	0.152	0.35

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
1,3-Dichlorobenzene	541-73-1	EPA SW846-8260C	Eurofins/TestAmerica	0.05	0.15
1,3-Dichloropropane	142-28-9	EPA SW846-8260C	Eurofins/TestAmerica	0.025	0.07
1,4-Dichlorobenzene	106-46-7	EPA SW846-8260C	Eurofins/TestAmerica	0.05	0.15
2,2-Dichloropropane	594-20-7	EPA SW846-8260C	Eurofins/TestAmerica	0.06	0.15
2-Chlorotoluene	95-49-8	EPA SW846-8260C	Eurofins/TestAmerica	0.116	0.35
4-Chlorotoluene	106-43-4	EPA SW846-8260C	Eurofins/TestAmerica	0.05	0.15
4-Isopropyltoluene	99-87-6	EPA SW846-8260C	Eurofins/TestAmerica	0.146	0.35
Benzene	71-43-2	EPA SW846-8260C	Eurofins/TestAmerica	0.03	0.07
Bromobenzene	108-86-1	EPA SW846-8260C	Eurofins/TestAmerica	0.035	0.07
Bromoform	75-25-2	EPA SW846-8260C	Eurofins/TestAmerica	0.157	0.35
Bromomethane	74-83-9	EPA SW846-8260C	Eurofins/TestAmerica	0.062	0.15
Carbon tetrachloride	56-23-5	EPA SW846-8260C	Eurofins/TestAmerica	0.025	0.07
Chlorobenzene	108-90-7	EPA SW846-8260C	Eurofins/TestAmerica	0.025	0.07
Chlorobromomethane	74-97-5	EPA SW846-8260C	Eurofins/TestAmerica	0.025	0.07
Chlorodibromomethane	124-48-1	EPA SW846-8260C	Eurofins/TestAmerica	0.055	0.15
Chloroethane	75-00-3	EPA SW846-8260C	Eurofins/TestAmerica	0.096	0.25
Chloroform	67-66-3	EPA SW846-8260C	Eurofins/TestAmerica	0.03	0.07
Chloromethane	74-87-3	EPA SW846-8260C	Eurofins/TestAmerica	0.068	0.15
cis-1,2-Dichloroethene	156-59-2	EPA SW846-8260C	Eurofins/TestAmerica	0.055	0.15
cis-1,3-Dichloropropene	10061-01-5	EPA SW846-8260C	Eurofins/TestAmerica	0.09	0.15
Dibromomethane	74-95-3	EPA SW846-8260C	Eurofins/TestAmerica	0.062	0.15
Dichlorobromomethane	75-27-4	EPA SW846-8260C	Eurofins/TestAmerica	0.06	0.15
Dichlorodifluoromethane	75-71-8	EPA SW846-8260C	Eurofins/TestAmerica	0.128	0.35
Ethylbenzene	100-41-4	EPA SW846-8260C	Eurofins/TestAmerica	0.03	0.07
Ethylene Dibromide	106-93-4	EPA SW846-8260C	Eurofins/TestAmerica	0.025	0.07
Hexachlorobutadiene	87-68-3	EPA SW846-8260C	Eurofins/TestAmerica	0.067	0.15
Isopropylbenzene	98-82-8	EPA SW846-8260C	Eurofins/TestAmerica	0.187	0.5
Methyl tert-butyl ether	1634-04-4	EPA SW846-8260C	Eurofins/TestAmerica	0.07	0.25
Methylene Chloride	75-09-2	EPA SW846-8260C	Eurofins/TestAmerica	1.2	3.5

Table B-5. Analytes and Reporting Limits for Sediment and Soil Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
m-Xylene & p-Xylene	179601-23-1	EPA SW846-8260C	Eurofins/TestAmerica	0.115	0.25
Naphthalene	91-20-3	EPA SW846-8260C	Eurofins/TestAmerica	0.221	0.5
n-Butylbenzene	104-51-8	EPA SW846-8260C	Eurofins/TestAmerica	0.225	0.5
N-Propylbenzene	103-65-1	EPA SW846-8260C	Eurofins/TestAmerica	0.091	0.25
o-Xylene	95-47-6	EPA SW846-8260C	Eurofins/TestAmerica	0.147	0.35
sec-Butylbenzene	135-98-8	EPA SW846-8260C	Eurofins/TestAmerica	0.168	0.5
Styrene	100-42-5	EPA SW846-8260C	Eurofins/TestAmerica	0.192	0.5
tert-Butylbenzene	98-06-6	EPA SW846-8260C	Eurofins/TestAmerica	0.257	0.35
Tetrachloroethene	127-18-4	EPA SW846-8260C	Eurofins/TestAmerica	0.084	0.25
Toluene	108-88-3	EPA SW846-8260C	Eurofins/TestAmerica	0.05	0.15
trans-1,2-Dichloroethene	156-60-5	EPA SW846-8260C	Eurofins/TestAmerica	0.033	0.07
trans-1,3-Dichloropropene	10061-02-6	EPA SW846-8260C	Eurofins/TestAmerica	0.092	0.15
Trichloroethene	79-01-6	EPA SW846-8260C	Eurofins/TestAmerica	0.066	0.15
Trichlorofluoromethane	75-69-4	EPA SW846-8260C	Eurofins/TestAmerica	0.043	0.15
Vinyl chloride	75-01-4	EPA SW846-8260C	Eurofins/TestAmerica	0.013	0.015

Notes:
MDLs are updated periodically by the laboratories. MDLs that are in effect at the laboratory at the time of analysis will be used.
These may differ slightly from the MDLs shown in this table.
The LOQ for project samples will vary with moisture content in the samples.
The LOQ represents the level of lowest calibration standard (i.e., the practical quantitation limit).
Data will not be used for screening against any specific cleanup levels.

APHA SM = American Public Health Association Standard Methods
CAS = Chemical Abstract Services
EPA = U.S. Environmental Protection Agency
MDL = method detection limit
LOQ = limit of quantitation
NE = not established
NWTPH = Northwest Total Petroleum Hydrocarbon
pCi/g = picoCuries per gram
PCB = polychlorinated biphenyl
TAL = target analyte list
WHO = World Health Organization

Table B-6. Analytes and Reporting Limits for Groundwater and Equipment Blank Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
Conventional Analyses					
Dissolved organic carbon (mg/L)	7440-44-0	EPA SW846-9060A	Eurofins/TestAmerica	0.38	1.5
Organochlorine Pesticides (µg/L)					
2,4'-DDD	53-19-0	EPA SW846-8081B	Eurofins/TestAmerica	0.009	0.03
2,4'-DDE	3424-82-6	EPA SW846-8081B	Eurofins/TestAmerica	0.005	0.03
2,4'-DDT	789-02-6	EPA SW846-8081B	Eurofins/TestAmerica	0.009	0.03
4,4'-DDD	72-54-8	EPA SW846-8081B	Eurofins/TestAmerica	0.006	0.015
4,4'-DDE	72-55-9	EPA SW846-8081B	Eurofins/TestAmerica	0.003	0.01
4,4'-DDT	50-29-3	EPA SW846-8081B	Eurofins/TestAmerica	0.005	0.02
alpha-BHC	319-84-6	EPA SW846-8081B	Eurofins/TestAmerica	0.004	0.018
gamma-BHC (Lindane)	58-89-9	EPA SW846-8081B	Eurofins/TestAmerica	0.005	0.02
beta-BHC	319-85-7	EPA SW846-8081B	Eurofins/TestAmerica	0.005	0.021
delta-BHC	319-86-8	EPA SW846-8081B	Eurofins/TestAmerica	0.005	0.015
Heptachlor	76-44-8	EPA SW846-8081B	Eurofins/TestAmerica	0.004	0.015
Aldrin	309-00-2	EPA SW846-8081B	Eurofins/TestAmerica	0.007	0.024
Heptachlor epoxide	1024-57-3	EPA SW846-8081B	Eurofins/TestAmerica	0.003	0.02
trans-Chlordane	5103-74-2	EPA SW846-8081B	Eurofins/TestAmerica	0.003	0.02
cis-Chlordane	5103-71-9	EPA SW846-8081B	Eurofins/TestAmerica	0.008	0.027
Endosulfan I	959-98-8	EPA SW846-8081B	Eurofins/TestAmerica	0.003	0.02
Dieldrin	60-57-1	EPA SW846-8081B	Eurofins/TestAmerica	0.005	0.018
Endrin	72-20-8	EPA SW846-8081B	Eurofins/TestAmerica	0.003	0.012
Endosulfan II	33213-65-9	EPA SW846-8081B	Eurofins/TestAmerica	0.005	0.024
Endrin aldehyde	7421-93-4	EPA SW846-8081B	Eurofins/TestAmerica	0.034	0.06
Endosulfan sulfate	1031-07-8	EPA SW846-8081B	Eurofins/TestAmerica	0.003	0.02
Methoxychlor	72-43-5	EPA SW846-8081B	Eurofins/TestAmerica	0.005	0.1
Endrin ketone	53494-70-5	EPA SW846-8081B	Eurofins/TestAmerica	0.002	0.02
Toxaphene	8001-35-2	EPA SW846-8081B	Eurofins/TestAmerica	0.46	2
Chlorinated Herbicides (µg/L)					
Dalapon	75-99-0	EPA SW846-8151A	Eurofins/TestAmerica	0.3	1
Dicamba	1918-00-9	EPA SW846-8151A	Eurofins/TestAmerica	0.2	1
Mecoprop	93-65-2	EPA SW846-8151A	Eurofins/TestAmerica	0.17	1

Table B-6. Analytes and Reporting Limits for Groundwater and Equipment Blank Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
MCPA	94-74-6	EPA SW846-8151A	Eurofins/TestAmerica	0.15	1
Dichlorprop	120-36-5	EPA SW846-8151A	Eurofins/TestAmerica	0.16	1
2,4-D	94-75-7	EPA SW846-8151A	Eurofins/TestAmerica	0.28	1
Pentachlorophenol	87-86-5	EPA SW846-8151A	Eurofins/TestAmerica	0.23	1
Silvex (2,4,5-TP)	93-72-1	EPA SW846-8151A	Eurofins/TestAmerica	0.23	1
2,4,5-T	93-76-5	EPA SW846-8151A	Eurofins/TestAmerica	0.23	1
Dinoseb	88-85-7	EPA SW846-8151A	Eurofins/TestAmerica	0.27	1
2,4-DB	94-82-6	EPA SW846-8151A	Eurofins/TestAmerica	0.16	1
TAL Metals (mg/L)					
Arsenic	7440-38-2	EPA SW846-6020A	Eurofins/TestAmerica	0.000204	0.001
Antimony	7440-36-0	EPA SW846-6020A	Eurofins/TestAmerica	0.00011	0.0008
Barium	7440-39-3	EPA SW846-6020A	Eurofins/TestAmerica	0.000212	0.0012
Beryllium	7440-41-7	EPA SW846-6020A	Eurofins/TestAmerica	0.000071	0.0004
Cadmium	7440-43-9	EPA SW846-6020A	Eurofins/TestAmerica	0.0001	0.0008
Chromium	7440-47-3	EPA SW846-6020A	Eurofins/TestAmerica	0.000173	0.0008
Cobalt	7440-48-4	EPA SW846-6020A	Eurofins/TestAmerica	0.000039	0.0004
Copper	7440-50-8	EPA SW846-6020A	Eurofins/TestAmerica	0.000603	0.002
Iron	7439-89-6	EPA SW846-6020A	Eurofins/TestAmerica	0.0356	0.2
Lead	7439-92-1	EPA SW846-6020A	Eurofins/TestAmerica	0.000199	0.0008
Manganese	7439-96-5	EPA SW846-6020A	Eurofins/TestAmerica	0.000459	0.002
Nickel	7440-02-0	EPA SW846-6020A	Eurofins/TestAmerica	0.000124	0.003
Selenium	7782-49-2	EPA SW846-6020A	Eurofins/TestAmerica	0.00206	0.008
Silver	7440-22-4	EPA SW846-6020A	Eurofins/TestAmerica	0.000055	0.0004
Thallium	7440-28-0	EPA SW846-6020A	Eurofins/TestAmerica	0.000065	0.001
Vanadium	7440-62-2	EPA SW846-6020A	Eurofins/TestAmerica	0.000456	0.004
Zinc	7440-66-6	EPA SW846-6020A	Eurofins/TestAmerica	0.0019	0.007
Aluminum	7429-90-5	EPA SW846-6020A	Eurofins/TestAmerica	0.0126	0.1
Calcium	7440-70-2	EPA SW846-6010C	Eurofins/TestAmerica	0.155	1.1
Magnesium	7439-95-4	EPA SW846-6010C	Eurofins/TestAmerica	0.133	1.1
Potassium	7440-09-7	EPA SW846-6010C	Eurofins/TestAmerica	0.411	3.3
Sodium	7440-23-5	EPA SW846-6010C	Eurofins/TestAmerica	0.33	2
Mercury	7439-97-6	EPA SW846-7471A	Eurofins/TestAmerica	0.00015	0.0003

Table B-6. Analytes and Reporting Limits for Groundwater and Equipment Blank Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
Polycyclic Aromatic Hydrocarbons (µg/L)					
Naphthalene	91-20-3	EPA SW846-8270D	Eurofins/TestAmerica	0.031	0.1
2-Methylnaphthalene	91-57-6	EPA SW846-8270D	Eurofins/TestAmerica	0.039	0.2
1-Methylnaphthalene	90-12-0	EPA SW846-8270D	Eurofins/TestAmerica	0.019	0.1
Acenaphthylene	208-96-8	EPA SW846-8270D	Eurofins/TestAmerica	0.009	0.05
Acenaphthene	83-32-9	EPA SW846-8270D	Eurofins/TestAmerica	0.014	0.1
Fluorene	86-73-7	EPA SW846-8270D	Eurofins/TestAmerica	0.017	0.1
Phenanthrene	85-01-8	EPA SW846-8270D	Eurofins/TestAmerica	0.031	0.1
Anthracene	120-12-7	EPA SW846-8270D	Eurofins/TestAmerica	0.022	0.1
Fluoranthene	206-44-0	EPA SW846-8270D	Eurofins/TestAmerica	0.05	0.2
Pyrene	129-00-0	EPA SW846-8270D	Eurofins/TestAmerica	0.033	0.1
Benzo[a]anthracene	56-55-3	EPA SW846-8270D	Eurofins/TestAmerica	0.014	0.05
Chrysene	218-01-9	EPA SW846-8270D	Eurofins/TestAmerica	0.016	0.1
Benzo[b]fluoranthene	205-99-2	EPA SW846-8270D	Eurofins/TestAmerica	0.011	0.05
Benzo[k]fluoranthene	207-08-9	EPA SW846-8270D	Eurofins/TestAmerica	0.012	0.05
Benzo[a]pyrene	50-32-8	EPA SW846-8270D	Eurofins/TestAmerica	0.011	0.1
Indeno[1,2,3-cd]pyrene	193-39-5	EPA SW846-8270D	Eurofins/TestAmerica	0.014	0.05
Dibenz(a,h)anthracene	53-70-3	EPA SW846-8270D	Eurofins/TestAmerica	0.026	0.1
Benzo[g,h,i]perylene	191-24-2	EPA SW846-8270D	Eurofins/TestAmerica	0.012	0.05
Volatile Organic Compounds (µg/L)					
1,1,1,2-Tetrachloroethane	630-20-6	EPA SW846-8260C	Eurofins/TestAmerica	0.027	0.3
1,1,1-Trichloroethane	71-55-6	EPA SW846-8260C	Eurofins/TestAmerica	0.025	0.2
1,1,2,2-Tetrachloroethane	79-34-5	EPA SW846-8260C	Eurofins/TestAmerica	0.056	0.2
1,1,2-Trichloroethane	79-00-5	EPA SW846-8260C	Eurofins/TestAmerica	0.07	0.2
1,1-Dichloroethane	75-34-3	EPA SW846-8260C	Eurofins/TestAmerica	0.025	0.2
1,1-Dichloroethene	75-35-4	EPA SW846-8260C	Eurofins/TestAmerica	0.035	0.2
1,1-Dichloropropene	563-58-6	EPA SW846-8260C	Eurofins/TestAmerica	0.036	0.2
1,2,3-Trichlorobenzene	87-61-6	EPA SW846-8260C	Eurofins/TestAmerica	0.149	0.5
1,2,3-Trichloropropane	96-18-4	EPA SW846-8260C	Eurofins/TestAmerica	0.05	0.2
1,2,4-Trichlorobenzene	120-82-1	EPA SW846-8260C	Eurofins/TestAmerica	0.172	0.5
1,2,4-Trimethylbenzene	95-63-6	EPA SW846-8260C	Eurofins/TestAmerica	0.072	0.3
1,2-Dibromo-3-Chloropropane	96-12-8	EPA SW846-8260C	Eurofins/TestAmerica	0.44	2
1,2-Dichlorobenzene	95-50-1	EPA SW846-8260C	Eurofins/TestAmerica	0.024	0.3
1,2-Dichloroethane	107-06-2	EPA SW846-8260C	Eurofins/TestAmerica	0.043	0.2
1,2-Dichloropropane	78-87-5	EPA SW846-8260C	Eurofins/TestAmerica	0.06	0.2

Table B-6. Analytes and Reporting Limits for Groundwater and Equipment Blank Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
1,3,5-Trimethylbenzene	108-67-8	EPA SW846-8260C	Eurofins/TestAmerica	0.152	0.5
1,3-Dichlorobenzene	541-73-1	EPA SW846-8260C	Eurofins/TestAmerica	0.05	0.3
1,3-Dichloropropane	142-28-9	EPA SW846-8260C	Eurofins/TestAmerica	0.025	0.2
1,4-Dichlorobenzene	106-46-7	EPA SW846-8260C	Eurofins/TestAmerica	0.05	0.3
2,2-Dichloropropane	594-20-7	EPA SW846-8260C	Eurofins/TestAmerica	0.06	0.5
2-Chlorotoluene	95-49-8	EPA SW846-8260C	Eurofins/TestAmerica	0.116	0.5
4-Chlorotoluene	106-43-4	EPA SW846-8260C	Eurofins/TestAmerica	0.05	0.3
4-Isopropyltoluene	99-87-6	EPA SW846-8260C	Eurofins/TestAmerica	0.146	0.5
Benzene	71-43-2	EPA SW846-8260C	Eurofins/TestAmerica	0.03	0.2
Bromobenzene	108-86-1	EPA SW846-8260C	Eurofins/TestAmerica	0.035	0.2
Bromoform	75-25-2	EPA SW846-8260C	Eurofins/TestAmerica	0.157	0.5
Bromomethane	74-83-9	EPA SW846-8260C	Eurofins/TestAmerica	0.062	0.5
Carbon tetrachloride	56-23-5	EPA SW846-8260C	Eurofins/TestAmerica	0.025	0.2
Chlorobenzene	108-90-7	EPA SW846-8260C	Eurofins/TestAmerica	0.025	0.2
Chlorobromomethane	74-97-5	EPA SW846-8260C	Eurofins/TestAmerica	0.025	0.2
Chlorodibromomethane	124-48-1	EPA SW846-8260C	Eurofins/TestAmerica	0.055	0.2
Chloroethane	75-00-3	EPA SW846-8260C	Eurofins/TestAmerica	0.096	0.5
Chloroform	67-66-3	EPA SW846-8260C	Eurofins/TestAmerica	0.03	0.2
Chloromethane	74-87-3	EPA SW846-8260C	Eurofins/TestAmerica	0.068	0.5
cis-1,2-Dichloroethene	156-59-2	EPA SW846-8260C	Eurofins/TestAmerica	0.055	0.2
cis-1,3-Dichloropropene	10061-01-5	EPA SW846-8260C	Eurofins/TestAmerica	0.09	0.2
Dibromomethane	74-95-3	EPA SW846-8260C	Eurofins/TestAmerica	0.062	0.2
Dichlorobromomethane	75-27-4	EPA SW846-8260C	Eurofins/TestAmerica	0.06	0.2
Dichlorodifluoromethane	75-71-8	EPA SW846-8260C	Eurofins/TestAmerica	0.128	0.4
Ethylbenzene	100-41-4	EPA SW846-8260C	Eurofins/TestAmerica	0.03	0.2
Ethylene Dibromide	106-93-4	EPA SW846-8260C	Eurofins/TestAmerica	0.025	0.1
Hexachlorobutadiene	87-68-3	EPA SW846-8260C	Eurofins/TestAmerica	0.067	0.5
Isopropylbenzene	98-82-8	EPA SW846-8260C	Eurofins/TestAmerica	0.187	1
Methyl tert-butyl ether	1634-04-4	EPA SW846-8260C	Eurofins/TestAmerica	0.07	0.3
Methylene Chloride	75-09-2	EPA SW846-8260C	Eurofins/TestAmerica	1.2	5
m-Xylene & p-Xylene	179601-23-1	EPA SW846-8260C	Eurofins/TestAmerica	0.115	0.5
Naphthalene	91-20-3	EPA SW846-8260C	Eurofins/TestAmerica	0.221	1
n-Butylbenzene	104-51-8	EPA SW846-8260C	Eurofins/TestAmerica	0.225	1

Table B-6. Analytes and Reporting Limits for Groundwater and Equipment Blank Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
N-Propylbenzene	103-65-1	EPA SW846-8260C	Eurofins/TestAmerica	0.091	0.3
o-Xylene	95-47-6	EPA SW846-8260C	Eurofins/TestAmerica	0.147	0.5
sec-Butylbenzene	135-98-8	EPA SW846-8260C	Eurofins/TestAmerica	0.168	1
Styrene	100-42-5	EPA SW846-8260C	Eurofins/TestAmerica	0.192	1
tert-Butylbenzene	98-06-6	EPA SW846-8260C	Eurofins/TestAmerica	0.257	0.5
Tetrachloroethene	127-18-4	EPA SW846-8260C	Eurofins/TestAmerica	0.084	0.5
Toluene	108-88-3	EPA SW846-8260C	Eurofins/TestAmerica	0.05	0.2
trans-1,2-Dichloroethene	156-60-5	EPA SW846-8260C	Eurofins/TestAmerica	0.033	0.2
trans-1,3-Dichloropropene	10061-02-6	EPA SW846-8260C	Eurofins/TestAmerica	0.092	0.2
Trichloroethene	79-01-6	EPA SW846-8260C	Eurofins/TestAmerica	0.066	0.2
Trichlorofluoromethane	75-69-4	EPA SW846-8260C	Eurofins/TestAmerica	0.043	0.5
Vinyl chloride	75-01-4	EPA SW846-8260C	Eurofins/TestAmerica	0.013	0.02

Table B-6. Analytes and Reporting Limits for Groundwater and Equipment Blank Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
Chlorinated Dioxins and Furans (pg/L)					
2,3,7,8-TCDD	1746-01-6	EPA1613B	Eurofins/TestAmerica	1.4	10
2,3,7,8-TCDF	51207-31-9	EPA1613B	Eurofins/TestAmerica	2.02	10
1,2,3,7,8-PeCDD	40321-76-4	EPA1613B	Eurofins/TestAmerica	1.9	50
1,2,3,7,8-PeCDF	57117-41-6	EPA1613B	Eurofins/TestAmerica	2.24	50
2,3,4,7,8-PeCDF	57117-31-4	EPA1613B	Eurofins/TestAmerica	3	50
1,2,3,4,7,8-HxCDD	39227-28-6	EPA1613B	Eurofins/TestAmerica	4.15	50
1,2,3,6,7,8-HxCDD	57653-85-7	EPA1613B	Eurofins/TestAmerica	5.76	50
1,2,3,7,8,9-HxCDD	19408-74-3	EPA1613B	Eurofins/TestAmerica	3.17	50
1,2,3,4,7,8-HxCDF	70648-26-9	EPA1613B	Eurofins/TestAmerica	2.09	50
1,2,3,6,7,8-HxCDF	57117-44-9	EPA1613B	Eurofins/TestAmerica	3	50
1,2,3,7,8,9-HxCDF	72918-21-9	EPA1613B	Eurofins/TestAmerica	2.12	50
2,3,4,6,7,8-HxCDF	60851-34-5	EPA1613B	Eurofins/TestAmerica	2.06	50
1,2,3,4,6,7,8-HpCDD	35822-46-9	EPA1613B	Eurofins/TestAmerica	9.38	50
1,2,3,4,6,7,8-HpCDF	67562-39-4	EPA1613B	Eurofins/TestAmerica	2.52	50
1,2,3,4,7,8,9-HpCDF	55673-89-7	EPA1613B	Eurofins/TestAmerica	2.49	50
OCDD	3268-87-9	EPA1613B	Eurofins/TestAmerica	45.9	100
OCDF	39001-02-0	EPA1613B	Eurofins/TestAmerica	9.07	100
Total tetrachlorinated dioxins	41903-57-5	EPA1613B	Eurofins/TestAmerica	--	--
Total pentachlorinated dioxins	36088-22-9	EPA1613B	Eurofins/TestAmerica	--	--
Total hexachlorinated dioxins	34465-46-8	EPA1613B	Eurofins/TestAmerica	--	--
Total heptachlorinated dioxins	37871-00-4	EPA1613B	Eurofins/TestAmerica	--	--
Total tetrachlorinated furans	30402-14-3	EPA1613B	Eurofins/TestAmerica	--	--
Total pentachlorinated furans	30402-15-4	EPA1613B	Eurofins/TestAmerica	--	--
Total hexachlorinated furans	55684-94-1	EPA1613B	Eurofins/TestAmerica	--	--
Total heptachlorinated furans	38998-75-3	EPA1613B	Eurofins/TestAmerica	--	--
PCB Congeners (pg/L)					
PCB-1	2051-60-7	EPA 1668C	Eurofns/TestAmerica	4	200
PCB-2	2051-61-8	EPA 1668C	Eurofns/TestAmerica	5.38	200
PCB-3	2051-62-9	EPA 1668C	Eurofns/TestAmerica	2.87	200
PCB-4	13029-08-8	EPA 1668C	Eurofns/TestAmerica	11.9	200
PCB-5	16605-91-7	EPA 1668C	Eurofns/TestAmerica	8.97	200

Table B-6. Analytes and Reporting Limits for Groundwater and Equipment Blank Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-6	25569-80-6	EPA 1668C	Eurofns/TestAmerica	10.2	200
PCB-7	33284-50-3	EPA 1668C	Eurofns/TestAmerica	12.1	200
PCB-8	34883-43-7	EPA 1668C	Eurofns/TestAmerica	10.4	200
PCB-9	34883-39-1	EPA 1668C	Eurofns/TestAmerica	22	200
PCB-10	33146-45-1	EPA 1668C	Eurofns/TestAmerica	17.4	200
PCB-11	2050-67-1	EPA 1668C	Eurofns/TestAmerica	12.3	200
PCB-12/13	STL01797	EPA 1668C	Eurofns/TestAmerica	19.2	400
PCB-14	34883-41-5	EPA 1668C	Eurofns/TestAmerica	10.4	200
PCB-15	2050-68-2	EPA 1668C	Eurofns/TestAmerica	6.37	200
PCB-16	38444-78-9	EPA 1668C	Eurofns/TestAmerica	15.5	200
PCB-17	37680-66-3	EPA 1668C	Eurofns/TestAmerica	3.91	200
PCB-18/30	STL01798	EPA 1668C	Eurofns/TestAmerica	21.1	400
PCB-19	38444-73-4	EPA 1668C	Eurofns/TestAmerica	3.96	200
PCB-20/28	STL01799	EPA 1668C	Eurofns/TestAmerica	15.8	400
PCB-21/33	STL01800	EPA 1668C	Eurofns/TestAmerica	12	400
PCB-22	38444-85-8	EPA 1668C	Eurofns/TestAmerica	4.8	200
PCB-23	55720-44-0	EPA 1668C	Eurofns/TestAmerica	5.85	200
PCB-24	55702-45-9	EPA 1668C	Eurofns/TestAmerica	5.91	200
PCB-25	55712-37-3	EPA 1668C	Eurofns/TestAmerica	7.15	200
PCB-26/29	STL01801	EPA 1668C	Eurofns/TestAmerica	11.6	400
PCB-27	38444-76-7	EPA 1668C	Eurofns/TestAmerica	6.17	200
PCB-31	16606-02-3	EPA 1668C	Eurofns/TestAmerica	8.85	200
PCB-32	38444-77-8	EPA 1668C	Eurofns/TestAmerica	4.75	200
PCB-34	37680-68-5	EPA 1668C	Eurofns/TestAmerica	7.07	200
PCB-35	37680-69-6	EPA 1668C	Eurofns/TestAmerica	3.61	200
PCB-36	38444-87-0	EPA 1668C	Eurofns/TestAmerica	4.54	200
PCB-37	38444-90-5	EPA 1668C	Eurofns/TestAmerica	4.21	200
PCB-38	53555-66-1	EPA 1668C	Eurofns/TestAmerica	6.35	200
PCB-39	38444-88-1	EPA 1668C	Eurofns/TestAmerica	3.66	200
PCB-41	52663-59-9	EPA 1668C	Eurofns/TestAmerica	4.45	200
PCB-40/71	STL01802	EPA 1668C	Eurofns/TestAmerica	8.9	400
PCB-42	36559-22-5	EPA 1668C	Eurofns/TestAmerica	6.09	200
PCB-43	70362-46-8	EPA 1668C	Eurofns/TestAmerica	3.61	200

Table B-6. Analytes and Reporting Limits for Groundwater and Equipment Blank Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-44/47/65	STL01803	EPA 1668C	Eurofns/TestAmerica	24.2	600
PCB-45	70362-45-7	EPA 1668C	Eurofns/TestAmerica	6.84	200
PCB-46	41464-47-5	EPA 1668C	Eurofns/TestAmerica	5.62	200
PCB-48	70362-47-9	EPA 1668C	Eurofns/TestAmerica	6.91	200
PCB-49/69	STL01805	EPA 1668C	Eurofns/TestAmerica	13.5	400
PCB-50/53	STL01806	EPA 1668C	Eurofns/TestAmerica	11.6	400
PCB-51	68194-04-7	EPA 1668C	Eurofns/TestAmerica	6.84	200
PCB-52	35693-99-3	EPA 1668C	Eurofns/TestAmerica	7.22	200
PCB-54	15968-05-5	EPA 1668C	Eurofns/TestAmerica	4	200
PCB-55	74338-24-2	EPA 1668C	Eurofns/TestAmerica	4.92	200
PCB-56	41464-43-1	EPA 1668C	Eurofns/TestAmerica	6.93	200
PCB-57	70424-67-8	EPA 1668C	Eurofns/TestAmerica	5.2	200
PCB-58	41464-49-7	EPA 1668C	Eurofns/TestAmerica	6.46	200
PCB-59/62/75	STL01807	EPA 1668C	Eurofns/TestAmerica	18	600
PCB-60	33025-41-1	EPA 1668C	Eurofns/TestAmerica	6.19	200
PCB-61/70/74/76	STL01808	EPA 1668C	Eurofns/TestAmerica	20.5	800
PCB-63	74472-34-7	EPA 1668C	Eurofns/TestAmerica	5.83	200
PCB-64	52663-58-8	EPA 1668C	Eurofns/TestAmerica	5.56	200
PCB-66	32598-10-0	EPA 1668C	Eurofns/TestAmerica	5.11	200
PCB-67	73575-53-8	EPA 1668C	Eurofns/TestAmerica	5.92	200
PCB-68	73575-52-7	EPA 1668C	Eurofns/TestAmerica	6.64	200
PCB-72	41464-42-0	EPA 1668C	Eurofns/TestAmerica	6.37	200
PCB-73	74338-23-1	EPA 1668C	Eurofns/TestAmerica	9.75	200
PCB-77	32598-13-3	EPA 1668C	Eurofns/TestAmerica	3.96	20
PCB-78	70362-49-1	EPA 1668C	Eurofns/TestAmerica	2.92	200
PCB-79	41464-48-6	EPA 1668C	Eurofns/TestAmerica	5.05	200
PCB-80	33284-52-5	EPA 1668C	Eurofns/TestAmerica	4.4	200
PCB-81	70362-50-4	EPA 1668C	Eurofns/TestAmerica	4	20
PCB-82	52663-62-4	EPA 1668C	Eurofns/TestAmerica	3.91	200
PCB-83	60145-20-2	EPA 1668C	Eurofns/TestAmerica	8.49	200
PCB-84	52663-60-2	EPA 1668C	Eurofns/TestAmerica	6.64	200
PCB-85/116/117	STL01810	EPA 1668C	Eurofns/TestAmerica	22.3	600
PCB-86/87/97/108/119/125	STL01811	EPA 1668C	Eurofns/TestAmerica	23.6	1200

Table B-6. Analytes and Reporting Limits for Groundwater and Equipment Blank Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-88/91	STL01812	EPA 1668C	Eurofns/TestAmerica	8.51	400
PCB-89	73575-57-2	EPA 1668C	Eurofns/TestAmerica	4.19	200
PCB-90/101/113	STL01813	EPA 1668C	Eurofns/TestAmerica	14.6	600
PCB-92	52663-61-3	EPA 1668C	Eurofns/TestAmerica	4.24	200
PCB-93/100	STL01814	EPA 1668C	Eurofns/TestAmerica	10.5	400
PCB-94	73575-55-0	EPA 1668C	Eurofns/TestAmerica	5.82	200
PCB-95	38379-99-6	EPA 1668C	Eurofns/TestAmerica	5.86	200
PCB-96	73575-54-9	EPA 1668C	Eurofns/TestAmerica	6.15	200
PCB-98/102	STL01843	EPA 1668C	Eurofns/TestAmerica	10.5	400
PCB-99	38380-01-7	EPA 1668C	Eurofns/TestAmerica	8.49	200
PCB-103	60145-21-3	EPA 1668C	Eurofns/TestAmerica	5.3	200
PCB-104	56558-16-8	EPA 1668C	Eurofns/TestAmerica	4.67	200
PCB-105	32598-14-4	EPA 1668C	Eurofns/TestAmerica	6.65	20
PCB-106	70424-69-0	EPA 1668C	Eurofns/TestAmerica	6.72	200
PCB-107/124	STL01815	EPA 1668C	Eurofns/TestAmerica	9.86	400
PCB-109	74472-35-8	EPA 1668C	Eurofns/TestAmerica	3.99	200
PCB-110/115	STL01826	EPA 1668C	Eurofns/TestAmerica	5.8	400
PCB-111	39635-32-0	EPA 1668C	Eurofns/TestAmerica	5.4	200
PCB-112	74472-36-9	EPA 1668C	Eurofns/TestAmerica	3.62	200
PCB-114	74472-37-0	EPA 1668C	Eurofns/TestAmerica	3.62	20
PCB-118	31508-00-6	EPA 1668C	Eurofns/TestAmerica	3.64	20
PCB-120	68194-12-7	EPA 1668C	Eurofns/TestAmerica	4.46	200
PCB-121	56558-18-0	EPA 1668C	Eurofns/TestAmerica	5.14	200
PCB-122	76842-07-4	EPA 1668C	Eurofns/TestAmerica	3.98	200
PCB-123	65510-44-3	EPA 1668C	Eurofns/TestAmerica	3.84	20
PCB-126	57465-28-8	EPA 1668C	Eurofns/TestAmerica	4.49	20
PCB-127	39635-33-1	EPA 1668C	Eurofns/TestAmerica	6.19	200
PCB-128/166	STL01816	EPA 1668C	Eurofns/TestAmerica	9.66	400
PCB-129/138/163	STL01817	EPA 1668C	Eurofns/TestAmerica	17.7	600
PCB-130	52663-66-8	EPA 1668C	Eurofns/TestAmerica	3.86	200
PCB-131	61798-70-7	EPA 1668C	Eurofns/TestAmerica	6.01	200
PCB-132	38380-05-1	EPA 1668C	Eurofns/TestAmerica	6.29	200
PCB-133	35694-04-3	EPA 1668C	Eurofns/TestAmerica	4.52	200

Table B-6. Analytes and Reporting Limits for Groundwater and Equipment Blank Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-134/143	STL01818	EPA 1668C	Eurofns/TestAmerica	11.3	400
PCB-135/151	STL01819	EPA 1668C	Eurofns/TestAmerica	11.8	400
PCB-136	38411-22-2	EPA 1668C	Eurofns/TestAmerica	5.12	200
PCB-137	35694-06-5	EPA 1668C	Eurofns/TestAmerica	7.71	200
PCB-139/140	STL01820	EPA 1668C	Eurofns/TestAmerica	10.4	400
PCB-141	52712-04-6	EPA 1668C	Eurofns/TestAmerica	5.01	200
PCB-142	41411-61-4	EPA 1668C	Eurofns/TestAmerica	4.65	200
PCB-144	68194-14-9	EPA 1668C	Eurofns/TestAmerica	4.61	200
PCB-145	74472-40-5	EPA 1668C	Eurofns/TestAmerica	5.2	200
PCB-146	51908-16-8	EPA 1668C	Eurofns/TestAmerica	6.76	200
PCB-147/149	STL01821	EPA 1668C	Eurofns/TestAmerica	13.2	400
PCB-148	74472-41-6	EPA 1668C	Eurofns/TestAmerica	3.8	200
PCB-150	68194-08-1	EPA 1668C	Eurofns/TestAmerica	5.61	200
PCB-152	68194-09-2	EPA 1668C	Eurofns/TestAmerica	5.22	200
PCB-153/168	STL01822	EPA 1668C	Eurofns/TestAmerica	10.9	400
PCB-154	60145-22-4	EPA 1668C	Eurofns/TestAmerica	4.86	200
PCB-155	33979-03-2	EPA 1668C	Eurofns/TestAmerica	3.95	200
PCB-156/157	STL01792	EPA 1668C	Eurofns/TestAmerica	6.65	40
PCB-158	74472-42-7	EPA 1668C	Eurofns/TestAmerica	6	200
PCB-159	39635-35-3	EPA 1668C	Eurofns/TestAmerica	4.84	200
PCB-160	41411-62-5	EPA 1668C	Eurofns/TestAmerica	5.65	200
PCB-161	74472-43-8	EPA 1668C	Eurofns/TestAmerica	3.62	200
PCB-162	39635-34-2	EPA 1668C	Eurofns/TestAmerica	5.67	200
PCB-164	74472-45-0	EPA 1668C	Eurofns/TestAmerica	7.49	200
PCB-165	74472-46-1	EPA 1668C	Eurofns/TestAmerica	4.57	200
PCB-167	52663-72-6	EPA 1668C	Eurofns/TestAmerica	3.31	20
PCB-169	32774-16-6	EPA 1668C	Eurofns/TestAmerica	4.84	20
PCB-170	35065-30-6	EPA 1668C	Eurofns/TestAmerica	6.45	200
PCB-171/173	STL01823	EPA 1668C	Eurofns/TestAmerica	10.3	400
PCB-172	52663-74-8	EPA 1668C	Eurofns/TestAmerica	4.87	200
PCB-174	38411-25-5	EPA 1668C	Eurofns/TestAmerica	5.38	200
PCB-175	40186-70-7	EPA 1668C	Eurofns/TestAmerica	5.41	200
PCB-176	52663-65-7	EPA 1668C	Eurofns/TestAmerica	5.14	200

Table B-6. Analytes and Reporting Limits for Groundwater and Equipment Blank Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
PCB-177	52663-70-4	EPA 1668C	Eurofns/TestAmerica	7.16	200
PCB-178	52663-67-9	EPA 1668C	Eurofns/TestAmerica	4.86	200
PCB-179	52663-64-6	EPA 1668C	Eurofns/TestAmerica	7.31	200
PCB-180/193	STL01824	EPA 1668C	Eurofns/TestAmerica	15.3	400
PCB-181	74472-47-2	EPA 1668C	Eurofns/TestAmerica	4.32	200
PCB-182	60145-23-5	EPA 1668C	Eurofns/TestAmerica	5.17	200
PCB-183	52663-69-1	EPA 1668C	Eurofns/TestAmerica	6.73	200
PCB-184	74472-48-3	EPA 1668C	Eurofns/TestAmerica	5.5	200
PCB-185	52712-05-7	EPA 1668C	Eurofns/TestAmerica	9.81	200
PCB-186	74472-49-4	EPA 1668C	Eurofns/TestAmerica	5.28	200
PCB-187	52663-68-0	EPA 1668C	Eurofns/TestAmerica	7	200
PCB-188	74487-85-7	EPA 1668C	Eurofns/TestAmerica	4.42	200
PCB-189	39635-31-9	EPA 1668C	Eurofns/TestAmerica	4.25	20
PCB-190	41411-64-7	EPA 1668C	Eurofns/TestAmerica	5.87	200
PCB-191	74472-50-7	EPA 1668C	Eurofns/TestAmerica	7.41	200
PCB-192	74472-51-8	EPA 1668C	Eurofns/TestAmerica	6.69	200
PCB-194	35694-08-7	EPA 1668C	Eurofns/TestAmerica	6.17	200
PCB-195	52663-78-2	EPA 1668C	Eurofns/TestAmerica	7.11	200
PCB-196	42740-50-1	EPA 1668C	Eurofns/TestAmerica	5.47	200
PCB-197	33091-17-7	EPA 1668C	Eurofns/TestAmerica	5.9	200
PCB-198/199	STL01825	EPA 1668C	Eurofns/TestAmerica	9.91	400
PCB-200	52663-73-7	EPA 1668C	Eurofns/TestAmerica	5.89	200
PCB-201	40186-71-8	EPA 1668C	Eurofns/TestAmerica	6.23	200
PCB-202	2136-99-4	EPA 1668C	Eurofns/TestAmerica	4.97	200
PCB-203	52663-76-0	EPA 1668C	Eurofns/TestAmerica	5.97	200
PCB-204	74472-52-9	EPA 1668C	Eurofns/TestAmerica	6.19	200
PCB-205	74472-53-0	EPA 1668C	Eurofns/TestAmerica	5.21	200
PCB-206	40186-72-9	EPA 1668C	Eurofns/TestAmerica	4.04	200
PCB-207	52663-79-3	EPA 1668C	Eurofns/TestAmerica	4.78	200
PCB-208	52663-77-1	EPA 1668C	Eurofns/TestAmerica	3.52	200
PCB-209	2051-24-3	EPA 1668C	Eurofns/TestAmerica	7.23	200

Table B-6. Analytes and Reporting Limits for Groundwater and Equipment Blank Samples

Analyte	CAS Number	Analytical Method	Laboratory	MDL	LOQ
Radiochemistry (pCi/L)					
Cesium-137	--	TBE-2007	Teledyne	NA	0.1
Lead-210	--	TBE-2015	Teledyne	NA	0.1
NWTPH (mg/L)					
Diesel Range Organics	-	NWTPH-Dx	Eurofins/TestAmerica	0.065	0.11
Motor Oil Range Organics	-	NWTPH-Dx	Eurofins/TestAmerica	0.096	0.35
Gasoline Range Organics	-	NWTPH-Gx	Eurofins/TestAmerica	0.1	0.25

Notes:

MDLs are updated periodically by the laboratories. MDLs that are in effect at the laboratory at the time of analysis will be used. These may differ slightly from the MDLs shown in this table.

APHA SM = American Public Health Association Standard Methods
CAS = Chemical Abstract Services
EPA = U.S. Environmental Protection Agency
LOQ = limit of quantitation
MDL = method detection limit
MRL = method reporting limit
NA = not applicable
NWTPH = Northwest Total Petroleum Hydrocarbon
PCB = polychlorinated biphenyl
RCRA = Resource Conservation and Recovery Act

Table B-7. Laboratory Control Limits for Surrogate Recoveries in Sediment and Soil Samples

Analyte	Control Limits for Percent Recovery
Eurofins/TestAmerica	
Volatile Organic Compounds	
1,2-Dichloroethane-d_4	80-121
4-Bromofluorobenzene	80-120
Dibromofluoromethane	80-120
Toluene-d_8	80-120
Trifluorotoluene	80-120
NWTPH-Dx	
o-Terphenyl	50-150
NWTPH-Gx	
4-Bromofluorobenzene	50-150
Trifluorotoluene	50-150
Organochlorine Pesticides	
Tetrachloro-m-xylene	50-123
Decachlorobiphenyl	36-136
Polycyclic Aromatic Hydrocarbons	
p-Terphenyl-d_{14}	57-120
Chlorinate Herbicides	
2,4-Dichlorophenylacetic acid	39-150
PCB Congeners	
PCB-1L	5-145
PCB-3L	5-145
PCB-4L	5-145
PCB-15L	5-145
PCB-19L	5-145
PCB-37L	5-145
PCB-54L	5-145
PCB-77L	10-145
PCB-81L	10-145
PCB-104L	10-145
PCB-105L	10-145
PCB-114L	10-145
PCB-118L	10-145
PCB-123L	10-145
PCB-126L	10-145
PCB-155L	10-145
PCB-156L/157L	10-145
PCB-167L	10-145
PCB-169L	10-145
PCB-188L	10-145
PCB-189L	10-145
PCB-202L	10-145
PCB-205L	10-145

Table B-7. Laboratory Control Limits for Surrogate Recoveries in Sediment and Soil Samples

Analyte	Control Limits for Percent Recovery
PCB-206L	10-145
PCB-208L	10-145
PCB-209L	10-145
PCB-28L	5-145
PCB-111L	10-145
PCB-178L	10-145
Polychlorinated Dioxins and Furans	
13C-2,3,7,8-TCDD	25-164
13C-2,3,7,8-TCDF	24-169
13C-1,2,3,7,8-PeCDD	25-181
13C-1,2,3,7,8-PeCDF	24-185
13C-2,3,4,7,8-PeCDF	21-178
13C-1,2,3,4,7,8-HxCDD	32-141
13C-1,2,3,6,7,8-HxCDD	28-130
13C-1,2,3,4,7,8-HxCDF	26-152
13C-1,2,3,6,7,8-HxCDF	26-123
13C-2,3,4,6,7,8-HxCDF	28-136
13C-1,2,3,7,8,9-HxCDF	29-147
13C-1,2,3,4,6,7,8-HpCDD	23-140
13C-1,2,3,4,6,7,8-HpCDF	28-143
13C-1,2,3,4,7,8,9-HpCDF	26-138
13C-OCDD	17-157
37Cl4-2,3,7,8-TCDD	35-197

Notes:

Control limits are updated periodically by the laboratories. Control limits that are in effect at the laboratory at the time of analysis will be used for sample analysis and data validation. These may differ slightly from the control limits shown in this table.

PCB = polychlorinated biphenyl

Table B-8. Laboratory Control Limits for Surrogate Recoveries in Groundwater and Equipment Blank Samples

Analyte	Control Limits for Percent Recovery
Eurofins/TestAmerica	
Volatile Organic Compounds	
Toluene-d_8	80-120
Trifluorotoluene	80-120
Dibromofluoromethane	80-120
4-Bromofluorobenzene	80-120
1,2-Dichloroethane-d_4	80-120
NWTPH-Dx	
o-Terphenyl	50-150
NWTPH-Gx	
4-Bromofluorobenzene	50-150
Trifluorotoluene	50-150
Polycyclic Aromatic Hydrocarbons	
p-Terphenyl-d_{14}	53-120
Chlorinate Herbicides	
2,4-Dichlorophenylacetic acid	44-145
Organochlorine Pesticides	
Tetrachloro-m-xylene	33-120
Decachlorobiphenyl	45-127
PCB Congeners	
PCB-1L	5-145
PCB-3L	5-145
PCB-4L	5-145
PCB-15L	5-145
PCB-19L	5-145
PCB-37L	5-145
PCB-54L	5-145
PCB-77L	10-145
PCB-81L	10-145
PCB-104L	10-145
PCB-105L	10-145
PCB-114L	10-145
PCB-118L	10-145
PCB-123L	10-145
PCB-126L	10-145
PCB-155L	10-145
PCB-156L/157L	10-145
PCB-167L	10-145
PCB-169L	10-145
PCB-188L	10-145
PCB-189L	10-145
PCB-202L	10-145
PCB-205L	10-145

Table B-8. Laboratory Control Limits for Surrogate Recoveries in Groundwater and Equipment Blank Samples

Analyte	Control Limits for Percent Recovery
PCB-206L	10-145
PCB-208L	10-145
PCB-209L	10-145
PCB-28L	5-145
PCB-111L	10-145
PCB-178L	10-145
Polychlorinated Dioxins and Furans	
13C-2,3,7,8-TCDD	25-164
13C-2,3,7,8-TCDF	24-169
13C-1,2,3,7,8-PeCDD	25-181
13C-1,2,3,7,8-PeCDF	24-185
13C-2,3,4,7,8-PeCDF	21-178
13C-1,2,3,4,7,8-HxCDD	32-141
13C-1,2,3,6,7,8-HxCDD	28-130
13C-1,2,3,4,7,8-HxCDF	26-152
13C-1,2,3,6,7,8-HxCDF	26-123
13C-2,3,4,6,7,8-HxCDF	28-136
13C-1,2,3,7,8,9-HxCDF	29-147
13C-1,2,3,4,6,7,8-HpCDD	23-140
13C-1,2,3,4,6,7,8-HpCDF	28-143
13C-1,2,3,4,7,8,9-HpCDF	26-138
13C-OCDD	17-157
37Cl4-2,3,7,8-TCDD	35-197

Notes:

Control limits are updated periodically by the laboratories. Control limits that are in effect at the laboratory at the time of analysis will be used for sample analysis and data validation. These may differ slightly from the control limits shown in this table.

PCB = polychlorinated biphenyl

Table B-9. Laboratory Control Limits for Matrix Spike and Laboratory Control Samples for Sediment and Soil Samples

	Accuracy		Precision	
Analyte	Matrix Spike Recovery (percent)	LCS Recovery (percent)	Type of Duplicate	Control Limit RPD
Eurofins/TestAmerica				
Conventionals				
Dissolved organic carbon (porewater)	85-115	85-115	MSD	20
Metals				
Aluminum	80-120	80-120	MSD	20
Antimony	80-120	80-120	MSD	20
Arsenic	80-120	80-120	MSD	20
Barium	80-120	80-120	MSD	20
Beryllium	80-120	80-120	MSD	20
Cadmium	80-120	80-120	MSD	20
Chromium	80-120	80-120	MSD	20
Cobalt	80-120	80-120	MSD	20
Copper	80-120	80-120	MSD	20
Iron	80-120	80-120	MSD	20
Lead	80-120	80-120	MSD	20
Manganese	80-120	80-120	MSD	20
Nickel	80-120	80-120	MSD	20
Selenium	80-120	80-120	MSD	20
Silver	80-120	80-120	MSD	20
Thallium	80-120	80-120	MSD	20
Vanadium	80-120	80-120	MSD	20
Zinc	80-120	80-120	MSD	20
Calcium	80-120	80-120	MSD	20
Magnesium	80-120	80-120	MSD	20
Potassium	80-120	80-120	MSD	20
Sodium	80-120	80-120	MSD	20
Mercury	80-120	80-120	MSD	20
Radiochemistry				
Cesium-137	60-140	80-120	MSD	50
Lead-210	60-140	80-120	MSD	50
VOC				
1,1,1,2-Tetrachloroethane	79-128	79-128	MSD	17
1,1,1-Trichloroethane	69-150	69-150	MSD	14
1,1,2,2-Tetrachloroethane	66-127	66-127	MSD	18
1,1,2-Trichloroethane	80-123	80-123	MSD	20
1,1-Dichloroethane	70-135	70-135	MSD	21
1,1-Dichloroethene	58-150	58-150	MSD	29
1,1-Dichloropropene	69-150	69-150	MSD	11
1,2,3-Trichlorobenzene	62-136	62-136	MSD	34
1,2,3-Trichloropropane	70-127	70-127	MSD	16
1,2,4-Trichlorobenzene	68-131	68-131	MSD	29
1,2,4-Trimethylbenzene	73-127	73-127	MSD	20
1,2-Dibromo-3-Chloropropane	62-135	62-135	MSD	25
1,2-Dibromoethane	77-123	77-123	MSD	20
1,2-Dichlorobenzene	78-126	78-126	MSD	21
1,2-Dichloroethane	68-132	68-132	MSD	17
1,2-Dichloropropane	65-136	65-136	MSD	13
1,3,5-Trimethylbenzene	72-136	72-136	MSD	21

Table B-9. Laboratory Control Limits for Matrix Spike and Laboratory Control Samples for Sediment and Soil Samples

	Accuracy		Precision	
Analyte	Matrix Spike Recovery (percent)	LCS Recovery (percent)	Type of Duplicate	Control Limit RPD
1,3-Dichlorobenzene	78-122	78-122	MSD	20
1,3-Dichloropropane	75-120	75-120	MSD	18
1,4-Dichlorobenzene	77-123	77-123	MSD	20
2,2-Dichloropropane	62-150	62-150	MSD	20
2-Chlorotoluene	77-127	77-127	MSD	16
4-Chlorotoluene	78-126	78-126	MSD	16
4-Isopropyltoluene	71-142	71-142	MSD	23
Benzene	72-135	72-135	MSD	15
Bromobenzene	78-126	78-126	MSD	19
Bromochloromethane	76-131	76-131	MSD	15
Bromodichloromethane	73-125	73-125	MSD	15
Bromoform	71-129	71-129	MSD	17
Bromomethane	42-150	42-150	MSD	22
Carbon tetrachloride	66-150	66-150	MSD	12
Chlorobenzene	80-123	80-123	MSD	18
Chloroethane	31-150	31-150	MSD	31
Chloroform	74-133	74-133	MSD	13
Chloromethane	43-150	43-150	MSD	26
cis-1,2-Dichloroethene	68-143	68-143	MSD	20
cis-1,3-Dichloropropene	80-122	80-122	MSD	16
Dibromochloromethane	75-125	75-125	MSD	18
Dibromomethane	72-130	72-130	MSD	14
Dichlorodifluoromethane	10-150	10-150	MSD	40
Ethylbenzene	80-135	80-135	MSD	16
Hexachlorobutadiene	65-150	65-150	MSD	36
Isopropylbenzene	74-140	74-140	MSD	17
Methyl tert-butyl ether	68-132	68-132	MSD	25
Methylene Chloride	54-149	54-149	MSD	30
m-Xylene & p-Xylene	80-132	80-132	MSD	20
Naphthalene	49-147	49-147	MSD	35
n-Butylbenzene	69-143	69-143	MSD	26
N-Propylbenzene	74-143	74-143	MSD	21
o-Xylene	80-125	80-125	MSD	14
sec-Butylbenzene	77-143	77-143	MSD	24
Styrene	79-129	79-129	MSD	15
t-Butylbenzene	72-144	72-144	MSD	24
Tetrachloroethene	71-145	71-145	MSD	16
Toluene	75-137	75-137	MSD	20
trans-1,2-Dichloroethene	61-150	61-150	MSD	22
trans-1,3-Dichloropropene	80-121	80-121	MSD	21
Trichloroethene	69-144	69-144	MSD	21
Trichlorofluoromethane	48-150	48-150	MSD	40
Vinyl chloride	13-150	13-150	MSD	40
Chlorinated Herbicides				
2,4,5-T	34-150	34-150	MSD	40
2,4-D	30-150	30-150	MSD	40
2,4-DB	20-150	20-150	MSD	40
4-Nitrophenol	10-150	10-150	MSD	40
Dicamba	36-144	36-144	MSD	40

Table B-9. Laboratory Control Limits for Matrix Spike and Laboratory Control Samples for Sediment and Soil Samples

	Accuracy		Precision	
Analyte	Matrix Spike Recovery (percent)	LCS Recovery (percent)	Type of Duplicate	Control Limit RPD
Dichlorprop	32-150	32-150	MSD	40
Dinoseb	10-150	10-150	MSD	40
MCPA	26-150	26-150	MSD	40
Mecoprop	25-150	25-150	MSD	40
Pentachlorophenol	24-150	24-150	MSD	40
Silvex (2,4,5-TP)	31-150	31-150	MSD	40
NWTPH-Dx				
Diesel Range Organics	70-125	70-125	MSD	16
Motor Oil Range Organics	70-129	70-129	MSD	16
NWTPH-Gx				
Gasoline Range Organics	80-120	80-120	MSD	10
Organochlorine Pesticides				
2,4'-DDD	50-150	50-150	MSD	40
2,4'-DDE	50-150	50-150	MSD	40
2,4'-DDT	50-150	50-150	MSD	40
4,4'-DDD	61-132	61-132	MSD	18
4,4'-DDE	53-124	53-124	MSD	18
4,4'-DDT	43-150	43-150	MSD	15
Aldrin	56-121	56-121	MSD	12
alpha-BHC	62-120	62-120	MSD	15
cis-Chlordane	62-125	62-125	MSD	13
beta-BHC	42-138	42-138	MSD	19
delta-BHC	60-124	60-124	MSD	18
Dieldrin	55-121	55-121	MSD	12
Endosulfan I	57-121	57-121	MSD	20
Endosulfan II	47-125	47-125	MSD	18
Endosulfan sulfate	50-125	50-125	MSD	13
Endrin	56-150	56-150	MSD	13
Endrin aldehyde	30-136	30-136	MSD	36
Endrin ketone	56-128	56-128	MSD	18
gamma-BHC (Lindane)	55-120	55-120	MSD	12
trans-Chlordane	60-120	60-120	MSD	13
Heptachlor	64-124	64-124	MSD	17
Heptachlor epoxide	52-120	52-120	MSD	20
Methoxychlor	42-150	42-150	MSD	14
Toxaphene	57-136	57-136	MSD	24
Polycyclic Aromatic Hydrocarbons				
Naphthalene	70-120	70-120	MSD	12
2-Methylnaphthalene	68-120	68-120	MSD	12
1-Methylnaphthalene	71-120	71-120	MSD	21
Acenaphthylene	68-120	68-120	MSD	22
Acenaphthene	68-120	68-120	MSD	12
Fluorene	73-120	73-120	MSD	13
Phenanthrene	66-120	66-120	MSD	11
Anthracene	73-125	73-125	MSD	12
Fluoranthene	74-125	74-125	MSD	19
Pyrene	70-120	70-120	MSD	12

Table B-9. Laboratory Control Limits for Matrix Spike and Laboratory Control Samples for Sediment and Soil Samples

	Accuracy		Precision	
Analyte	Matrix Spike Recovery (percent)	LCS Recovery (percent)	Type of Duplicate	Control Limit RPD
Benzo[a]anthracene	66-120	66-120	MSD	14
Chrysene	63-120	63-120	MSD	10
Benzo[b]fluoranthene	63-132	63-132	MSD	25
Benzo[k]fluoranthene	63-131	63-131	MSD	15
Benzo[a]pyrene	72-124	72-124	MSD	19
Indeno[1,2,3-cd]pyrene	65-132	65-132	MSD	15
Dibenz(a,h)anthracene	70-133	70-133	MSD	13
Benzo[g,h,i]perylene	63-128	63-128	MSD	14
PCB Congeners				
PCB-1	60-135	60-135	MSD	50
PCB-3	60-135	60-135	MSD	50
PCB-4	60-135	60-135	MSD	50
PCB-15	60-135	60-135	MSD	50
PCB-19	60-135	60-135	MSD	50
PCB-37	60-135	60-135	MSD	50
PCB-54	60-135	60-135	MSD	50
PCB-77	60-135	60-135	MSD	50
PCB-81	60-135	60-135	MSD	50
PCB-104	60-135	60-135	MSD	50
PCB-105	60-135	60-135	MSD	50
PCB-114	60-135	60-135	MSD	50
PCB-118	60-135	60-135	MSD	50
PCB-123	60-135	60-135	MSD	50
PCB-126	60-135	60-135	MSD	50
PCB-155	60-135	60-135	MSD	50
PCB-156/157	60-135	60-135	MSD	50
PCB-167	60-135	60-135	MSD	50
PCB-169	60-135	60-135	MSD	50
PCB-188	60-135	60-135	MSD	50
PCB-189	60-135	60-135	MSD	50
PCB-202	60-135	60-135	MSD	50
PCB-205	60-135	60-135	MSD	50
PCB-206	60-135	60-135	MSD	50
PCB-208	60-135	60-135	MSD	50
PCB-209	60-135	60-135	MSD	50
Polychlorinated Dioxins and Furans				
2,3,7,8-TCDD	67-158	67-158	MSD	50
2,3,7,8-TCDF	75-158	75-158	MSD	50
1,2,3,7,8-PeCDD	70-142	70-142	MSD	50
1,2,3,7,8-PeCDF	80-134	80-134	MSD	50
2,3,4,7,8-PeCDF	68-160	68-160	MSD	50
1,2,3,4,7,8-HxCDD	70-164	70-164	MSD	50
1,2,3,6,7,8-HxCDD	76-134	76-134	MSD	50
1,2,3,7,8,9-HxCDD	64-162	64-162	MSD	50
1,2,3,4,7,8-HxCDF	72-134	72-134	MSD	50
1,2,3,6,7,8-HxCDF	84-130	84-130	MSD	50
1,2,3,7,8,9-HxCDF	78-130	78-130	MSD	50
2,3,4,6,7,8-HxCDF	70-156	70-156	MSD	50
1,2,3,4,6,7,8-HpCDD	70-140	70-140	MSD	50

Table B-9. Laboratory Control Limits for Matrix Spike and Laboratory Control Samples for Sediment and Soil Samples

	Accuracy		Precision	
Analyte	Matrix Spike Recovery (percent)	LCS Recovery (percent)	Type of Duplicate	Control Limit RPD
1,2,3,4,6,7,8-HpCDF	82-122	82-122	MSD	50
1,2,3,4,7,8,9-HpCDF	78-138	78-138	MSD	50
OCDD	78-144	78-144	MSD	50
OCDF	63-170	63-170	MSD	50

Notes:

Control limits are updated periodically by the laboratories. Control limits that are in effect at the laboratory at the time of analysis will be used for sample analysis and data validation. These may differ slightly from the control limits shown in this table.

LCS = laboratory control sample
MSD = matrix spike duplicate
NA = not applicable
PCB = polychlorinated biphenyl
RPD = relative percent difference
VOC = volatile organic compound

Table B-10. Laboratory Control Limits for Matrix Spike and Laboratory Control Samples for Groundwater and Equipment Blank Samples

	Accuracy		Precision	
Analyte	Matrix Spike Recovery (percent)	LCS Recovery (percent)	Type of Duplicate	Limit RPD
Eurofins/TestAmerica				
Metals				
Aluminum	80-120	80-120	MSD	20
Antimony	80-120	80-120	MSD	20
Arsenic	80-120	80-120	MSD	20
Barium	80-120	80-120	MSD	20
Beryllium	80-120	80-120	MSD	20
Cadmium	80-120	80-120	MSD	20
Chromium	80-120	80-120	MSD	20
Cobalt	80-120	80-120	MSD	20
Copper	80-120	80-120	MSD	20
Iron	80-120	80-120	MSD	20
Lead	80-120	80-120	MSD	20
Manganese	80-120	80-120	MSD	20
Nickel	80-120	80-120	MSD	20
Selenium	80-120	80-120	MSD	20
Silver	80-120	80-120	MSD	20
Thallium	80-120	80-120	MSD	20
Vanadium	80-120	80-120	MSD	20
Zinc	80-120	80-120	MSD	20
Calcium	80-120	80-120	MSD	20
Magnesium	80-120	80-120	MSD	20
Potassium	80-120	80-120	MSD	20
Sodium	80-120	80-120	MSD	20
Mercury	80-120	80-120	MSD	20
Radiochemistry				
Cesium-137	60-140	80-120	MSD	30
Lead-210	60-140	80-120	MSD	30
VOC				
Dichlorodifluoromethane	20-137	20-137	MSD	22
Chloromethane	32-143	32-143	MSD	23
Vinyl chloride	52-128	52-128	MSD	21
Bromomethane	68-120	68-120	MSD	18
Chloroethane	49-135	49-135	MSD	27
Trichlorofluoromethane	60-132	60-132	MSD	20
1,1-Dichloroethene	71-126	71-126	MSD	17
Methylene Chloride	75-134	75-134	MSD	18
Methyl tert-butyl ether	60-150	60-150	MSD	25
trans-1,2-Dichloroethene	63-133	63-133	MSD	17
1,1-Dichloroethane	74-135	74-135	MSD	20
2,2-Dichloropropane	58-150	58-150	MSD	28
cis-1,2-Dichloroethene	72-130	72-130	MSD	20
Chlorobromomethane	79-131	79-131	MSD	20
Chloroform	80-130	80-130	MSD	20

Table B-10. Laboratory Control Limits for Matrix Spike and Laboratory Control Samples for Groundwater and Equipment Blank Samples

	Accuracy		Precision	
Analyte	Matrix Spike Recovery (percent)	LCS Recovery (percent)	Type of Duplicate	Limit RPD
1,1,1-Trichloroethane	74-128	74-128	MSD	14
Carbon tetrachloride	71-132	71-132	MSD	15
1,1-Dichloropropene	72-132	72-132	MSD	13
Benzene	73-133	73-133	MSD	20
1,2-Dichloroethane	74-130	74-130	MSD	15
Trichloroethene	72-136	72-136	MSD	14
1,2-Dichloropropane	80-130	80-130	MSD	14
Dibromomethane	65-141	65-141	MSD	20
Dichlorobromomethane	74-131	74-131	MSD	20
cis-1,3-Dichloropropene	66-141	66-141	MSD	22
Toluene	80-126	80-126	MSD	20
trans-1,3-Dichloropropene	71-128	71-128	MSD	21
1,1,2-Trichloroethane	80-127	80-127	MSD	19
Tetrachloroethene	75-131	75-131	MSD	20
1,3-Dichloropropane	80-130	80-130	MSD	19
Chlorodibromomethane	76-131	76-131	MSD	20
Ethylene Dibromide	80-126	80-126	MSD	20
Chlorobenzene	80-123	80-123	MSD	12
1,1,1,2-Tetrachloroethane	79-127	79-127	MSD	20
Ethylbenzene	80-130	80-130	MSD	20
m-Xylene & p-Xylene	78-130	78-130	MSD	20
o-Xylene	80-139	80-139	MSD	20
Styrene	74-136	74-136	MSD	20
Bromoform	69-137	69-137	MSD	20
Isopropylbenzene	75-137	75-137	MSD	20
Bromobenzene	80-130	80-130	MSD	20
1,1,2,2-Tetrachloroethane	69-139	69-139	MSD	22
1,2,3-Trichloropropane	80-127	80-127	MSD	20
N-Propylbenzene	77-142	77-142	MSD	20
2-Chlorotoluene	80-136	80-136	MSD	20
4-Chlorotoluene	80-130	80-130	MSD	20
1,3,5-Trimethylbenzene	80-139	80-139	MSD	20
tert-Butylbenzene	77-140	77-140	MSD	20
1,2,4-Trimethylbenzene	78-136	78-136	MSD	20
sec-Butylbenzene	78-140	78-140	MSD	20
4-Isopropyltoluene	78-132	78-132	MSD	14
1,3-Dichlorobenzene	80-130	80-130	MSD	12
1,4-Dichlorobenzene	80-129	80-129	MSD	11
n-Butylbenzene	73-135	73-135	MSD	18
1,2-Dichlorobenzene	80-129	80-129	MSD	14
1,2-Dibromo-3-Chloropropane	69-130	69-130	MSD	26
1,2,4-Trichlorobenzene	79-130	79-130	MSD	20
Hexachlorobutadiene	72-138	72-138	MSD	20
Naphthalene	64-132	64-132	MSD	20
1,2,3-Trichlorobenzene	75-137	75-137	MSD	20

Table B-10. Laboratory Control Limits for Matrix Spike and Laboratory Control Samples for Groundwater and Equipment Blank Samples

	Accuracy		Precision	
Analyte	Matrix Spike Recovery (percent)	LCS Recovery (percent)	Type of Duplicate	Limit RPD
Chlorinated Herbicides				
2,4,5-T	20-120	20-120	MSD	35
2,4-D	41-120	41-120	MSD	35
2,4-DB	61-135	61-135	MSD	35
4-Nitrophenol	32-121	32-121	MSD	35
Dicamba	51-142	51-142	MSD	35
Dichlorprop	20-135	20-135	MSD	35
Dinoseb	48-120	48-120	MSD	26
MCPA	57-140	57-140	MSD	35
Mecoprop	20-126	20-126	MSD	35
Pentachlorophenol	46-150	46-150	MSD	22
Silvex (2,4,5-TP)	50-150	50-150	MSD	32
NWTPH-Dx				
Diesel Range Organics	50-120	50-120	MSD	26
Motor Oil Range Organics	64-120	64-120	MSD	24
NWTPH-Gx				
Gasoline Range Organics	79-120	79-120	MSD	10
Polycyclic Aromatic Hydrocarbons				
Naphthalene	36-120	36-120	MSD	27
2-Methylnaphthalene	33-120	33-120	MSD	30
1-Methylnaphthalene	35-120	35-120	MSD	34
Acenaphthylene	42-120	42-120	MSD	26
Acenaphthene	42-120	42-120	MSD	24
Fluorene	49-120	49-120	MSD	21
Phenanthrene	54-120	54-120	MSD	21
Anthracene	56-120	56-120	MSD	29
Fluoranthene	52-129	52-129	MSD	32
Pyrene	50-127	50-127	MSD	35
Benzo[a]anthracene	61-129	61-129	MSD	31
Chrysene	47-126	47-126	MSD	23
Benzo[b]fluoranthene	53-133	53-133	MSD	25
Benzo[k]fluoranthene	51-132	51-132	MSD	25
Benzo[a]pyrene	56-130	56-130	MSD	27
Indeno[1,2,3-cd]pyrene	56-135	56-135	MSD	24
Dibenz(a,h)anthracene	60-133	60-133	MSD	25
Benzo[g,h,i]perylene	55-127	55-127	MSD	27
Organochlorine Pesticides				
alpha-BHC	53-120	53-120	MSD	18
gamma-BHC (Lindane)	53-120	53-120	MSD	21
beta-BHC	63-120	63-120	MSD	19
delta-BHC	44-120	44-120	MSD	18
Heptachlor	38-127	38-127	MSD	26

Table B-10. Laboratory Control Limits for Matrix Spike and Laboratory Control Samples for Groundwater and Equipment Blank Samples

	Accuracy		Precision	
Analyte	Matrix Spike Recovery (percent)	LCS Recovery (percent)	Type of Duplicate	Limit RPD
Aldrin	30-124	30-124	MSD	27
Heptachlor epoxide	49-126	49-126	MSD	18
trans-Chlordane	49-121	49-121	MSD	18
cis-Chlordane	56-120	56-120	MSD	17
Endosulfan I	62-123	62-123	MSD	18
4,4'-DDE	47-126	47-126	MSD	20
Dieldrin	61-122	61-122	MSD	20
Endrin	45-140	45-140	MSD	35
4,4'-DDD	53-139	53-139	MSD	19
Endosulfan II	52-121	52-121	MSD	21
4,4'-DDT	38-150	38-150	MSD	23
Endrin aldehyde	47-136	47-136	MSD	25
Endosulfan sulfate	60-120	60-120	MSD	26
Methoxychlor	35-150	35-150	MSD	30
Endrin ketone	60-137	60-137	MSD	18
Toxaphene	57-120	57-120	MSD	17
PCB Congeners				
PCB-1	60-135	60-135	MSD	50
PCB-3	60-135	60-135	MSD	50
PCB-4	60-135	60-135	MSD	50
PCB-15	60-135	60-135	MSD	50
PCB-19	60-135	60-135	MSD	50
PCB-37	60-135	60-135	MSD	50
PCB-54	60-135	60-135	MSD	50
PCB-77	60-135	60-135	MSD	50
PCB-81	60-135	60-135	MSD	50
PCB-104	60-135	60-135	MSD	50
PCB-105	60-135	60-135	MSD	50
PCB-114	60-135	60-135	MSD	50
PCB-118	60-135	60-135	MSD	50
PCB-123	60-135	60-135	MSD	50
PCB-126	60-135	60-135	MSD	50
PCB-155	60-135	60-135	MSD	50
PCB-156/157	60-135	60-135	MSD	50
PCB-167	60-135	60-135	MSD	50
PCB-169	60-135	60-135	MSD	50
PCB-188	60-135	60-135	MSD	50
PCB-189	60-135	60-135	MSD	50
PCB-202	60-135	60-135	MSD	50
PCB-205	60-135	60-135	MSD	50
PCB-206	60-135	60-135	MSD	50
PCB-208	60-135	60-135	MSD	50
PCB-209	60-135	60-135	MSD	50

Table B-10. Laboratory Control Limits for Matrix Spike and Laboratory Control Samples for Groundwater and Equipment Blank Samples

	Accuracy		Precision	
Analyte	Matrix Spike Recovery (percent)	LCS Recovery (percent)	Type of Duplicate	Limit RPD
Polychlorinated Dioxins and Furans				
2,3,7,8-TCDD	67-158	67-158	MSD	50
2,3,7,8-TCDF	75-158	75-158	MSD	50
1,2,3,7,8-PeCDD	70-142	70-142	MSD	50
1,2,3,7,8-PeCDF	80-134	80-134	MSD	50
2,3,4,7,8-PeCDF	68-160	68-160	MSD	50
1,2,3,4,7,8-HxCDD	70-164	70-164	MSD	50
1,2,3,6,7,8-HxCDD	76-134	76-134	MSD	50
1,2,3,7,8,9-HxCDD	64-162	64-162	MSD	50
1,2,3,4,7,8-HxCDF	72-134	72-134	MSD	50
1,2,3,6,7,8-HxCDF	84-130	84-130	MSD	50
1,2,3,7,8,9-HxCDF	78-130	78-130	MSD	50
2,3,4,6,7,8-HxCDF	70-156	70-156	MSD	50
1,2,3,4,6,7,8-HpCDD	70-140	70-140	MSD	50
1,2,3,4,6,7,8-HpCDF	82-122	82-122	MSD	50
1,2,3,4,7,8,9-HpCDF	78-138	78-138	MSD	50
OCDD	78-144	78-144	MSD	50
OCDF	63-170	63-170	MSD	50

Notes:

Control limits are updated periodically by the laboratories. Control limits that are in effect at the laboratory at the time of analysis will be used for sample analysis and data validation. These may differ slightly from the control limits shown in this table.

LCS = laboratory control sample
MSD = matrix spike duplicate
NA = not applicable
PCB = polychlorinated biphenyl
RPD = relative percent difference
VOC = volatile organic compound

Table B-11. Summary of Samples and Analyses

Analysis	Number of Samples			
	Field Samples	Field Duplicates[a]	Equipment Rinse Blanks	Total
Sediments				
Surface Sediment (if needed for Phase 2)				
PCB Congeners	TBD			
Organochlorine pesticides (DDx only)[b]	TBD			
PCDD/Fs	TBD			
PAHs	TBD			
Subsurface Sediment				
Organochlorine pesticides (DDx only)[b]	392	20	1	413
PCDD/Fs	392	20	1	413
PCB Congeners	392	20	1	413
PAHs	40	2	1	43
Chlorobenzene	300	15	1	316
NAPL Assessment				
VOCs	96	5	1	102
NWTPH-Dx	96	5	1	102
NWTPH-Gx	96	5	1	102
Geotechnical Parameters				
Water content, unconsolidated undrained triaxial shear strength, Atterberg limits, consolidated undrained triaxial shear strength, unit weight, particle size by sieve, particle size by hydrometer, specific gravity by pycnometer, DRET, and EET	TBD	TBD	TBD	TBD
Sediment Stability (if needed for Phase 2)				
Cesium 137	TBD			
Lead 210	TBD			
Additional Analytes				
Organochlorine pesticides (full list)	15	1	1	17
Chlorinated herbicides	15	1	1	17
TAL Metals	15	1	1	17
VOCs	15	1	1	17
Soils				
Asbestos	80	4	NA	84
PCB Congeners	148	8	1	157
Organochlorine pesticides (DDx only)[b]	148	8	1	157
PCDD/Fs	148	8	1	157
Water content, unconsolidated undrained triaxial shear strength, Atterberg limits, consolidated undrained triaxial shear strength, unit weight, particle size by sieve, particle size by hydrometer, specific gravity by pycnometer, DRET, and EET	TBD	TBD	TBD	TBD
Groundwater (Monitoring Wells and Piezometers)				
VOCs	13	1	1	15
Organochlorine pesticides (DDx only)[b]	13	1	1	15
Transition Zone Water (UltraSeep Meter)				
Organochlorine pesticides (DDx only)[b]	8	1	1	10
VOCs	8	1	1	10

Table B-11. Summary of Samples and Analyses

Analysis	Number of Samples			
	Field Samples	Field Duplicates[a]	Equipment Rinse Blanks	Total
Sediment Porewater (Trident Probe)				
DOC	9	1	1	11
VOCs	9	1	1	11

Notes:

Field duplicate and blank samples will be analyzed at the same laboratory as the primary field samples.

DOC = dissolved organic carbon
DRET = dredge elutriate test
EET = effluent elutriate test
NA = not applicable
PCB = polychlorinated biphenyl
PCDD/F = polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran
TBD = to be determined
TOC = total organic carbon
VOC = volatile organic compound

[a] Field duplicates collected at a frequency of 1 in 20 natural samples. One equipment blank will be collected for each type of sampling equipment.

[b] DDx only = 2,4'- and 4,4'-isomers of DDT, DDD, and DDE.

Table B-12. Sample Containers and Preservation Requirements

Analysis	Laboratory	Container Type	Container Size	Preservation	Holding Time
Sediments and Soils					
Metals	Eurofins/TestAmerica	WMG	8 oz.	None	6 months
Mercury	Eurofins/TestAmerica	WMG	8 oz.	None	28 days
Radiochemistry	Teledyne	WMG	16 oz.	≤6°C	6 months
PCB Congeners	Eurofins/TestAmerica	WMG	8 oz.	<-10°C in the dark	1 year
Organochlorine pesticides	Eurofins/TestAmerica	WMG	8 oz.	≤6°C	14 days/40 days [a]
Chlorinated herbicides	Eurofins/TestAmerica	WMG	8 oz.	≤6°C	14 days/40 days [a]
PAHs	Eurofins/TestAmerica	WMG	8 oz.	≤6°C	14 days/40 days [a]
Chlorinated dioxins/furans	Eurofins/TestAmerica	WMG	8 oz.	<-10°C in the dark	1 year
NWTPH-Dx	Eurofins/TestAmerica	WMG	8 oz.	≤6°C	14 days
NWTPH-Gx	Eurofins/TestAmerica	WMG with Septa	2 oz.	No headspace, ≤6°C Do not freeze	14 days
Volatile organic compounds	Eurofins/TestAmerica	Terra Core™ kit	--	≤6°C Do not freeze	14 days
Chlorobenzene	Eurofins/TestAmerica	Terra CoreTM kit	--	≤6°C Do not freeze	14 days
Asbestos	Eurofins/TestAmerica	WMG	8 oz.	None	None
Groundwater					
Organochlorine pesticides	Eurofins/TestAmerica	AG	250 mL	≤6°C	7 days/40 days[b]
Volatile organic compounds	Eurofins/TestAmerica	AG	3 x 40 ml w/septum	No headspace; HCl to pH < 2; ≤6°C	14 days
Sediment Porewater					
Dissolved organic carbon[c]	Eurofins/TestAmerica	AG	250 ml	≤6°C	28 days
Volatile organic compounds	Eurofins/TestAmerica	AG	3 x 40 ml w/septum	No headspace; HCl to pH < 2; ≤6°C	14 days

Table B-12. Sample Containers and Preservation Requirements

Analysis	Laboratory	Container Type	Container Size	Preservation	Holding Time
Field Blanks					
Volatile organic compounds	Eurofins/TestAmerica	AG	3 x 40 mL w/septum	No headspace; HCl to pH < 2; ≤6°C	14 days
NWTPH-Gx	Eurofins/TestAmerica	AG	3 x 40 mL w/septum	No headspace; HCl to pH < 2; ≤6°C	14 days
Dissolved organic carbon	Eurofins/TestAmerica	AG	250 mL	≤6°C; H_2SO_4 to pH < 2	28 days
Chloride	Eurofins/TestAmerica	HDPE	250 mL	None	28 days
PAHs	Eurofins/TestAmerica	AG	250 mL	≤6°C	7 days/40 days[b]
Metals	Eurofins/TestAmerica	HDPE	250 mL	HNO_3 to pH < 2	6 months
PCB Congeners	Eurofins/TestAmerica	AG	1 L	≤6°C	1 year
Organochlorine pesticides	Eurofins/TestAmerica	AG	250 mL	≤6°C	7 days/40 days[b]
Chlorinated herbicides	Eurofins/TestAmerica	AG	1 L	≤6°C	7 days/40 days[b]
Chlorinated dioxins/furans	Eurofins/TestAmerica	AG	1 L	0-4°C in the dark	1 year
Radiochemistry	Teledyne	AG	2 x 1 L	≤6°C: HNO3 to pH < 2	6 months
NWTPH-Dx	Eurofins/TestAmerica	AG	250 mL	HCl to pH < 2; ≤6°C	7 days

Notes:

-- = not applicable
AG = amber glass
HCl = hydrochloric acid
HDPE = high density polyethylene
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
TBD = to be determined
VOA = volatile organic analysis
WMG = wide mouth glass

[a] Holding time is 14 days to extraction and extracts must be analyzed within 40 days from extraction.
[b] The holding time is 7 days from collection to extraction and 40 days from extraction to analysis.
[c] Sample will be filtered and preserved at the laboratory.

Table B-13. Sample Size, Containers, and Holding Times for Geotechnical Sample Analysis

Analysis	Matrix	Method	Container Type and Size	Transport and Storage	Holding Time
Water Content	Soil or Sediment	ASTM D-2216	Jar or sealed bag; 50 g	Watertight container. Room temperature.	Not specified.
Unconsolidated, Undrained Triaxial Shear Strength		ASTM D-2850	Intact tube; Cylinder 33 mm dia. by 66 mm long, minimum	ASTM D-4220 Method C - Intact core Room temperature.	
Atterberg Limits		ASTM D-4318	Jar or sealed bag; 200 g for particles < 0.43 mm.	Watertight container. Room temperature.	
Consolidated, Undrained Triaxial Shear Strength		ASTM D-4767	Intact tube; Three cylinders 33 mm dia. by 66 mm long, minimum	ASTM D-4220 Method C - Intact core Room temperature.	
Unit Weight		ASTM D-7263	Intact tube; Cylinder 30 mm dia. for particles < 3 mm.	ASTM D-4220 Method C - Intact core Room temperature.	
Particle Size by Sieve		ASTM D-6913	500 g for particles < 4.75 mm	Watertight container. Room temp.	
Particle Size by Hydrometer		ASTM D-7928	500 g	Watertight container. Room temperature.	
Specific Gravity by Water Pycnometer		ASTM D 854-14	100 g	Watertight container. Room temperature.	
Dredge Elutriate Test (DRET)	Sediment/Surface Water	USACE	Bulk samples 4 L sediment 12 L surface water	NA	
Effluent Elutriate Test (EET)		USACE	Bulk samples 4 L sediment 12 L surface water	NA	

Notes:

ASTM = ASTM International

USACE = U.S. Army Corps of Engineers

ATTACHMENT 1

LABORATORY QUALITY ASSURANCE MANUALS

TELEDYNE
BROWN ENGINEERING, INC.
A Teledyne Technologies Company

Rev 33 Effective November 9, 2018
Document K-QAM-1

Quality Assurance Manual

For

Teledyne Brown Engineering

Environmental Services

2508 Quality Lane
Knoxville, Tennessee 37931-3133
865-690-6819

Generated by: _____
Sharon Northcutt, QA Manager

Approved by: _____
Keith Jeter, Operations Manager

Copy No.: _____

Issued To: _____

Date: _____

TELEDYNE
BROWN ENGINEERING, INC.
A Teledyne Technologies Company

Table of Contents

Page

REVISION HISTORY 5
1.0 Knoxville QAM Section Introduction 7
2.0 QUALITY SYSTEM 12
2.1 Policy 12
2.2 Quality System Structure 12
2.3 Quality System Objectives 12
2.4 Personnel Orientation, Training, and Qualification 13
3.0 ORGANIZATION, AUTHORITY, AND RESPONSIBILITY 14
4.0 PERSONNEL ORIENTATION, DATA INTEGRITY, TRAINING, AND QUALIFICATION 15
4.1 Orientation 15
4.2 Data Integrity 15
4.3 Training 15
4.4 Qualification 15
4.5 Records 15
5.0 CUSTOMER INTERFACES 16
5.1 Interface Personnel 16
5.2 Bid Requests and Tenders 16
5.3 Contracts 16
5.4 TBE's Expectation of Customers 16
5.5 Customer Satisfaction 17
5.5.1 Customer Complaints 17
5.5.2 Customer Confidentiality 17
6.0 DOCUMENTATION GENERATION & CONTROL 18
6.1 General 18
6.2 New Documentation 18
6.3 Documentation Changes 18
6.4 Documentation Lists and Distributions 18
6.5 Other Documentation 18
6.6 Documentation Reviews 19
7.0 DESIGN OF LABORATORY CONTROLS 20
7.1 General 20
7.2 Facility 20
7.3 Technical Processes and Methods 20
7.3.1 Operational Flow 20
7.3.2 Methods 21
7.3.3 Data Reduction and Analysis 21

Table of Contents (cont'd)

Page

7.4 Verification of Technical Processes, Methods, and Software 21
7.4.1 Operational Flow Verification 21
7.4.2 Method Verifications 21
7.4.3 Data Reduction and Analysis Verification 22
7.5 Design of Quality Controls 22
7.5.1 General 22
7.5.2 Demonstration of Capability (D of C) 22
7.5.3 Process Control Checks 22
7.5.3.1 Inter-Lab Samples 22
7.5.3.2 QC Samples 23
7.5.3.3 Customer-Provided Samples 23
7.6 Counting Instrument Controls 24
8.0 PURCHASING AND SUBCONTRACT CONTROLS 24
8.1 General 24
8.2 Source Selection 24
8.3 Procurement of Supplies and Support Services 24
8.3.1 Catalog Supplies 24
8.3.2 Support Services 24
8.3.3 Equipment and Software 25
8.3.4 Commercial Grade Dedication 25
8.4 Subcontracting of Analytical Services 25
8.5 Acceptance of Items or Services 25
9.0 TEST SAMPLE IDENTIFICATION AND CONTROL 26
9.1 Sample Identification 26
9.2 LIMS 26
9.3 Sample Control 26
10.0 SPECIAL PROCESSES, INSPECTION, AND TEST 27
10.1 Special Processes 27
10.2 Inspections and Tests 27
10.2.1 Intra Laboratory Checks (QC Checks) 27
10.2.2 Inter Laboratory Checks 27
10.2.3 Data Reviews 27
10.3 Control of Sampling of Samples 27
10.4 Reference Standards / Material 28
10.4.1 Weights and Temperatures 28
10.4.2 Radioactive Materials 28

Table of Contents (cont'd)

Page

11.0 EQUIPMENT MAINTENANCE AND CALIBRATION 29
11.1 General 29
11.2 Support Equipment 29
11.3 Instruments 29
11.4 Nonconformances and Corrective Actions 29
11.5 Records 30
12.0 NONCONFORMANCE CONTROLS 31
12.1 General 31
12.2 Responsibility and Authority 31
12.3 10CFR21 Reporting 31
13.0 CORRECTIVE AND PREVENTIVE ACTION 32
13.1 General 32
13.2 Corrective Actions 32
13.3 Preventive Actions 32
14.0 RESULTS ANALYSIS AND REPORTING 33
14.1 General 33
14.2 Results Review 33
14.3 Reports 33
15.0 RECORDS 34
15.1 General 34
15.2 Type of Records 34
15.3 Storage and Retention 34
15.4 Destruction or Disposal 34
16.0 ASSESSMENTS 35
16.1 General 35
16.2 Audits 35
16.3 Management Reviews 35
ATTACHMENT A
EPA Manual Cross Reference to TBE's QA Manual 36

TELEDYNE
BROWN ENGINEERING, INC.
A Teledyne Technologies Company

REVISION HISTORY

Revision 7	Complete re-write	January 1, 2005	Bill Meyer
Revision 8	Updated Organization Chart, minor change to 1.0, 4.4, 7.5.3.2, 10.2.3, and 12.3	October 26, 2005	Bill Meyer
Revision 9	Table 1-1, Figure 3.1, Section 3.3	June 13, 2006	Lynne Perry
Revision 10	Table 1-1, Sections 2.2, 4.3	June 20, 2006	Lynne Perry
Revision 11	Reformatted headers, Changed 'Procedure #' to 'procedure TBE-#' throughout document, Table 1-1, Figure 3.1, section 5.5.1	November 15, 2006	Lynne Perry
Revision 12	Section 15.3	April 30, 2007	Lynne Perry
Revision 13	Section 1.0	June 21, 2007	Lynne Perry
Revision 14	Table 1.1, Figure 3.1, Sections 10.3, 13.0, added Appendix A	October 19, 2007	Lynne Perry
Revision 15	Table 1.1, Section 4.0 title, 6.6, Figure 3.1, 7.3.1 Removed ref to TBE-5004 8.3.3, 14.3, Attachment A	September 5, 2008	Lynne Perry
Revision 16	Section 6.3, 16.2	October 02, 2008	Lynne Perry
Revision 17	Table 1.1	January 26, 2010	Lynne Perry
Revision 18	Section 2.2	November 5, 2010	Lynne Perry
Revision 19	Section 8.2	January 27, 2011	Lynne Perry
Revision 20	Figure 3.1	November 9, 2011	Lynne Perry
Revision 21	Figure 3.1, Section 8.5	December 17, 2012	Lynne Perry

TELEDYNE
BROWN ENGINEERING, INC.
A Teledyne Technologies Company

REVISION HISTORY (cont'd)

Revision 22	Figure 3.1	March 14, 2013	Lynne Perry
Revision 22	Figure 3.1	March 14, 2013	Lynne Perry
Revision 23	Sections 1.0, Table 1-1, 2.1, 3.0, 4.2, 5.1-5.3, 5.5.1, 7.3.1, 8.4, 8.5, 9.1, 14.2	October 23, 2013	Lynne Perry
Revision 24	Section 1.0	December 09, 2013	Lynne Perry
Revision 25	Figure 3.1	May 09, 2014	Lynne Perry
Revision 26	Figure 3.1	June 30, 2014	Lynne Perry
Revision 27	Sections 7.4.3, 10.4.2, 11.3 11.4	November 10, 2014	Lynne Perry
Revision 28	Figure 3.1	January 21, 2015	Lynne Perry
Revision 29	Table 1-1	September 15, 2015	Lynne Perry
Revision 30	Table 1.1, Sections 12.1,	July 29, 2016	Brandy Bicoll
Revision 31	Added items to Table of Contents, Figure 3.1, Section 7.3.1, replaced title 'Program Manager' with 'Project Manager' throughout	November 14, 2017	Sharon Northcutt
Revision 32	Table1-1, Section 8.5	March 15, 2018	Sharon Northcutt
Revision 33	Sections 1.0, Section 6.6, Figure 3.1	November 9, 2018	Sharon Northcutt

1.0 Knoxville QAM Section Introduction

This Quality Assurance Manual (QAM) and related procedures describes the Knoxville Environmental Services Laboratory's Quality Assurance (QA) system. The system is designed to meet multiple quality standards imposed by Customers and regulatory agencies and to support customer programs. The standards and regulations include, but are not limited to:

NRC 10 CFR 50 Appendix B
NRC 10 CFR 61
NRC Regulatory Guide 1.21
NRC Regulatory Guide 4.15, Rev 1, 1979
ANSI N 42.23
ANSI N 13.30
NELAC Standard, Chapter 5
TNI Standard, current revision
ISO Guide 17025

The Environmental Services (ES) Laboratory does low level radioactivity analyses for Power Plants and other customers. It primarily analyzes environmental samples (natural products from around plants such as milk), in-plant samples (air filters, waters), bioassay samples from customer's employees, and waste disposal samples (liquids and solids).

Potable and non-potable water samples are tested using methods based on EPA standards as cited in State licenses (see procedure TBE-4010). The listing *[current as of initial printing of this Manual – see current index for revision status*] of implementing procedures (SOPs) covering Administration, Methods, Counting Instruments, Technical, Miscellaneous, and LIMS is shown in Table 1-1. Reference to these procedures by number is made throughout this QAM.

Table 1-1

Number	Title
Part 1	**Administrative Procedures**
TBE-1001	Validation and Verification of Computer Programs for Radiochemistry Data Reduction
TBE-1002	Organization and Responsibility
TBE-1003	Control, Retention, and Disposal of Quality Assurance Records
TBE-1004	Definitions
TBE-1005	Data Integrity
TBE-1006	Job Descriptions
TBE-1007	Training, Qualification and Certification of Personnel
TBE-1008	Document and Document Control

Number	Title
TBE-1009	Calibration Systems
TBE-1010	Nonconformance Controls
TBE-1011	10CFR21 Reporting
TBE-1012	Corrective and Preventive Action
TBE-1013	Audits and Management Review
TBE-1014	RFP, Contract Review, and Project Set Up
TBE-1015	Procurement Controls
TBE-1016	Documentation of Customer Complaints
TBE-1017	Commercial Grade Dedication
Part 2	**Method Procedures**
TBE-2001	Alpha Isotopic and Plutonium-241
TBE-2002	Carbon-14 Activity in Various Matrices
TBE-2003	Carbon-14 and Tritium in Soils, Solids, and Biological Samples: Harvey Oxidizer Method
TBE-2004	Cerium-141 and Cerium-144 by Radiochemical Separation
TBE-2005	Cesium-137 by Radiochemical Separation
TBE-2006	Iron-55 Activity in Various Matrices
TBE-2007	Gamma Emitting Radioisotope Analysis
TBE-2008	Gross Alpha and/or Gross Beta Activity in Various Matrices
TBE-2009	**RETIRED** (Gross Beta Minus Potassium-40 Activity in Urine and Fecal Samples)
TBE-2010	Tritium and Carbon-14 Analysis by Liquid Scintillation
TBE-2011	Tritium Analysis in Drinking Water by Liquid Scintillation
TBE-2012	Radioiodine in Various Matrices
TBE-2013	Radionickel Activity in Various Matrices
TBE-2014	Phosphorus-32 Activity in Various Matrices
TBE-2015	Lead-210 Activity in Various Matrices
TBE-2016	**RETIRED** (Radium-226 Analysis in Various Matrices)
TBE-2017	**RETIRED** (Total Radium in Water Samples)
TBE-2018	Radiostrontium Analysis by Chemical Separation
TBE-2019	Radiostrontium Analysis by Ion Exchange
TBE-2020	Sulfur-35 Analysis
TBE-2021	Technetium-99 Analysis by Eichrom® Resin Separation
TBE-2022	**RETIRED** (Total U by KPA)
TBE-2023	Compositing of Samples

Number	Title
TBE-2024	Dry Ashing of Environmental Samples
TBE-2025	Preparation and Standardization of Carrier Solutions
TBE-2026	Renumbered as 4019
TBE-2027	Glassware Washing and Storage
TBE-2028	Moisture Content of Various Matrices
TBE-2029	**RETIRED** (Polonium-210 Activity in Various Matrices)
TBE-2030	**RETIRED** (Promethium-147 Activity in Various Matrices)
TBE-2031	Radioactive Iodine in Drinking Water EPA Method 902.0
TBE-2032	10CFR61 Sample Preparation
TBE-2033	Pyrosulfate Fusion Preparation
TBE-2034	Drying and Grinding of Solid Samples
TBE-2035	**RETIRED** (Ra-226 and Ra-228 in Aqueous Samples)
TBE-2036	**RETIRED** (Standard Test Method for 24-h Batch-Type Measurement of Contaminant Sorption in Soils and Sediments)
TBE-2037	Radiochemical Determination of Gross Alpha Activity in Drinking Water by Coprecipitation
TBE-2038	Foreign Soil Handling
Part 3	**Instrument Procedures**
TBE-3001	Calibration and Control of Gamma-Ray Spectrometers
TBE-3002	Calibration of Alpha Spectrometers
TBE-3003	Calibration and Control of Alpha and Beta Counting Instruments
TBE-3004	Calibration and Control of Liquid Scintillation Counters
TBE-3005	**RETIRED** Calibration and Operation of pH Meters
TBE-3006	Balance Calibration and Check
TBE-3007	**RETIRED** (Reporting Defects and Non Compliances)
TBE-3008	**RETIRED** (Negative Results Evaluation Policy)
TBE-3009	Use and Maintenance of Mechanical Pipettors
TBE-3010	Microwave Digestion System Use and Maintenance
Part 4	**Technical Procedures**
TBE-4001	Renumbered as 1014
TBE-4002	Quality Control Checking of Analytical Data
TBE-4003	Sample Receipt and Control
TBE-4004	Preparation of a Data Package
TBE-4005	Quality Control Samples - Blanks, Spikes and Duplicates

Number	Title
TBE-4006	Inter-Laboratory Performance Evaluation Programs
TBE-4007	Method Basis, Validation and Demonstration of Capability
TBE-4008	*Unassigned*
TBE-4009	Detection Levels
TBE-4010	State and Government Agency Certifications
TBE-4011	Quality Calculations and Charting (Accuracy, Precision, Recovery, Efficiency, Control Charts and Data Quality Objectives)
TBE-4012	*Unassigned*
TBE-4013	*Unassigned*
TBE-4014	Laboratory Facilities
TBE-4015	Documentation of Analytical Laboratory Logbooks
TBE-4016	Uncertainty of Measurements
TBE-4017	Laboratory Information Management Systems (LIMS)
TBE-4018	Instrument Setup, Maintenance, and Calibration
TBE-4019	Radioactive Reference Standard Solutions and Records
Part 5	**Miscellaneous Procedures**
TBE-5001	Laboratory Hood Operations
TBE-5002	Operation and Maintenance of Deionized Water System
TBE-5003	Waste Management
TBE-5004	**RETIRED** (Acid Neutralization and Purification System Operation)
Part 6	**LIMS**
TBE-6001	LIMS Raw Data Processing and Reporting
TBE-6002	Software Development and/or Pilots of COTS Packages
TBE-6003	Software Change and Version Control
TBE-6004	Backup of Data and System Files
TBE-6005	Disaster Recovery Plan
TBE-6006	LIMS Hardware
TBE-6007	LIMS User Access
TBE-6008	LIMS Training
TBE-6009	LIMS Security
Part 7	**Radiation Protection Program Procedures**
TBE-7001	Receiving Packaged Radioactive Materials
TBE-7002	Laboratory Contamination Control
TBE-7003	Facility and Personnel Exposure Monitoring

Number	Title
TBE-7004	Controlled Areas and Radiation Controlled Areas
TBE-7005	Facility Surveys
TBE-7006	Radiation Source Control and Leak Testing
TBE-7007	Radiation Protection Program Assessments
TBE-7008	Radiation Protection Records
TBE-7009	Radiation Waste Management
Part 8	**Environmental Regulatory**
TBE-8001	Attorney-Client Privilege and Work Product Doctrine
TBE-8002	Container Controls
TBE-8003	Data Management System
TBE-8004	Environmental Management System
TBE-8005	Management of Change
TBE-8006	**RETIRED** (Hazardous Waste Marking and Accumulation)
TBE-8007	Facility Inspections
TBE-8008	Waste Minimization Plan
TBE-8009	**RETIRED** (Slug/Waste Water Operation Discharge Prevention & Contingency Plan)
TBE-8010	Hazardous Material Communication Information
TBE-8011	Hazardous Material Security Plan
TBE-8012	Asbestos Management Plan
TBE-8013	Asbestos – Employee Information and Training
TBE-8014	**RETIRED** (Oxygen Monitor Calibration)
TBE-8015	Precious Metals

2.0 QUALITY SYSTEM

The TBE-ES QA system is designed to comply with multiple customer- and regulatory agency-imposed specifications related to quality. This quality system applies to all activities of TBE-ES that affect the quality of analyses performed by the laboratory.

2.1 Policy

The TBE quality policy, given in Company Policy P-501, is "*TBE will continually improve our processes and effectiveness in providing high-quality technical services, manufactured products and engineered systems that adhere to our Quality Management System and exceed our customer's expectations*."

This policy is amplified by this Laboratory's commitment, as attested to by the title page signatures, to perform all work to good professional practices and to deliver high quality services to our customers with full data integrity. (See Section 4.0 and procedure TBE-1005).

2.2 Quality System Structure

The Quality System is operated by the organizations described in Section 3.0 of this Manual. The Quality System is described in this Manual and in the procedures Manual, both of which are maintained by the QA Manager. Procedures are divided into 8 sections – Administrative, Methods, Equipment, Technical, Miscellaneous, LIMS, Radiation Protection Program, and Environmental Regulatory. This QA Manual is structured as shown in the Table of Contents and refers to procedures when applicable. Cross references to the various imposed quality specifications are contained in Appendices to procedures, as appropriate.

2.3 Quality System Objectives

The Quality System is established to meet the objective of assuring all operations are planned and executed in accordance with system requirements. The Quality System also assures that performance evaluations are performed (see procedure TBE-4006), and that appropriate verifications are performed (see procedures in the 1000 and 4000 series) to further assure compliance. Verification includes examination of final reports (prior to submittal to customers) to determine their quality (see procedure TBE-4004).

To further these objectives, various in-process assessments of data, as well as assessments of the system, via internal audits and management reviews, are performed. Both internal experts and customer / regulatory agencies perform further assessments of the system and compliance to requirements.

2.4 Personnel Orientation, Training, and Qualification

TBE provides indoctrination and training to employees and performs proficiency evaluation of technical personnel. This effort is described in Section 4.0.

3.0 ORGANIZATION, AUTHORITY, AND RESPONSIBILITY

TBE has established an effective organization for conducting laboratory analyses at the Knoxville Environmental Services Laboratory. The basic organization is shown in Figure 3-1. Detail organization charts with names, authorities, and responsibilities are given in procedure TBE-1002. Job descriptions are given in procedure TBE-1006.

This organization provides clearly established quality assurance authorities, duties, and functions. QA has the organizational freedom needed to:

(1) Identify problems
(2) Stop nonconforming work
(3) Initiate investigations
(4) Recommend corrective and preventive actions
(5) Provide solutions or recommend solutions
(6) Verify implementation of actions

All Laboratory personnel have the authority and resources to do their assigned duties and have the freedom to act on problems. The QA personnel have direct, independent access to Company management as shown in Figure 3-1.

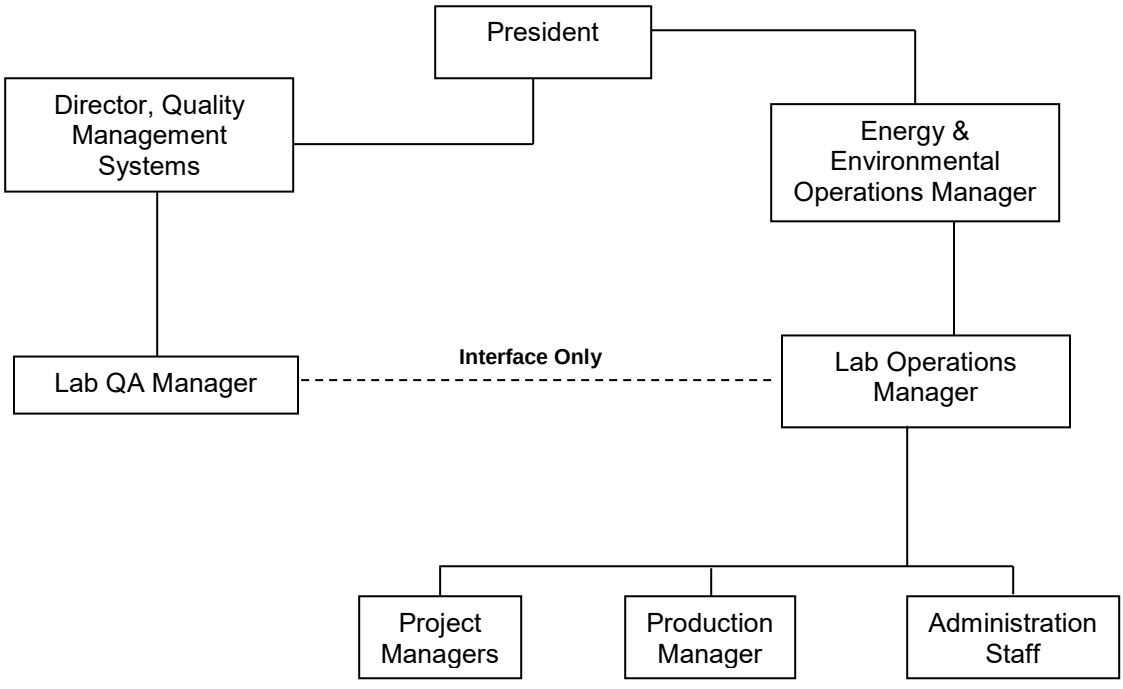


Figure 3.1. Laboratory Organization

4.0 PERSONNEL ORIENTATION, DATA INTEGRITY, TRAINING, AND QUALIFICATION

4.1 Orientation

All laboratory personnel must receive orientation to the quality program if their work can affect quality. Orientation includes a brief review of customer and regulatory agency imposed quality requirements, the structure of the QAM, and the implementing procedures. The goal of orientation is to cover the nature and goals of the QA program.

4.2 Data Integrity

The primary output of the Laboratory is data. Special emphasis and training in data integrity is given to all personnel whose work provides or supports data delivery. The Laboratory Data Integrity procedure (procedure TBE-1005) describes training, personnel attestations, and monitoring operations. Annual reviews of the Laboratory Data Integrity procedure are required.

4.3 Training

The Quality Assurance Manager (QAM) maintains a training matrix indicating laboratory personnel training status in specific procedures. This matrix is updated when personnel change or change assignments. All personnel are trained per these requirements and procedures. This training program is described in procedure TBE-1007. The assigned responsibilities for employees are described in procedure TBE-1002 (See Section 3.0) on Organization and in procedure TBE-1006, Job Descriptions. Refresher training or re-training is given annually as appropriate.

4.4 Qualification

Personnel are qualified as required by their job description. Management and non-analysts are evaluated based on past experience, education, and management's assessment of their capabilities. Formal qualification is required of analysts and related technical personnel who perform laboratory functions. Each applicable person is given training and then formally evaluated by the Operations Manager (or his designees) and by QA. Each analyst must initially demonstrate capability to perform each assigned analytical effort. Each year, thereafter, he or she must perform similar analyses on Interlab Comparison Samples (see procedure TBE-4006) or on equivalent blanks and spikes samples. Acceptable results extend qualifications (certification). Unacceptable results require retraining in the subject method / procedures. (See procedure TBE-1007 for added information, records, forms, etc. used.)

4.5 Records

Records of training subjects, contents, attendees, instructors, and certifications are maintained by QA.

5.0 CUSTOMER INTERFACES

5.1 Interface Personnel

The Laboratory has designated Project Managers as the primary interface with all customers. Other interfaces may be the QA Manager or the Lab Operations Manager.

5.2 Bid Requests and Tenders

Project Managers respond to customer requests for bids and proposals per procedure TBE-1014 for bids, proposals, and contract reviews. They clarify customer requests so both the customer and the lab staff understand requests. As responses are developed, internal reviews are conducted to ensure that requirements are adequately defined and documented and to verify that the laboratory has adequate resources in physical capabilities, personal skills, and technical information to perform the work. Accreditation needs are reviewed. If subcontracts are required to perform any analysis, the subcontractor is similarly evaluated and the client notified in writing of the effort. Most qualifications are routine with standard pricing and the review of these quotes is performed by the Project Manager. Larger or more complex quotes are reviewed by the Operations Manager and the QA Manager (or designees). Evidence of review is by initialing and dating applicable papers, signatures on quotations, or by memo.

5.3 Contracts

Project Managers receive contract awards (oral or written) and generate the work planning for initiation preparation (charge numbers, data structure or contents in LIMS, etc.). They review contracts for possible differences from quotations and, if acceptable, contracts are processed. Documentation of the review is by initials and date as a minimum. Contract changes receive similar reviews and planning.

5.4 TBE's Expectation of Customers

TBE expects customers to provide samples suitable for lab analyses. These expectations include:

- Accurate and unambiguous identification of samples
- Proper collection and preservation of samples
- Use of appropriate containers free from external and internal contamination
- Integrity preservation during shipment and timely delivery of samples that are age-sensitive
- Adequate sized samples that allow for retest, if needed
- Specification of unique MOA/MDC requirements
- Alerting the lab about abnormal samples (high activity, different chemical contents, etc.)
- Chain of custody initiation, when required

5.5 Customer Satisfaction

TBE's quality policy centers on customer satisfaction (See 2.0). TBE will work to satisfy customers through full compliance with contract requirements, providing accurate data and properly responding to any questions or complaints. Customers are provided full cooperation in their monitoring of Laboratory performance. Customers are notified if any applicable State Accreditation is withdrawn, revoked, or suspended.

5.5.1 Customer Complaints

Any customer complaints are documented and tracked to closure per procedure TBE-1016. Most complaints concern analysis data and are received by Project Managers. They log each such complaint, order retests for verification, and provide documented results to customers. Complaints may also be received by QA or Operations.

If complaints are other than re-test type, the nonconformance and corrective action systems (Sections 12 and 13) are used to resolve them and record all actions taken.

5.5.2 Customer Confidentiality

All laboratory personnel maintain confidentiality of customer-unique information.

6.0 DOCUMENTATION GENERATION & CONTROL

6.1 General

The documentation generation and control system is detailed in procedure TBE-1008. An overview is given below. The basic quality system documents are described in Section 2.0.

6.2 New Documentation

Each Procedure and this QAM is written by appropriate personnel, validated if applicable (see Section 7.0), reviewed for adequacy, completeness, and correctness, and, if acceptable, accepted by the authorized approver [QA Manager, Operations Manager (or their designee)]. Both approvals are required if a Procedure affects both QA and Operations (see Responsibilities in Section 3.0). These procedures control the quality measurements and their accuracy.

Each document carries a unique identification number, a revision level, dates, page numbers and total page count, and approver identification and sign off. If TBE writes code for software, the software is version identified and issued after Verification and Validation per Section 7.0.

6.3 Documentation Changes

Each change is reviewed in the same manner and by the same group as new documentation. Revision identifications are updated and changes indicated by side bars, italicized words, or by revision description when practical. Obsolete revisions are maintained by QA after being identified as obsolete.

Departures from documented policies, procedures or standard specifications shall be put in writing by the Operation Manager, or designee, and distributed to the laboratory technician, as appropriate.

6.4 Documentation Lists and Distributions

Computer indexes of documents are maintained by Quality showing the current authorized revision level of each document. These revisions are placed on the Laboratory server and obsolete ones are removed so that all personnel have only the current documents. If hard copies are produced and distributed, separate distribution lists are maintained indicating who has them and their revision level(s). Copies downloaded off the server are uncontrolled unless verified by the user (on the computer) to be the latest revision.

6.5 Other Documentation

In addition to TBE-generated documentation, QA maintains copies of applicable specifications, regulations, and standard methods.

6.6 Documentation Reviews

Each issued document is reviewed at least every third year by the approving personnel. EPA documents are reviewed every one to two years. Procedures TBE-1002 Organization and Responsibility, TBE-1003 Control and Retention of Quality Assurance Records, TBE-1005 Data Integrity and TBE-1006 Job Descriptions are reviewed annually. This review determines continued suitability for use and compliance with requirements.

7.0 DESIGN OF LABORATORY CONTROLS

7.1 General

The Laboratory and its operating procedures are designed specifically for low level (environmental and in-plant) radioactive sample analysis. The various aspects of the laboratory design include the following which are discussed in subsequent paragraphs of this Section:

(a) Facility
(b) Technical Processes and Methods
(c) Verification of Design of Processes, Methods, and Software.
(d) Design of Quality Controls
(e) Counting Instrument Controls

7.2 Facility

The facility was designed and built in 2000 to facilitate correct performance of operations in accordance with good laboratory practices and regulatory requirements. It provides security for operations and samples. It separates sample storage areas based on activity levels, separates wet chemistry from counting instrumentation for contamination control, and provides space and electronic systems for documentation, analysis, and record storage. Procedure TBE-4014 describes the facility, room uses, layouts, etc.

7.3 Technical Processes and Methods

7.3.1 Operational Flow

The laboratory design provides for sample receipt and storage (including special environmental provisions for perishable items) where samples are received from clients and other labs (see Section 9.0). The samples are logged into the computer-based Laboratory Information Management System (LIMS) and receive unique identification numbers and bar code labels (see procedure TBE-4017 for LIMS description and user procedures), and are placed into appropriate storage areas. Project Managers plan the work and assure that LIMS contains any special instructions to analysts. Samples then go to sample preparation, wet chemistry (for chemical separation), and counting-based on the radionuclides (see procedures in the 2000 and 3000 series). Analysts perform the required tasks with data being entered into logbooks, LIMS, and counting equipment data systems as appropriate. Results are collected and reviewed by the Operations Manager and Project Managers and reports to clients are generated (See Section 14.0). All records (electronic or hard copy) are maintained in files or as back-up electronic copies (see Section 15.0). After the required hold periods, client notification and approval, samples are disposed of in compliance with regulatory requirements (see procedure TBE-5003).

7.3.2 Methods

The laboratory methods documented in the 2000 and 3000 series of procedures were primarily developed by senior TBE laboratory personnel based on years of experience at our prior facility in New Jersey. They have been improved, supplemented and implemented at our current location. Where EPA or other accepted national methods exist (primarily for water analyses under State certification programs - see procedure TBE-4010), the TBE methods conform to the imposed requirements or State-accepted alternate requirements. Any method modifications are documented and described in the Procedure. There are no nationally-recognized methods for most other analysis methods but references to other method documents are noted where applicable.

7.3.3 Data Reduction and Analysis

Whenever possible automatic data capture and computerized data reduction programs are used. Calculations are either performed using commercial software (counting system operating systems) or TBE-developed and validated software is used (see 7.4 below). Analysis of reduced data is performed as described in Section 14.0 and in procedure TBE-4004.

7.4 Verification of Technical Processes, Methods, and Software

7.4.1 Operational Flow Verification

The entire QA Manual and related procedures describe the verification of elements of the technical process flow and the establishment of quality check points, reviews, and controls.

7.4.2 Method Verifications

Methods are verified and validated per procedure TBE-4007 prior to use unless otherwise agreed to by the client. For most TBE methods initial validation occurred well in the past. New or significantly revised Methods receive initial validation by demonstration of their performance using known analytes (NIST-traceable) in appropriate matrices. Sufficient samples are run to obtain statistical data that provides evidence of process capability and control, establishes detection levels (see procedure TBE-4009), bias and precision data (see procedure TBE-4011). All method procedures and validation data are available to respective clients. Also see Section 7.5 below for the Demonstration of Capability program.

7.4.3 Data Reduction and Analysis Verification

Data reduction is performed by software and analysis verification is performed by personnel who did not generate the data, i.e. the Operations Manager, or designee (see Section 14.0).

7.5 Design of Quality Controls

7.5.1 General

There are multiple quality controls designed into the laboratory operations. Many of these are described elsewhere in this manual and include personnel qualification (Section 4.0), Document control (6.0), Sample identification and control (9.0), Use of reference standards (10.0), intra- and inter- laboratory tests (10.0), etc. This Section describes the basic quality control systems used to verify Method capability and performance.

7.5.2 Demonstration of Capability (D of C)

The demonstration of capability (D of C) system verifies and documents that the method, analyst, and the equipment can perform within acceptable limits. The D of C is certified for each combination of analyte, method, and instrument type. D of C's are certified based on objective evidence at least annually. This program is combined with the analyst D of C program (See Section 4.0). Initial D of C's use the method validation effort as covered above. Subsequent D of C's use Inter-Laboratory samples (procedure TBE-4006) or, if necessary, laboratory-generated samples using NIST-traceable standards. If results are outside of control limits, re-demonstration is required after investigation and corrective action is accomplished (See Sections 12.0 and 13.0).

7.5.3 Process Control Checks

Process control checks are designed to include Inter-Lab samples, Intra-Lab QC check samples, and customer-provided check samples. 10% of laboratory analysis samples are for process control purposes.

7.5.3.1 Inter-Lab Samples

Inter-lab samples are procured or obtained from sources providing analytes of interest in matrices similar to normal client samples. These samples may be used for analyst D of C's, equipment and methods. They also provide for independent insight into the lab's process capabilities. Any value reported as being in the warning zone (over 2 sigma) is reviewed and improvements taken. Any value failing (over 3 sigma) is documented in an NCR and formal investigation per Section 12.0 and 13.0 is performed. If root causes are not clearly understood

and fixed, re-tests are required using lab prepared samples (See procedure TBE-4006).

7.5.3.2 QC Samples

QC samples, along with Inter-lab samples and customer check samples, are 10% of the annual lab workload for the applicable analyte and method. If batch processing is used, some specifications require specific checks with each batch or each day rather than as continuous process controls (See procedure TBE-4005).

QC samples consist of multiple types of samples including:

(a) Method blanks
(b) Blank spikes
(c) Matrix spikes
(d) Duplicates
(e) Tracers and carriers

Acceptance limits for these samples are given in procedures or in lab standards. The number, frequency, and use of these sample types varies with the method, matrix, and supplemental requirements. The patterns of use versus method and the use of the resulting test data is described in procedure TBE-4005.

7.5.3.3 Customer-Provided Check Samples

Customers may provide blind check samples and duplicates to aid in their evaluation of the Laboratory. When the lab is notified that samples are check samples their results are included in the QC sample percentage counts. Any reported problems are treated as formal complaints and investigated per Section 5.

7.6 Counting Instrument Controls

The calibration of instruments is their primary control and is described in Section 11.0. In addition, counting procedures (3000 series) also specify use of background checks (method blank data is not used for this) to evaluate possible counting equipment contamination. Instrument calibration checks using a lab standard from a different source than the one used for calibration are also used. Background data can be used to adjust client and test data. Checks with lab standards indicate potential calibration changes.

8.0 PURCHASING AND SUBCONTRACT CONTROLS

8.1 General

Procurement and Subcontracts efforts use the Huntsville-based Cost Point computer system to process orders. The Laboratory-generated Purchase Requisitions are electronically copied into Purchase Orders in Huntsville. The Laboratory also specifies sources to be used. Procured items and services are received at the Laboratory where receiving checks and inspections are made. Laboratory procedure TBE-1015 provides details on the procurement control system at the Laboratory and references the Huntsville procedures as applicable.

8.2 Source Selection

Sources for procurements of items and services are evaluated and approved by QA as described in procedure TBE-1015. Nationally-recognized catalog item sources are approved by the QA Manager based on reputation. Maintenance services by an approved distributor or the equipment manufacturing company are pre-approved. Sources for other services are evaluated by QA, based on service critical to the quality system, by phone, mail out, ILAC accreditation or site visit using a commercial survey.

Subcontract sources for laboratory analysis services are only placed with accredited laboratories (by NELAP, State, Client, etc.) as applicable for the type of analysis to be performed. QA maintains lists of approved vendors and records of evaluations performed.

8.3 Procurement of Supplies and Support Services

8.3.1 Catalog Supplies

The Laboratory procures reagents, processing chemicals, laboratory “glassware,” consumables, and other catalog items from nationally-known vendors and to applicable laboratory grades, purities, concentrations, accuracy levels, etc. Purchase Requisitions for these items specify catalog numbers or similar call-outs for these off-the-shelf items. Requisitions are generated by the personnel in the lab needing the item and are approved by the Operations or Production Manager.

8.3.2 Support Services

Purchase Requisitions for support services (such as balance calibration, equipment maintenance, etc.) are processed as in 8.3.1, but technical requirements are specified and reviewed before approvals are given.

8.3.3 Equipment and Software

Purchase Requisitions for new equipment, software programs, and major facility modifications affecting the quality system are reviewed and approved by the Operations Manager and the QA Manager, as appropriate.

8.3.4 Commercial Grade Dedication Procedure

Evaluation, acceptance and procurement of commercial-grade items and /or services for safety related items initiated by Teledyne Brown Engineering for suppliers that do not meet the requirements of 10CFR50.

8.4 Subcontracting of Analytical Services

When necessary, the Laboratory may subcontract analytical services required by a client. This may be because of special needs, infrequency of analysis, etc. Applicable quality and regulatory requirements are imposed in the Purchase Requisition and undergo a technical review by QA. Quality requirements (calibrations, acceptance criteria, corrective action) for chemical analyses are inherent in chemical methods (e.g. EPA SW-846 Method 1311[TCLP]). TBE reserves the right of access by TBE and our client for verification purposes.

8.5 Acceptance of Items or Services

Items and services affecting the quality system are verified at receipt based on objective evidence supplied by the vendor. Supply items are reviewed by the requisitioner and, if acceptable, are accepted via annotation on the vendor packing list or similar document. Similarly, equipment services are accepted by the requisitioning lab person. Calibration services are accepted by QA based on KQA-30 and certification reviews (see Section 11.0.)

Data reports from analytical subcontractors are evaluated by Project Managers, and subsequently by the Operations Manager (or designee), as part of client report reviews.

M&TE, standards, and TBE cross-check samples are not used until accepted. If rejected, QA is notified and nonconformance controls per Section 12.0 are followed, if required. After vendor notification, rejected items are returned. Vendors may be removed from the approved vendor’s list if their performance is unacceptable.

9.0 TEST SAMPLE IDENTIFICATION AND CONTROL

9.1 Sample Identification

Incoming samples are inspected for customer identification, container condition, chain of custody forms, and radioactivity levels. If acceptable, the sample information is entered into LIMS, which generates bar coded labels for attachment to the sample(s). The labels are attached and samples stored in the assigned location. If environmental controls are needed (refrigeration, freezing, etc.), the samples are placed in these storage locations. If not acceptable, the Project Manager is notified, the customer contacted, and the problem resolved (return of sample, added data receipts, etc.). See procedure TBE-4003 for more information on sample receipt.

9.2 LIMS

The LIMS is used to schedule work, provide special information to analysts, and record all actions taken on samples. See procedure TBE-4017 and the 6000 series of procedures for more information on LIMS operations.

9.3 Sample Control

The sample, with its bar coded label, is logged out to the applicable lab operation where the sample is processed per the applicable methods (procedures 2000 and 3000). The LIMS-assigned numbers are used for identification through all operations to record data. Data is entered into LIMS, log books (kept by the analysts) or equipment data systems to record data. The combination of LIMS, logbooks, and equipment data systems provide the Chain of Custody data and document all actions taken on samples. Unused sample portions are returned to its storage area for possible verification use. Samples are discarded after required time limits are passed and after client notification and approval, if required.

10.0 SPECIAL PROCESSES, INSPECTION, AND TEST

10.1 Special Processes

The Laboratory's special processes are the methods used to analyze a sample and control equipment. These methods are defined in procedures in the 2000 and 3000 series. These processes are performed to the qualified methods (see Section 7.0) by qualified people (see 4.0).

10.2 Inspections and Tests

The quality of the process is monitored by indirect means. This program involves calibration checks on counting equipment (see Section 11.0), intra-laboratory checks, and inter-laboratory checks. In addition, some customers submit quality control check samples (blinds, duplicates, external reference standards). All generated data gets independent reviews.

10.2.1 Intra-Laboratory Checks (QC Checks)

The quantity and types of checks varies with the method, but basic checks which may include blanks, spiked blanks, matrix spikes, matrix spike duplicates, and duplicates are used as appropriate for customer samples. This process is described in procedure TBE-4005 and in Section 7.0.

10.2.2 Inter-Laboratory Checks

TBE participates in Inter-lab performance evaluation (check) programs with multiple higher level labs. These programs provide blind matrices for the types of matrix/analyte combinations routinely processed by the Lab, if available. This program is described in procedure TBE-4006.

10.2.3 Data Reviews

Raw data and reports are reviewed by the Operations Manager, or designees. This review checks for data logic, expected results, procedure compliance, etc. (See Section 14.0).

10.3 Control of Sampling of Samples

Samples for analysis are supplied by customers preferably in quantities sufficient to allow re-verification analyses if needed. For state-reportable drinking water samples, if the client does not specify the sampling procedure(s) to be followed, the laboratory must inform the client as to how the samples should be obtained. This process is described in procedure TBE-1014.

The samples are prepared for analysis by analysts and then an aliquot (partial sample extraction) is taken from the homogeneous customer sample for the initial analysis. Methods specify standard volumes of sample material required. Sampling data is recorded in LIMS and/or logbooks.

10.4 Reference Standards / Material

10.4.1 Weights and Temperatures

Reference standards are used by the Laboratory's calibration vendor to calibrate the Lab's working instruments measuring weights and thermometers.

10.4.2 Radioactive Materials

Reference radioactive standards, traceable to NIST, are procured from higher level laboratories. These reference materials are maintained in the standards area and are diluted down for use by laboratory analysts. All original and diluted volumes are fully traceable to source, analyst, dilution, and reference dates (see Section 11.0 and procedure TBE-1009).

11.0 EQUIPMENT MAINTENANCE AND CALIBRATION

11.1 General

There are two types of equipment used by the Laboratory: support equipment (scales, glassware, weights, thermometers, etc.) and instruments for counting. Standards traceable to NIST are used for calibration and are of the needed accuracy for laboratory operations. Procedures TBE-1009, TBE-4018, and TBE-4019 describe the calibration and maintenance programs.

11.2 Support Equipment

Analytical support equipment is purchased with the necessary accuracies and appropriate calibration data. If needed, initial calibration by the Laboratory or its calibration vendor is performed. Recalibration schedules are established and equipment recalibrated by the scheduled date by a calibration vendor or by Laboratory personnel. Maintenance is performed, as needed, per manufacturer's manuals or lab procedures.

In addition to calibrations and recalibrations, checks are made on the continued accuracy of items as described in procedure TBE-1009. Records are maintained of calibration and specified checks.

11.3 Instruments

Instruments receive initial calibration using radioactive sources traceable to NIST. The initial calibration establishes statistical limits of variation that are used to set control limits for future checks and recalibration. This process is described in procedure TBE-4018. Instruments are maintained per Instrument Manual requirements. Recalibrations are performed per the instrument procedure.

Between calibrations, check sources are used to assure no significant changes have occurred in the calibration of items. Background checks are performed to check for possible radioactive contamination. Background values are used to adjust sample results. Hardware and software are safeguarded from adjustments that could invalidate calibrations or results.

11.4 Nonconformances and Corrective Actions

If calibrations or checks indicate a problem, the nonconformance system (Section 12.0) and corrective action system (Section 13.0) are initiated, if required, to document the problem and its resolution. Equipment is promptly removed from service if questionable.

11.5 Records

Records of calibrations are maintained. Calibration certificates from calibration vendors are maintained by QA. Other calibration data and check data is maintained in log books, LIMS, or instrument software as appropriate and as described in procedures TBE-1009, TBE-4018, and TBE-4019.

12.0 NONCONFORMANCE CONTROLS

12.1 General

The nonconformance control system is implemented whenever a nonconforming condition on any aspect of Laboratory analysis, testing, internal/external audit findings or results exist. The system takes graded actions based on the nature and severity of the nonconformance. Nonconforming items or processes are controlled to prevent inadvertent use. Nonconformances are documented and dispositioned. Notification is made to affected organizations, including clients. Procedure TBE-1010 describes the procedures followed. Sample results are only reported after resolution.

12.2 Responsibility and Authority

Each Laboratory employee has the responsibility to report nonconformances and the authority to stop performing nonconforming work or using nonconforming equipment. Laboratory supervision can disposition and take corrective actions on minor problems. Any significant problem is documented by QA using the Laboratory's NCR system per procedure TBE-1010. QA conducts or assures the conduct of cause analyses, disposition of items or data, and initiation of corrective action if the nonconformance could recur.

12.3 10CFR21 Reporting

The QA Manager reviews NCR's for possible need of customer and/or NRC notification per the requirements of 10CFR21. Procedure TBE-1011 is followed in this review and for any required reporting.

13.0 CORRECTIVE AND PREVENTIVE ACTION

13.1 General

The Laboratory takes corrective actions on significant nonconformances (see Section 12.0). It also initiates preventive and improvement actions per the Company Quality Policy (see Section 2.0). The procedures for Corrective Action/Preventive Action systems are contained in procedure TBE-1012.

13.2 Corrective Actions

Corrective actions are taken by Operations and Quality to promptly correct significant conditions adverse to quality. The condition is identified and cause analysis is performed to identify root causes. Solutions are evaluated and the optimum one selected that will prevent recurrence, can be implemented by the Laboratory, allows the Laboratory to meet its other goals, and is commensurate with the significance of the problem. All steps are documented, action plans developed for major efforts, and reports made to Management. QA verifies the implementation effectiveness. Procedure TBE-1012 provides instructions and designates authorities and responsibilities.

13.3 Preventive Actions

Preventive actions are improvements intended to reduce the potential for nonconformances. Possible preventive actions are developed from suggestions from employees and from analysis of Laboratory technical and quality systems by management. If preventive actions or improvements are selected for investigation, the issues, investigation, recommendations, and implementation actions are documented. Follow-up verifies effectiveness.

14.0 RESULTS ANALYSIS AND REPORTING

14.1 General

The Laboratory's role is to provide measurement-based information to clients that is technically valid, legally defensible, and of known quality.

14.2 Results Review

The results obtained from analytical efforts are collected and reviewed by the Operations Manager and the Project Manager. This review verifies the reasonableness and consistency of the results. It includes review of sample and the related QC activity data. Procedure TBE-4002 describes the process. Any deficiencies are corrected by re-analyses, recalculations, or corrective actions per Sections 12.0 and 13.0. Use of the LIMS with its automatic data loading features (see procedure TBE-4017) minimizes the possibility of transcription or calculation errors.

14.3 Reports

Reports range from simple results reporting to elaborate analytical reports based on the client requirements and imposed specifications and standards (see procedure TBE-4004). Reports present results accurately, clearly, unambiguously, objectively, and as required by the applicable Method(s). Reports include reproduction restrictions, information on any deviations from methods, and any needed data qualifiers based on QC data. If any data is supplied by analytical subcontractors (see Section 8.0), it is clearly identified and attributed to that Laboratory by either name or accreditation number.

If results are faxed or transmitted electronically, confidentiality statements are included in case of receipt by other than the intended client.

Reports are reviewed by the Project Manager and approved by the Operations Manager, or designee, and record copies kept in file (See Section 15.0).

15.0 RECORDS

15.1 General

The Laboratory collects generated data and information related to quality or technical data and maintains them as records. Records are identified, prepared, reviewed, placed in storage, and maintained as set forth in procedure TBE-1003.

15.2 Type of Records

All original observations, calculations, derived data, calibration data, and test reports are included. In addition QA data such as audits, management reviews, corrective and preventive actions, manuals, and procedures are included.

15.3 Storage and Retention

Records are stored in files after completion in the lab. Files are in specified locations and under the control of custodians. Filing systems provide for retrieval. Electronic files are kept on Company servers (with regular back up) or on media stored in fireproof file cabinets. Records are kept in Laboratory files for at least 2 years after the last entry and then in Company files for another year as a minimum. Records generated for nonpotable and potable water are maintained for 5 years and 10 years, respectively. Some customers specify larger periods (up to 7 years) which is also met. Generic records supporting multiple customers are kept for the longest applicable period.

15.4 Destruction or Disposal

Records may be destroyed after the retention period and after client notification and acceptance, if required. If the Laboratory closes, records will go into company storage in Huntsville unless otherwise directed by customers. If the Laboratory is sold, either the new owner will accept record ownership or the records will go into Company storage as stated above.

16.0 ASSESSMENTS

16.1 General

Assessments consist of internal audits and management reviews as set forth in procedure TBE-1013.

16.2 Audits

Internal audits are planned, performed at least annually on all areas of the quality system, and are performed by qualified people who are independent from the activity audited. Audits are coordinated by the Quality Assurance Manager who verifies that audit plans and checklists are generated and the results documented. Reports include descriptions of any findings and provide the auditor's assessment of the effectiveness of the audited activity. Report data includes personnel contacted.

Audit findings are reviewed with management and corrective actions agreed to and scheduled. Follow up is performed by QA to verify accomplishment and effectiveness of the corrective action.

16.3 Management Reviews

The Annual Quality Assurance Report, prepared for some clients, is the Management Review vehicle. These reports cover audit results, corrective and preventive actions, external assessments, and QC and inter-laboratory performance checks. The report is reviewed with Management by the QA Manager for the continued suitability of the Quality Program and its effectiveness. Any needed improvements are defined, documented, and implemented. Follow ups are made to verify implementation and effectiveness.

TELEDYNE
BROWN ENGINEERING, INC.
A Teledyne Technologies Company

ATTACHMENT A

EPA Manual Cross Reference to TBE's QA Manual

EPA QA Manual Element	TBE QA Manual Section	TBE Procedure Number
1. Laboratory Organization and Responsibility	3.0 Organization, Authority and Responsibility	TBE-1002 Organization and Responsibility TBE-1006 Job Descriptions
2. Process used to identify clients' data quality objectives	1.0 Knoxville QAM Section Introduction 5.0 Customer Interfaces	TBE-1014 RFP, Contract Review, and Project Set-Up
3. SOPs with dates of last revision	1.0 Knoxville QAM Section Introduction, Table 1-1 6.0 Documentation Generation and Control	TBE-1008 Documents and Document Control
4. Field sampling procedures	9.0 Test Sample Identification and Control *Knoxville currently does no field sampling*	TBE-4003 Sample Receipt and Control
5. Laboratory sampling receipt and handling procedures	7.0 Design of Laboratory Controls 9.0 Test Sample Identification and Control	TBE-4003 Sample Receipt and Control
6. Instrument calibration procedures	11.0 Equipment Maintenance and Calibration	TBE-1009 Calibration Systems TBE-3001-3006, 3009 individual systems TBE-4018 Instrument Setup, Maintenance and Calibration
7. Analytical procedures	1.0 Knoxville QA Section Introduction, Table 1-1	Procedures 2000 series
8. Data reduction, validation, reporting and verification	7.0 Design of Laboratory Controls 14.0 Results Analysis and Reporting	TBE-1001 Validation and Verification of Computer Programs for Radiochemistry Data Reduction TBE-4002 Quality Control Checking of Analytical Data TBE-4011 Quality Calculations and Charting TBE-4017 LIMS
9. Type of QC checks and the frequency of their use	7.0 Design of Laboratory Controls 10.0 Special Processes, Inspection and Test	TBE-4005 Quality Control Samples
10. List schedule of internal and external system and data quality audits and Inter-laboratory comparisons	16.0 Assessments 7.0 Design of Laboratory Controls 10.0 Special Processes, Inspection and Test	TBE-1013 Audits and Management Review TBE-4006 Inter-Laboratory Performance Evaluation Programs
11. Preventive maintenance procedures and schedules	11.0 Equipment Maintenance and Calibration	TBE-1009 Calibration Systems TBE-3001-3006, 3009 individual systems TBE-4018 Instrument Setup, Maintenance and Calibration
12. Corrective action contingencies	13.0 Corrective and Preventive Action	TBE-1012 Corrective and Preventive Action
13. Record-keeping procedures	15.0 Records	TBE-1003 Control, Retention and Disposal of Quality Assurance Records TBE-1008 Documents and Document Control

Quality Assurance Manual

TestAmerica Seattle
5755 8th Avenue East
Tacoma, WA 98424
Phone No. (253) 922-2310
Fax No. (253) 922-5047
www.testamericainc.com

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED

Facility Distribution No. Uncontrolled **Distributed To:**_____

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

ATTACHMENT 2

METHOD DETECTION LIMIT STUDIES

TestAmerica West Sacramento

Detection Limit (DL) Study

Date Analyzed:	2/17/2011			Matrix:	Soil										
Method ID	1668A			Instrument	12D5										
Method Description	1668A	pg/g		Analyst:	kss										
Prep Method / Date				Quality Assurance											
Analyte	Spike pg/g	MDL #1 pg/g	MDL #2 pg/g	MDL #3 pg/g	MDL #4 pg/g	MDL #5 pg/g	MDL #6 pg/g	MDL #7 pg/g	AVE. pg/g	%R	SD pg/g	MDL pg/g	RL pg/g	AVE/MDL	* Status (see footnote)
PCB-1	2.00	1.862	1.797	2.106	2.041	2.101	2.383	1.857	2	101%	0.20	0.64	2	3.2	PASS
PCB-2	2.00	1.549	1.654	1.695	1.542	2.252	2.068	1.786	2	90%	0.27	0.85	2	2.1	PASS
PCB-3	2.00	1.523	1.818	2.718	1.821	1.883	2.809	1.763	2	102%	0.50	1.58	2	1.3	PASS
PCB-4 through PCB-15 (use results from higher spiking level immediately after this Table															
PCB-16	2.00	1.924	1.792	2.472	2.130	2.029	2.333	1.915	2	104%	0.24	0.77	2	2.7	PASS
PCB-17	2.00	1.675	1.428	1.954	1.546	1.642	1.645	1.857	2	84%	0.18	0.56	2	3.0	PASS
PCB-18/30	4.00	3.342	3.014	4.350	3.071	3.712	3.797	3.659	4	89%	0.47	1.46	4	2.4	PASS
PCB-19	2.00	1.959	1.652	2.044	2.134	1.764	1.946	2.183	2	98%	0.19	0.60	2	3.2	PASS
PCB-20/28	4.00	4.443	3.713	5.360	3.554	4.159	4.130	4.571	4	107%	0.60	1.89	4	2.3	PASS
PCB-21/33	4.00	3.496	3.531	3.775	3.449	3.501	3.722	3.997	4	91%	0.20	0.63	4	5.8	PASS
PCB-22	2.00	2.011	1.786	2.583	1.998	2.038	2.202	2.139	2	105%	0.25	0.78	2	2.7	PASS
PCB-23	2.00	1.463	1.432	1.614	1.507	1.475	1.558	1.476	2	75%	0.06	0.20	2	7.7	PASS
PCB-24	2.00	1.342	1.296	1.312	1.337	1.321	1.341	1.453	1	67%	0.05	0.16	2	8.3	PASS
PCB-25	2.00	1.713	1.513	1.525	1.460	1.655	1.656	1.538	2	79%	0.09	0.29	2	5.4	PASS
PCB-26/29	4.00	3.177	2.935	3.430	3.086	3.323	3.331	3.657	3	82%	0.24	0.74	4	4.4	PASS
PCB-27	2.00	1.616	1.384	1.550	1.418	1.456	1.498	1.546	1	75%	0.08	0.26	2	5.8	PASS
PCB-31	2.00	2.794	2.089	3.934	2.180	2.803	2.405	2.941	3	137%	0.62	1.95	2	1.4	PASS
PCB-32	2.00	1.770	1.477	2.069	1.521	1.782	1.751	1.786	2	87%	0.20	0.62	2	2.8	PASS
PCB-34	2.00	1.464	1.417	1.523	1.510	1.466	1.538	1.617	2	75%	0.06	0.20	2	7.4	PASS
PCB-35	2.00	1.673	1.610	1.803	1.669	1.783	2.029	1.869	2	89%	0.14	0.45	2	4.0	PASS
PCB-36	2.00	1.682	1.700	1.673	1.837	1.803	1.750	1.754	2	87%	0.06	0.19	2	9.0	PASS
PCB-37	2.00	2.000	1.791	2.178	2.019	2.025	2.146	1.991	2	101%	0.13	0.39	2	5.1	PASS
PCB-38	2.00	1.611	1.669	1.607	1.725	1.717	1.921	1.868	2	87%	0.12	0.38	2	4.5	PASS
PCB-39	2.00	1.843	1.696	1.620	1.715	1.827	1.922	1.826	2	89%	0.10	0.33	2	5.4	PASS
PCB-40/41/71	6.00	4.646	4.714	5.404	4.772	4.896	4.838	4.973	5	82%	0.25	0.79	6	6.2	PASS
PCB-42	2.00	1.577	1.743	2.016	1.616	1.638	1.693	1.668	2	85%	0.15	0.46	2	3.7	PASS
PCB-43	2.00	1.331	1.350	1.552	1.339	1.498	1.425	1.503	1	71%	0.09	0.28	2	5.0	PASS
PCB-44/47/65	6.00	5.371	4.815	6.444	4.961	5.606	5.427	5.673	5	91%	0.53	1.68	6	3.3	PASS
PCB-45/51	4.00	2.853	2.671	2.986	2.599	2.590	2.810	2.908	3	69%	0.16	0.49	4	5.7	PASS
PCB-46	2.00	1.484	1.476	1.443	1.426	1.403	1.397	1.498	1	72%	0.04	0.13	2	11.5	See QA
PCB-48	2.00	1.680	1.647	1.992	1.522	1.666	1.556	1.637	2	84%	0.15	0.48	2	3.5	PASS
PCB-49/69	4.00	3.330	2.783	3.617	2.957	3.173	3.213	3.238	3	80%	0.27	0.84	4	3.8	PASS
PCB-50/53	4.00	2.632	2.532	3.038	2.550	2.675	2.522	3.013	3	68%	0.22	0.70	4	3.9	PASS
PCB-52	2.00	2.381	1.931	3.598	1.968	2.293	2.076	2.465	2	119%	0.57	1.80	2	1.3	PASS

PCB-54	2.00	1.545	1.681	1.684	1.630	1.604	1.548	1.600	2	81%	0.06	0.18	2	9.2	PASS
PCB-55	2.00	1.574	1.667	1.639	1.786	1.733	1.622	1.801	2	84%	0.09	0.27	2	6.2	PASS
PCB-56	2.00	1.946	2.024	2.305	1.894	1.951	2.217	2.078	2	103%	0.15	0.48	2	4.3	PASS
PCB-57	2.00	1.533	1.469	1.432	1.642	1.461	1.423	1.633	2	76%	0.09	0.29	2	5.2	PASS
PCB-58	2.00	1.557	1.631	1.666	1.620	1.713	1.559	1.563	2	81%	0.06	0.19	2	8.6	PASS
PCB-59/62/75	6.00	4.060	4.003	4.324	3.959	4.223	4.417	4.530	4	70%	0.22	0.69	6	6.1	PASS
PCB-60	2.00	1.901	1.922	2.104	1.914	1.923	1.960	1.911	2	97%	0.07	0.22	2	8.7	PASS
PCB-61/70/74/76	8.00	7.256	7.034	8.992	7.298	7.435	7.673	7.580	8	95%	0.65	2.03	8	3.8	PASS
PCB-63	2.00	1.655	1.643	1.733	1.827	1.753	1.670	1.801	2	86%	0.07	0.23	2	7.5	PASS
PCB-64	2.00	1.633	1.757	2.251	1.664	1.691	1.741	1.874	2	90%	0.21	0.67	2	2.7	PASS
PCB-66	2.00	2.154	2.012	2.873	2.297	2.176	2.455	2.460	2	117%	0.28	0.89	2	2.6	PASS
PCB-67	2.00	1.566	1.677	1.629	1.732	1.688	1.836	1.648	2	84%	0.09	0.27	2	6.3	PASS
PCB-68	2.00	1.632	1.624	1.625	1.751	1.678	1.822	1.823	2	85%	0.09	0.28	2	6.0	PASS
PCB-72	2.00	1.301	1.241	1.342	1.228	1.341	1.376	1.394	1	66%	0.06	0.20	2	6.5	PASS
PCB-73	2.00	1.467	1.261	1.459	1.561	1.308	1.592	1.456	1	72%	0.12	0.38	2	3.8	PASS
PCB-77	2.00	2.007	1.953	2.136	1.945	1.950	2.084	2.088	2	101%	0.08	0.25	2	8.2	PASS
PCB-78	2.00	1.689	1.656	1.674	1.793	1.885	1.835	1.847	2	88%	0.09	0.29	2	6.0	PASS
PCB-79	2.00	1.421	1.453	1.607	1.588	1.537	1.549	1.725	2	78%	0.10	0.32	2	4.9	PASS
PCB-80	2.00	1.750	1.631	1.636	1.733	1.841	1.653	1.602	2	85%	0.09	0.27	2	6.3	PASS
PCB-81	2.00	1.793	1.757	1.679	1.699	1.806	1.908	1.821	2	89%	0.08	0.24	2	7.3	PASS
PCB-82	2.00	1.719	1.753	1.704	1.739	1.667	1.656	1.744	2	86%	0.04	0.12	2	14.4	See QA
PCB-83/99	4.00	3.259	3.403	3.336	3.268	3.082	3.242	3.409	3	82%	0.11	0.35	4	9.3	PASS
PCB-84	2.00	1.625	1.649	1.810	1.594	1.543	1.533	1.665	2	82%	0.09	0.29	2	5.6	PASS
PCB-85/110/116/117	8.00	8.535	9.245	9.427	9.123	9.017	8.993	9.018	9	113%	0.28	0.87	8	10.5	See QA
PCB-86/87/97/108/119/125	12.00	8.668	8.994	8.763	8.623	8.538	8.943	9.564	9	74%	0.35	1.09	12	8.1	PASS
PCB-88/91	4.00	3.031	2.826	3.136	2.728	2.933	2.868	3.096	3	74%	0.15	0.47	4	6.3	PASS
PCB-89	2.00	1.445	1.534	1.617	1.531	1.437	1.474	1.531	2	75%	0.06	0.20	2	7.7	PASS
PCB-90/101/113	6.00	4.901	5.025	5.226	4.863	5.135	5.042	5.182	5	84%	0.14	0.43	6	11.7	See QA
PCB-92	2.00	1.727	1.680	1.627	1.526	1.700	1.615	1.606	2	82%	0.07	0.21	2	7.7	PASS
PCB-93/98/100/102	8.00	5.824	5.862	5.844	5.572	5.419	5.711	5.862	6	72%	0.17	0.54	8	10.6	See QA
PCB-94	2.00	1.483	1.409	1.614	1.372	1.356	1.367	1.371	1	71%	0.09	0.30	2	4.8	PASS
PCB-95	2.00	1.851	1.855	2.288	1.910	1.861	1.841	1.795	2	96%	0.17	0.53	2	3.6	PASS
PCB-96	2.00	1.235	1.359	1.471	1.418	1.288	1.269	1.442	1	68%	0.09	0.29	2	4.7	PASS
PCB-103	2.00	1.390	1.360	1.330	1.350	1.488	1.517	1.561	1	71%	0.09	0.29	2	4.9	PASS
PCB-104	2.00	1.826	1.869	1.913	2.047	2.040	1.962	1.909	2	97%	0.08	0.26	2	7.4	PASS
PCB-105	2.00	1.927	1.898	2.181	1.998	2.142	2.277	2.155	2	104%	0.14	0.45	2	4.7	PASS
PCB-106	2.00	1.638	1.525	1.628	1.776	1.911	1.670	1.652	2	84%	0.12	0.39	2	4.3	PASS
PCB-109	2.00	1.712	1.490	1.483	1.723	1.717	1.562	1.559	2	80%	0.11	0.34	2	4.7	PASS
PCB-107/124	4.00	3.283	3.330	3.359	3.337	3.387	3.315	3.235	3	83%	0.05	0.16	4	21.1	See QA
PCB-111	2.00	1.643	1.692	1.565	1.558	1.613	1.515	1.693	2	81%	0.07	0.22	2	7.5	PASS
PCB-112	2.00	1.436	1.398	1.665	1.607	1.616	1.541	1.485	2	77%	0.10	0.31	2	4.9	PASS
PCB-114	2.00	1.890	1.855	1.894	1.898	2.103	2.071	2.071	2	98%	0.11	0.34	2	5.9	PASS
PCB-115	2.00	1.677	1.093	1.231	1.188	1.230	1.322	1.534	1	66%	0.21	0.65	2	2.0	PASS
PCB-118	2.00	2.108	2.303	2.335	2.543	2.574	2.465	2.460	2	120%	0.16	0.51	2	4.7	PASS
PCB-120	2.00	1.540	1.543	1.580	1.614	1.603	1.621	1.719	2	80%	0.06	0.19	2	8.4	PASS
PCB-121	2.00	1.413	1.478	1.486	1.496	1.470	1.441	1.550	1	74%	0.04	0.14	2	10.9	See QA
PCB-122	2.00	1.764	1.835	1.803	1.873	1.796	1.891	1.856	2	92%	0.05	0.14	2	12.8	See QA
PCB-123	2.00	1.723	1.828	1.897	1.821	1.944	2.067	2.122	2	96%	0.14	0.44	2	4.3	PASS
PCB-126	2.00	1.731	2.031	1.989	1.918	2.057	1.996	2.080	2	99%	0.12	0.37	2	5.3	PASS
PCB-127	2.00	1.706	1.820	1.722	1.779	1.892	1.684	1.724	2	88%	0.07	0.23	2	7.6	PASS
PCB-128/166	4.00	3.474	3.351	3.535	3.383	3.449	3.576	3.534	3	87%	0.08	0.26	4	13.2	See QA

PCB-129/138/163	6.00	5.169	5.619	5.319	5.698	5.621	6.215	5.275	6	93%	0.35	1.11	6	5.0	PASS
PCB-130	2.00	1.711	1.705	1.644	1.715	1.840	1.596	1.767	2	86%	0.08	0.25	2	6.9	PASS
PCB-131	2.00	1.425	1.519	1.490	1.444	1.516	1.485	1.461	1	74%	0.04	0.11	2	13.3	See QA
PCB-132	2.00	1.759	1.658	1.847	1.901	1.766	1.915	1.864	2	91%	0.09	0.29	2	6.3	PASS
PCB-133	2.00	1.475	1.521	1.621	1.526	1.530	1.502	1.474	2	76%	0.05	0.16	2	9.7	PASS
PCB-134/143	4.00	2.856	3.010	2.876	2.678	2.886	2.781	2.947	3	72%	0.11	0.34	4	8.4	PASS
PCB-135/151	4.00	3.124	3.162	3.007	3.153	3.127	3.026	3.022	3	77%	0.07	0.21	4	14.6	See QA
PCB-136	2.00	1.386	1.369	1.400	1.411	1.477	1.321	1.420	1	70%	0.05	0.15	2	9.3	PASS
PCB-137	2.00	1.712	1.415	1.471	1.429	1.675	1.527	1.717	2	78%	0.13	0.42	2	3.7	PASS
PCB-139/140	4.00	2.936	2.939	2.932	2.841	2.803	2.862	2.964	3	72%	0.06	0.19	4	15.2	See QA
PCB-141	2.00	1.630	1.535	1.713	1.820	1.737	1.847	1.678	2	85%	0.11	0.34	2	5.1	PASS
PCB-142	2.00	1.477	1.393	1.607	1.467	1.419	1.480	1.527	1	74%	0.07	0.22	2	6.7	PASS
PCB-144	2.00	1.416	1.486	1.426	1.436	1.396	1.580	1.506	1	73%	0.06	0.20	2	7.2	PASS
PCB-145	2.00	1.271	1.279	1.329	1.200	1.245	1.217	1.346	1	63%	0.05	0.17	2	7.4	PASS
PCB-146	2.00	1.648	1.701	1.728	1.652	1.606	1.620	1.674	2	83%	0.04	0.14	2	12.2	See QA
PCB-147/149	4.00	3.469	3.511	3.352	3.609	3.426	3.753	3.452	4	88%	0.13	0.42	4	8.4	PASS
PCB-148	2.00	1.392	1.492	1.443	1.476	1.371	1.389	1.405	1	71%	0.05	0.15	2	9.7	PASS
PCB-150	2.00	1.343	1.335	1.359	1.446	1.210	1.261	1.323	1	66%	0.07	0.23	2	5.6	PASS
PCB-152	2.00	1.366	1.246	1.334	1.153	1.374	1.399	1.309	1	66%	0.09	0.27	2	4.9	PASS
PCB-153/168	4.00	3.665	3.858	3.668	3.906	3.543	3.971	3.657	4	94%	0.16	0.50	4	7.6	PASS
PCB-154	2.00	1.379	1.344	1.429	1.285	1.370	1.332	1.346	1	68%	0.04	0.14	2	9.7	PASS
PCB-155	2.00	1.822	1.744	1.795	1.849	1.939	1.918	1.833	2	92%	0.07	0.21	2	8.7	PASS
PCB-156/157	4.00	3.690	3.847	4.446	3.820	3.985	3.913	3.870	4	98%	0.24	0.76	4	5.2	PASS
PCB-158	2.00	1.590	1.658	1.658	1.699	1.773	1.828	1.743	2	85%	0.08	0.25	2	6.8	PASS
PCB-159	2.00	1.825	1.731	1.795	1.569	1.607	1.816	1.744	2	86%	0.10	0.32	2	5.4	PASS
PCB-160	2.00	1.921	1.441	1.691	1.661	1.604	1.648	2.008	2	86%	0.19	0.61	2	2.8	PASS
PCB-161	2.00	1.497	1.369	1.428	1.331	1.411	1.384	1.528	1	71%	0.07	0.22	2	6.4	PASS
PCB-162	2.00	1.747	1.714	1.874	1.741	1.912	1.887	1.828	2	91%	0.08	0.25	2	7.2	PASS
PCB-164	2.00	1.624	1.650	2.020	1.798	1.725	1.800	1.662	2	88%	0.14	0.43	2	4.1	PASS
PCB-165	2.00	1.558	1.446	1.514	1.630	1.576	1.481	1.658	2	78%	0.08	0.24	2	6.4	PASS
PCB-167	2.00	1.922	2.058	2.007	1.906	1.982	2.181	2.105	2	101%	0.10	0.31	2	6.5	PASS
PCB-169	2.00	1.857	1.854	2.063	1.770	1.965	1.965	1.984	2	96%	0.10	0.31	2	6.1	PASS
PCB-170	2.00	2.234	2.091	2.127	2.180	2.102	2.379	2.215	2	109%	0.10	0.31	2	7.0	PASS
PCB-171/173	4.00	3.432	3.582	3.393	3.502	3.581	3.646	3.697	4	89%	0.11	0.35	4	10.2	See QA
PCB-172	2.00	1.868	1.903	1.645	1.806	1.954	1.793	1.762	2	91%	0.10	0.32	2	5.7	PASS
PCB-174	2.00	1.538	2.029	2.001	1.927	1.879	1.793	2.025	2	94%	0.18	0.55	2	3.4	PASS
PCB-175	2.00	1.534	1.641	1.714	1.671	1.590	1.705	1.657	2	82%	0.06	0.20	2	8.2	PASS
PCB-176	2.00	1.596	1.561	1.642	1.601	1.478	1.583	1.618	2	79%	0.05	0.17	2	9.5	PASS
PCB-177	2.00	1.763	1.822	2.150	1.917	1.806	1.957	1.809	2	94%	0.13	0.42	2	4.5	PASS
PCB-178	2.00	1.764	1.753	1.875	1.749	1.727	1.729	1.717	2	88%	0.05	0.17	2	10.4	See QA
PCB-179	2.00	1.582	1.445	1.607	1.727	1.539	1.577	1.680	2	80%	0.09	0.29	2	5.5	PASS
PCB-180/193	4.00	3.658	4.174	3.952	4.155	3.854	4.070	3.881	4	99%	0.18	0.58	4	6.8	PASS
PCB-181	2.00	1.662	1.659	1.778	1.665	1.689	1.752	1.740	2	85%	0.05	0.15	2	11.0	See QA
PCB-182	2.00	1.633	1.828	1.788	1.652	1.695	1.696	1.723	2	86%	0.07	0.22	2	7.8	PASS
PCB-183	2.00	1.660	1.555	1.703	1.856	1.771	1.823	1.764	2	87%	0.10	0.32	2	5.4	PASS
PCB-184	2.00	1.510	1.537	1.470	1.550	1.498	1.466	1.591	2	76%	0.04	0.14	2	10.7	See QA
PCB-185	2.00	1.608	1.643	1.815	1.794	1.765	1.685	1.445	2	84%	0.13	0.41	2	4.1	PASS
PCB-186	2.00	1.571	1.547	1.691	1.528	1.466	1.529	1.616	2	78%	0.07	0.23	2	6.9	PASS
PCB-187	2.00	1.935	2.098	1.950	1.977	1.883	1.873	1.996	2	98%	0.08	0.24	2	8.2	PASS
PCB-188	2.00	1.947	1.785	1.816	1.817	1.781	1.773	1.702	2	90%	0.07	0.23	2	7.7	PASS
PCB-189	2.00	2.134	1.974	1.932	2.009	2.297	2.231	2.252	2	106%	0.15	0.46	2	4.6	PASS

PCB-190	2.00	1.734	1.755	1.913	1.919	1.801	1.948	2.010	2	93%	0.11	0.33	2	5.7	PASS
PCB-191	2.00	1.594	1.771	1.961	1.828	1.846	1.755	1.823	2	90%	0.11	0.35	2	5.1	PASS
PCB-192	2.00	1.743	1.773	1.768	1.797	1.874	1.830	1.719	2	89%	0.05	0.16	2	10.8	See QA
PCB-194	2.00	1.706	1.846	1.872	1.729	1.914	1.965	2.001	2	93%	0.11	0.35	2	5.3	PASS
PCB-195	2.00	1.742	1.647	1.734	1.767	1.770	1.792	1.995	2	89%	0.11	0.33	2	5.3	PASS
PCB-196	2.00	1.644	1.900	1.784	1.767	1.738	1.788	1.907	2	89%	0.09	0.29	2	6.2	PASS
PCB-197	2.00	1.527	1.454	1.482	1.596	1.579	1.580	1.755	2	78%	0.10	0.31	2	5.1	PASS
PCB-198/199	4.00	3.278	3.441	3.453	3.518	3.521	3.282	3.291	3	85%	0.11	0.35	4	9.7	PASS
PCB-200	2.00	1.823	1.722	1.572	1.692	1.659	1.665	1.604	2	84%	0.08	0.26	2	6.5	PASS
PCB-201	2.00	1.528	1.587	1.614	1.675	1.570	1.566	1.559	2	79%	0.05	0.15	2	10.6	See QA
PCB-202	2.00	1.581	1.591	1.656	1.707	1.583	1.672	1.678	2	82%	0.05	0.16	2	10.0	PASS
PCB-203	2.00	1.598	1.554	1.775	1.798	1.772	1.857	1.736	2	86%	0.11	0.35	2	5.0	PASS
PCB-204	2.00	1.622	1.574	1.570	1.524	1.502	1.573	1.561	2	78%	0.04	0.12	2	12.8	See QA
PCB-205	2.00	1.730	1.741	1.712	1.748	1.876	1.930	1.841	2	90%	0.08	0.27	2	6.7	PASS
PCB-206	2.00	1.882	1.797	1.891	1.858	1.997	2.107	2.190	2	98%	0.14	0.45	2	4.3	PASS
PCB-207	2.00	1.762	1.763	1.700	1.746	1.530	1.760	1.760	2	86%	0.09	0.27	2	6.4	PASS
PCB-208	2.00	1.857	1.800	1.835	1.795	1.803	1.830	1.946	2	92%	0.05	0.16	2	11.1	See QA
PCB-209	2.00	2.363	1.965	2.410	2.072	2.135	2.509	2.286	2	112%	0.20	0.62	2	3.6	PASS
Surrogates															
PCB-1L	200.0	113.1	77.5	100.6	99.3	66.2	68.1	66.9	85	42%	19.41	60.93	200.0	1.4	PASS
PCB-3L	200.0	144.4	99.4	128.0	123.5	72.9	79.3	81.2	104	52%	28.01	87.97	200.0	1.2	PASS
PCB-4L	200.0	107.2	74.3	86.0	82.6	76.5	79.1	77.5	83	42%	11.24	35.28	200.0	2.4	PASS
PCB-15L	200.0	167.4	137.1	144.1	153.2	106.8	102.0	108.9	131	66%	25.64	80.50	200.0	1.6	PASS
PCB-19L	200.0	123.1	102.8	110.0	110.6	111.0	104.4	115.8	111	56%	6.85	21.50	200.0	5.2	See QA
PCB-37L	200.0	197.4	172.0	165.4	186.4	139.1	131.5	140.3	162	81%	25.45	79.92	200.0	2.0	PASS
PCB-54L	200.0	96.0	90.4	92.7	90.0	84.8	80.6	87.7	89	44%	5.11	16.04	200.0	5.5	See QA
PCB-77L	200.0	172.4	164.9	153.2	170.8	132.7	128.7	122.9	149	75%	21.00	65.94	200.0	2.3	PASS
PCB-81L	200.0	164.0	156.6	146.4	161.2	122.7	117.0	116.5	141	70%	21.28	66.83	200.0	2.1	PASS
PCB-104L	200.0	85.3	85.1	83.1	85.8	114.5	108.6	110.4	96	48%	14.21	44.63	200.0	2.2	PASS
PCB-105L	200.0	145.8	146.0	142.6	153.7	146.0	144.3	135.1	145	72%	5.52	17.32	200.0	8.4	See QA
PCB-114L	200.0	139.8	139.4	134.0	143.9	138.6	134.5	131.2	137	69%	4.34	13.63	200.0	10.1	See QA
PCB-118L	200.0	143.1	141.9	135.6	145.1	141.1	137.3	130.9	139	70%	4.95	15.55	200.0	9.0	See QA
PCB-123L	200.0	141.3	140.3	136.2	145.2	139.1	136.3	130.1	138	69%	4.79	15.03	200.0	9.2	See QA
PCB-126L	200.0	144.8	147.8	142.5	160.9	145.9	149.0	134.4	146	73%	7.97	25.02	200.0	5.9	See QA
PCB-155L	200.0	108.5	111.9	108.7	111.5	106.9	102.4	107.6	108	54%	3.19	10.01	200.0	10.8	See QA
PCB-156L/157L	400.0	359.8	376.3	360.1	383.4	308.6	299.4	292.1	340	85%	38.54	121.03	400.0	2.8	PASS
PCB-167L	200.0	173.4	181.3	174.4	185.3	151.4	147.3	143.1	165	83%	17.39	54.62	200.0	3.0	PASS
PCB-169L	200.0	186.3	197.2	183.9	203.9	163.6	155.2	149.6	177	89%	21.10	66.26	200.0	2.7	PASS
PCB-188L	200.0	121.6	121.2	117.7	122.2	135.9	131.0	131.3	126	63%	6.79	21.31	200.0	5.9	See QA
PCB-189L	200.0	203.6	215.1	201.8	219.0	170.9	168.1	159.7	191	96%	24.31	76.32	200.0	2.5	PASS
PCB-202L	200.0	132.5	134.8	139.0	141.0	115.0	112.7	115.2	127	64%	12.36	38.80	200.0	3.3	PASS
PCB-205L	200.0	169.6	176.1	172.9	182.3	140.6	140.6	140.5	160	80%	18.93	59.44	200.0	2.7	PASS
PCB-206L	200.0	157.0	166.1	165.3	171.7	133.0	133.2	132.7	151	76%	17.65	55.43	200.0	2.7	PASS
PCB-208L	200.0	150.9	160.3	160.2	163.8	132.8	132.5	132.5	148	74%	14.56	45.73	200.0	3.2	PASS
PCB-209L	200.0	145.3	155.2	153.6	156.9	146.4	145.3	146.5	150	75%	5.10	16.03	200.0	9.4	See QA
PCB-28L	200.0	153.2	128.8	133.6	141.1	105.8	100.6	110.4	125	62%	19.66	61.73	200.0	2.0	PASS
PCB-111L	200.0	117.0	115.0	111.3	118.1	116.7	111.9	110.0	114	57%	3.18	9.97	200.0	11.5	See QA
PCB-178L	200.0	123.9	126.4	122.8	127.5	141.4	137.4	134.5	131	65%	7.19	22.58	200.0	5.8	See QA

* PASS = Met all criteria
PASS# = RL elevated due to the PFK interference in the second channel.

See QA = Met criteria but average/MDL was >5 for a water or >10 for other matrices
This is advisory and used to evaluate future spiking levels

FAIL: Did not meet criteria

MDL> RL: Met criteria but calculated MDL value unacceptably high

TestAmerica West Sacramento

Detection Limit (DL) Study for Dichloro PCBs only. Spiked at 10 pg/g to compensate for PFK interference to the 223.9974 mass.

Date Analyzed:	4/6/2011				Matrix:	Soil									
Method ID	1668A				Instrument		12D5								
Method Description	1668A			pg/g	Analyst:		kss								
Prep Method / Date					Quality Assurance										
Analyte	**Spike pg/g**	MDL #1 **pg/g**	MDL #2 **pg/g**	MDL #3 **pg/g**	MDL #4 **pg/g**	MDL #5 **pg/g**	MDL #6 **pg/g**	MDL #7 **pg/g**	**AVE. pg/g**	**%R**	**SD pg/g**	**MDL pg/g**	**RL pg/g**	**AVE/MDL**	
PCB-4	10.00	10.191	8.868	9.467	9.507	9.651	9.942	9.224	10	95%	0.44	1.38	10	6.9	**PASS**
PCB-5	10.00	6.990	7.355	7.554	7.117	7.679	8.395	7.679	8	75%	0.46	1.45	10	5.2	**PASS**
PCB-6	10.00	7.507	7.369	7.925	7.458	7.763	8.202	8.241	8	78%	0.36	1.12	10	7.0	**PASS**
PCB-7	10.00	4.912	5.762	5.744	6.145	6.547	6.850	6.405	6	61%	0.64	2.02	10	3.0	**PASS**
PCB-8	10.00	7.830	7.624	7.844	8.161	7.645	8.230	8.142	8	79%	0.25	0.79	10	10.0	**See QA**
PCB-9	10.00	7.988	7.284	7.658	7.468	7.529	7.874	7.800	8	77%	0.25	0.78	10	9.8	**PASS**
PCB-10	10.00	6.912	7.318	6.700	6.414	6.774	7.535	7.379	7	70%	0.41	1.30	10	5.4	**PASS**
PCB-11	10.00	15.324	13.165	13.867	20.631	14.464	12.867	13.000	15	148%	2.74	8.59	10	1.7	**PASS**
PCB-12/13	20.00	17.013	15.643	17.273	17.367	16.594	15.820	17.652	17	84%	0.78	2.45	10	6.8	**PASS**
PCB-14	10.00	7.989	7.113	8.131	8.119	7.913	7.764	8.148	8	79%	0.37	1.15	10	6.8	**PASS**
PCB-15	10.00	8.390	7.628	8.310	8.939	8.188	8.531	8.585	8	84%	0.40	1.27	10	6.6	**PASS**
Surrogates															
PCB-4L	200.0	81.4	82.0	83.9	60.6	74.2	65.8	71.9	74	37%	8.83	27.71	200.0	2.7	**PASS**
PCB-15L	200.0	99.9	93.6	99.0	77.4	87.7	72.6	85.4	88	44%	10.40	32.66	200.0	2.7	**PASS**

300.0_28D Method Detection Limits

Analyte	Spike Conc	Units	Active MDL	Calc MDL	Calc MDLb	Active RL	RL Rule	RL/MDL	Mean/MDL	MDL > 10%Spike	% Rec 50-150	Calc MDL/ ActiveMDL	95% Conf	Method	Mean Result	Mean % Rec	Calc Std Dev	N	Add Limits	Prep Method	Min Val	Max Val	Stud. T
Bromide	0.6	mg/L	0.25	0.20406847	0	1.0	Pass	4.9	3	Pass	Pass	.816	=	300.0_28D	0.6186	103.1	0.06806820109	8	TRUE		0.55370000	0.74270000	2.998

Analyte	Spike Conc	Units	Active MDL	Calc MDL	Calc MDLb	Active RL	RL Rule	RL/MDL	Mean/MDL	MDL > 10%Spike	% Rec 50-150	Calc MDL/ ActiveMDL	95% Conf	Method	Mean Result	Mean % Rec	Calc Std Dev	N	Add Limits	Prep Method	Min Val	Max Val	Stud. T
Chloride	0.8	mg/L	0.14	0.14025237	0.4209	0.9	Pass	6.4	8.4	Pass	Pass	1.002	=	300.0_28D	1.174625	146.828125	0.04678197913	8	TRUE		1.06000000	1.19700000	2.998

Analyte	Spike Conc	Units	Active MDL	Calc MDL	Calc MDLb	Active RL	RL Rule	RL/MDL	Mean/MDL	MDL > 10%Spike	% Rec 50-150	Calc MDL/ ActiveMDL	95% Conf	Method	Mean Result	Mean % Rec	Calc Std Dev	N	Add Limits	Prep Method	Min Val	Max Val	Stud. T
Fluoride	0.08	mg/L	0.03	0.04612021	0	0.2	Pass	4.3	1.9	Pass	Pass	1.537	=	300.0_28D	0.0853375	106.671875	0.01538365900	8	TRUE		0.05840000	0.09800000	2.998

Analyte	Spike Conc	Units	Active MDL	Calc MDL	Calc MDLb	Active RL	RL Rule	RL/MDL	Mean/MDL	MDL > 10%Spike	% Rec 50-150	Calc MDL/ ActiveMDL	95% Conf	Method	Mean Result	Mean % Rec	Calc Std Dev	N	Add Limits	Prep Method	Min Val	Max Val	Stud. T
Nitrate as N	0.08	mg/L	0.02	0.02581204	0.0098	0.2	Pass	7.7	2.8	Pass	Pass	1.291	=	300.0_28D	0.072625	90.78125	0.00860975360	8	TRUE		0.05970000	0.08210000	2.998

Analyte	Spike Conc	Units	Active MDL	Calc MDL	Calc MDLb	Active RL	RL Rule	RL/MDL	Mean/MDL	MDL > 10%Spike	% Rec 50-150	Calc MDL/ ActiveMDL	95% Conf	Method	Mean Result	Mean % Rec	Calc Std Dev	N	Add Limits	Prep Method	Min Val	Max Val	Stud. T
Nitrite as N	0.08	mg/L	0.03	0.06438629	0.0729	0.4	Pass	6.2	1.4	Pass	Pass	2.146	=	300.0_28D	0.091925	114.90625	0.02147641563	8	TRUE		0.06590000	0.13370000	2.998

Analyte	Spike Conc	Units	Active MDL	Calc MDL	Calc MDLb	Active RL	RL Rule	RL/MDL	Mean/MDL	MDL > 10%Spike	% Rec 50-150	Calc MDL/ ActiveMDL	95% Conf	Method	Mean Result	Mean % Rec	Calc Std Dev	N	Add Limits	Prep Method	Min Val	Max Val	Stud. T
Sulfate	0.6	mg/L	0.26	0.40934314	0.4263	1.2	Pass	2.9	2	Pass	Pass	1.574	=	300.0_28D	0.8379875	139.664583333	0.13653873796	8	TRUE		0.69950000	1.13280000	2.998

415.1 Method Detection Limits

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type
Total Organic Carbon	mg/L	0.19	1	415.1	0.151800548	0.062289866	146		-0.03345	0.36	0.324185	99th Percentile

6010B Method Detection Limits

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type
Ag	mg/Kg	0.56	2.5	6010B	0.000901962	0.158688339	170	3050B	-0.43	0.465	0.40825	99th Percentile
Al	mg/Kg	9.95	75	6010B	0.783422083	1.950447714	169	3050B	-4.16	6.315	5.5472	99th Percentile
As	mg/Kg	0.248	3	6010B	-0.018910986	0.129977523	176	3050B	-0.38	0.31	0.2775	99th Percentile
B	mg/Kg	2.2	125	6010B	0.063790475	0.444555485	175	3050B	-1.325	0.9	0.861366667	99th Percentile
Ba	mg/Kg	0.079	0.5	6010B	-0.001223507	0.033879672	173	3050B	-0.105	0.1	0.0828	99th Percentile
Be	mg/Kg	0.015	1	6010B	-0.000317919	0.004318372	173	3050B	-0.015	0.01	0.01	99th Percentile
Bi	mg/Kg	0.21	14	6010B	0.035107527	0.102169412	155	3050B	-0.185	0.32	0.2815	99th Percentile
Ca	mg/Kg	10	55	6010B	1.248383533	2.735573217	166	3050B	-8.3	12.75	11.3555	99th Percentile
Cd	mg/Kg	0.049	1	6010B	-0.002428571	0.007288338	175	3050B	-0.025	0.02	0.0163	99th Percentile
Co	mg/Kg	0.025	1	6010B	-0.005596591	0.009231114	176	3050B	-0.03	0.02	0.015	99th Percentile
Cr	mg/Kg	0.093	1.3	6010B	0.011839081	0.09541093	174	3050B	-0.265	0.275	0.21635	99th Percentile
Cu	mg/Kg	0.4	2.5	6010B	-0.003153411	0.216555831	176	3050B	-0.695	0.58	0.50375	99th Percentile
Fe	mg/Kg	15.5	65	6010B	0.182121233	4.064192579	165	3050B	-12.35	10.7	10.4138	99th Percentile
K	mg/Kg	6.81	165	6010B	1.262560955	3.205547801	164	3050B	-7.345	10.955	9.8889	99th Percentile
Mg	mg/Kg	7.92	55	6010B	0.491181822	1.429463791	165	3050B	-3.18	5.875	5.2526	99th Percentile
Mn	mg/Kg	0.383	2	6010B	0.023176101	0.037561853	159	3050B	-0.105	0.145	0.1334	99th Percentile
Mo	mg/Kg	0.118	2	6010B	0.018568738	0.045419876	177	3050B	-0.09	0.145	0.1262	99th Percentile
Na	mg/Kg	18.8	100	6010B	-0.330499982	6.802757678	160	3050B	-25.045	17.975	15.8333	99th Percentile
Ni	mg/Kg	0.103	1	6010B	-0.001868979	0.026272662	173	3050B	-0.075	0.075	0	Min+Max=0
P	mg/Kg	0.748	300	6010B	0.357558137	0.240563115	172	3050B	-0.4	0.985	0.96225	99th Percentile
Pb	mg/Kg	0.222	1.5	6010B	-0.012956686	0.05336306	177	3050B	-0.155	0.125	0.1212	99th Percentile
Sb	mg/Kg	0.263	3	6010B	0.004816955	0.170628347	173	3050B	-0.545	0.565	0.4966	99th Percentile
Se	mg/Kg	0.396	5	6010B	-0.01747159	0.255945863	176	3050B	-0.79	0.745	0.63625	99th Percentile
Si	mg/Kg	2.43	52.3	6010B	0.038592346	1.232721238	148	3050B	-3.415	3.63	2.8674	99th Percentile
Sn	mg/Kg	0.381	5	6010B	0.362749042	0.133048685	174	3050B	-0.055	0.76	0.67175	99th Percentile
Sr	mg/Kg	0.121	5	6010B	-0.012132937	0.031366592	168	3050B	-0.135	0.1	0.09	99th Percentile
Ti	mg/Kg	0.427	2	6010B	0.031481482	0.103340361	171	3050B	-0.28	0.35	0.3345	99th Percentile
Tl	mg/Kg	0.42	5	6010B	-0.061716867	0.214909222	166	3050B	-0.72	0.63	0.551	99th Percentile
V	mg/Kg	0.261	2	6010B	0.028757396	0.138565978	169	3050B	-0.41	0.405	0.3648	99th Percentile
Zn	mg/Kg	0.955	4	6010B	0.071772152	0.093224399	158	3050B	-0.195	0.46	0.398	99th Percentile

6020 Method Detection Limits

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type
Ag	mg/Kg	0.02	0.2	6020	-0.00016397	0.003636164	175	3050B	-0.023795	0.01012	0.0076147	99th Percentile
Al	mg/Kg	6.6	30	6020	0.635142279	1.230174577	158	3050B	-0.52565	9.88575	6.2520695	99th Percentile
As	mg/Kg	0.1	0.5	6020	-0.002949005	0.013540611	177	3050B	-0.05175	0.034115	0.0288494	99th Percentile
Ba	mg/Kg	0.228	1	6020	0.001600011	0.010327997	175	3050B	-0.04828	0.038255	0.0287917	99th Percentile
Be	mg/Kg	0.048	0.2	6020	0.000213751	0.006666731	171	3050B	-0.03455	0.019745	0.0186835	99th Percentile
Ca	mg/Kg	6.24	100	6020	0.361525222	1.559742786	165	3050B	-4.7465	6.175	5.5706	99th Percentile
Cd	mg/Kg	0.077	0.4	6020	0.000711663	0.004335426	177	3050B	-0.017005	0.01387	0.0122812	99th Percentile
Co	mg/Kg	0.01	0.2	6020	-3.0876E-05	0.002344824	168	3050B	-0.00835	0.009775	0.0062509	99th Percentile
Cr	mg/Kg	0.063	0.5	6020	-0.003790211	0.009632012	175	3050B	-0.04875	0.02925	0.0181272	99th Percentile
Cu	mg/Kg	0.22	1	6020	0.003089184	0.042953376	174	3050B	-0.0992	0.29655	0.17161	99th Percentile
Fe	mg/Kg	11.53	40	6020	0.45744665	0.818822534	172	3050B	-1.5275	4.061	3.1702035	99th Percentile
Hg	mg/Kg	0.017	0.2	6020	0.001743749	0.003244119	150	3050B	-0.007545	0.015555	0.00941805	99th Percentile
K	mg/Kg	17.47	100	6020	0.42300146	2.805380447	162	3050B	-8.12	9.805	8.786083	99th Percentile
Mg	mg/Kg	2.64	100	6020	0.108265349	0.30607555	156	3050B	-1.1028	1.308	1.007955	99th Percentile
Mn	mg/Kg	0.453	1	6020	0.010789512	0.041824381	174	3050B	-0.0484	0.49895	0.08751	99th Percentile
Mo	mg/Kg	0.079	0.4	6020	5.14198E-05	0.009955784	177	3050B	-0.0541	0.03092	0.0237744	99th Percentile
Na	mg/Kg	52.31	150	6020	-2.968892308	3.847269598	91	3050B	-14.665	8.59755	6.143356025	Equation
Ni	mg/Kg	0.193	0.5	6020	-0.008382573	0.037406417	173	3050B	-0.1322	0.3439	0.077716	99th Percentile
P	mg/Kg	9.41	10	6020	-2.077466713	5.7843839	170	3050B	-20.565	19.025	16.15295	99th Percentile
Pb	mg/Kg	0.048	0.5	6020	-0.000166515	0.006922499	177	3050B	-0.04295	0.0359	0.0166088	99th Percentile
Sb	mg/Kg	0.068	0.2	6020	0.003691246	0.004166124	174	3050B	-0.012835	0.016705	0.01399615	99th Percentile
Se	mg/Kg	0.286	1	6020	0.010616635	0.044075809	177	3050B	-0.1122	0.16975	0.150434	99th Percentile
Sn	mg/Kg	0.864	3	6020	0.008053975	0.019964572	172	3050B	-0.0571	0.06445	0.0616015	99th Percentile
Sr	mg/Kg	0.069	0.5	6020	0.00220949	0.008222684	164	3050B	-0.024535	0.02782	0.02470065	99th Percentile
Ti	mg/Kg	0.182	1	6020	0.021458332	0.032091575	155	3050B	-0.041035	0.13735	0.128401	99th Percentile
Tl	mg/Kg	0.055	0.4	6020	-0.003179572	0.006416383	171	3050B	-0.0285	0.005465	0.00453835	99th Percentile
U	mg/Kg	0.042	0.2	6020	0.000524537	0.001438178	164	3050B	-0.0026	0.005435	0.00446801	99th Percentile
V	mg/Kg	0.272	2	6020	0.000706721	0.014439529	171	3050B	-0.05835	0.0604	0.037104	99th Percentile
Zn	mg/Kg	1.61	5	6020	0.076647668	0.255818789	170	3050B	-0.14725	2.6585	0.990875	99th Percentile

7471A Method Detection Limits

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type
Hg	mg/Kg	0.009	0.03	7471A	-0.000462724	0.005516132	175	7471A_Prep	-0.015758333	0.014075	0.010505667	99th Percentile

8081A Method Detection Limits

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type
2,4'-DDD	ug/Kg	1.1	5	8081A	0	0	102	3550B	0	0	0	Min+Max=0
2,4'-DDE	ug/Kg	0.91	5	8081A	8.75321E-05	0.000643624	102	3550B	0	0.005639701	0.003255684	99th Percentile
2,4'-DDT	ug/Kg	1.9	5	8081A	0	0	102	3550B	0	0	0	Min+Max=0
4,4'-DDD	ug/Kg	0.39	2	8081A	0.01124567	0.044485221	100	3550B	0	0.268573116	0.224279973	99th Percentile
4,4'-DDE	ug/Kg	0.53	2	8081A	0	0	100	3550B	0	0	0	Min+Max=0
4,4'-DDT	ug/Kg	0.39	2	8081A	0	0	100	3550B	0	0	0	Min+Max=0
Aldrin	ug/Kg	0.77	3	8081A	0.005328522	0.026738726	100	3550B	0	0.181051377	0.165938199	99th Percentile
alpha-BHC	ug/Kg	0.32	2	8081A	0.000250617	0.002081695	100	3550B	0	0.020317	0.004900466	99th Percentile
beta-BHC	ug/Kg	1.5	5	8081A	0.006713433	0.032805931	100	3550B	0	0.199534413	0.169341224	99th Percentile
Chlordane (technical)	ug/Kg	3.8	10	8081A	0	0	102	3550B	0	0	0	Min+Max=0
cis-Chlordane	ug/Kg	1.25	3	8081A	0.010611138	0.074943273	100	3550B	0	0.667301532	0.35040886	99th Percentile
cis-Nonachlor	ug/Kg	1.2	5	8081A	0	0	102	3550B	0	0	0	Min+Max=0
delta-BHC	ug/Kg	0.7	3	8081A	0.006138182	0.02754989	100	3550B	0	0.179678198	0.133067517	99th Percentile
Dieldrin	ug/Kg	0.12	2	8081A	0.000580584	0.005024597	100	3550B	0	0.049617181	0.008852974	99th Percentile
Endosulfan I	ug/Kg	0.43	2	8081A	0.000856615	0.006142075	100	3550B	0	0.051173819	0.034654579	99th Percentile
Endosulfan II	ug/Kg	0.4	2	8081A	0	0	100	3550B	0	0	0	Min+Max=0
Endosulfan sulfate	ug/Kg	0.32	2	8081A	0.00421931	0.018181582	100	3550B	0	0.119655743	0.087358053	99th Percentile
Endrin	ug/Kg	0.23	2	8081A	0	0	100	3550B	0	0	0	Min+Max=0
Endrin aldehyde	ug/Kg	3	20	8081A	0.311545333	0.812226999	100	3550B	0	3.343416902	3.026505072	99th Percentile
Endrin ketone	ug/Kg	0.38	2	8081A	0.022011943	0.074633992	100	3550B	0	0.560972111	0.32396476	99th Percentile
gamma-BHC (Lindane)	ug/Kg	0.21	2	8081A	0.003644429	0.014716934	100	3550B	0	0.071851505	0.069292318	99th Percentile
Heptachlor	ug/Kg	0.89	3	8081A	0.066890104	0.152365198	100	3550B	0	0.672491551	0.597636476	99th Percentile
Heptachlor epoxide	ug/Kg	0.74	3	8081A	0.000554392	0.004479652	100	3550B	0	0.043221915	0.012527318	99th Percentile
Hexachlorobenzene	ug/Kg	1.33	3	8081A	0.017701309	0.052585627	100	3550B	0	0.288488766	0.224440463	99th Percentile
Hexachlorobutadiene	ug/Kg	2.75	4	8081A	0.002327707	0.011619207	102	3550B	0	0.081767001	0.076920477	99th Percentile
Methoxychlor	ug/Kg	0.36	10	8081A	0	0	100	3550B	0	0	0	Min+Max=0
Mirex	ug/Kg	3.3	10	8081A	0	0	102	3550B	0	0	0	Min+Max=0
oxy-Chlordane	ug/Kg	0.88	4	8081A	0.000234825	0.00169513	102	3550B	0	0.01409634	0.009757288	99th Percentile
Technical Chlordane	ug/Kg	3.8	10	8081A	0	0	84	3550B	0	0	0	Min+Max=0
Toxaphene	ug/Kg	32	100	8081A	0	0	102	3550B	0	0	0	Min+Max=0
trans-Chlordane	ug/Kg	1.25	3	8081A	0.008257854	0.058110673	100	3550B	0	0.422020127	0.403947838	99th Percentile
trans-Nonachlor	ug/Kg	1.1	4	8081A	0	0	102	3550B	0	0	0	Min+Max=0

8081A Method Detection Limits

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type
2,4'-DDD	ug/L	0.009	0.03	8081A	0	0	190	3510C_LVI	0	0	0	Min+Max=0
2,4'-DDE	ug/L	0.005	0.03	8081A	-1.17395E-05	0.000147893	190	3510C_LVI	-0.002029713	0	0	99th Percentile
2,4'-DDT	ug/L	0.009	0.03	8081A	0	0	190	3510C_LVI	0	0	0	Min+Max=0
4,4'-DDD	ug/L	0.006	0.015	8081A	0	0	190	3510C_LVI	0	0	0	Min+Max=0
4,4'-DDE	ug/L	0.003	0.01	8081A	2.61118E-05	0.000283661	190	3510C_LVI	0	0.003851486	0.000423626	99th Percentile
4,4'-DDT	ug/L	0.005	0.02	8081A	6.39328E-05	0.000463546	190	3510C_LVI	0	0.004358073	0.003020047	99th Percentile
Aldrin	ug/L	0.007	0.024	8081A	6.50055E-06	6.45149E-05	190	3510C_LVI	0	0.000743919	5.40305E-05	99th Percentile
alpha-BHC	ug/L	0.004	0.018	8081A	2.65022E-05	0.000267146	190	3510C_LVI	0	0.003536044	0.000592893	99th Percentile
beta-BHC	ug/L	0.012	0.021	8081A	1.73821E-05	0.00017004	190	3510C_LVI	0	0.001836302	0.000161294	99th Percentile
Chlordane (technical)	ug/L	0.03	0.2	8081A	-3.34692E-05	0.000325714	190	3510C_LVI	-0.00332853	0	0	99th Percentile
cis-Chlordane	ug/L	0.008	0.027	8081A	0	0	190	3510C_LVI	0	0	0	Min+Max=0
cis-Nonachlor	ug/L	0.009	0.03	8081A	1.34985E-05	0.000205393	186	3510C_LVI	-0.000275408	0.002786134	0	99th Percentile
delta-BHC	ug/L	0.005	0.015	8081A	1.94466E-05	0.000229531	190	3510C_LVI	0	0.003130505	9.41519E-05	99th Percentile
Dieldrin	ug/L	0.005	0.018	8081A	3.87576E-06	3.91697E-05	190	3510C_LVI	0	0.000472341	2.90458E-05	99th Percentile
Endosulfan I	ug/L	0.003	0.02	8081A	5.43205E-06	5.33406E-05	190	3510C_LVI	0	0.000589358	4.87004E-05	99th Percentile
Endosulfan II	ug/L	0.005	0.024	8081A	0	0	190	3510C_LVI	0	0	0	Min+Max=0
Endosulfan sulfate	ug/L	0.003	0.02	8081A	4.99531E-06	5.37629E-05	190	3510C_LVI	0	0.000698868	2.75264E-05	99th Percentile
Endrin	ug/L	0.003	0.012	8081A	1.31045E-05	9.16747E-05	190	3510C_LVI	0	0.000790307	0.00059336	99th Percentile
Endrin aldehyde	ug/L	0.034	0.06	8081A	0.004642675	0.011558917	189	3510C_LVI	0	0.063673363	0.055479519	99th Percentile
Endrin ketone	ug/L	0.002	0.02	8081A	0.000197547	0.000677746	189	3510C_LVI	0	0.003896523	0.003262915	99th Percentile
gamma-BHC (Lindane)	ug/L	0.005	0.02	8081A	7.82872E-06	5.95701E-05	190	3510C_LVI	0	0.000560888	0.00031068	99th Percentile
Heptachlor	ug/L	0.004	0.015	8081A	4.04791E-05	0.000210973	190	3510C_LVI	0	0.001450431	0.001348076	99th Percentile
Heptachlor epoxide	ug/L	0.003	0.02	8081A	7.41266E-06	7.28866E-05	190	3510C_LVI	0	0.000810714	6.57461E-05	99th Percentile
Hexachlorobenzene	ug/L	0.006	0.05	8081A	0.000328424	0.001024706	186	3510C_LVI	-0.001727479	0.00806052	0.003414266	99th Percentile
Hexachlorobutadiene	ug/L	0.005	0.05	8081A	4.2972E-07	0.00022052	186	3510C_LVI	-0.00110063	0.001248332	0.001128035	99th Percentile
Methoxychlor	ug/L	0.014	0.1	8081A	0	0	190	3510C_LVI	0	0	0	Min+Max=0
Mirex	ug/L	0.52	2	8081A	6.66763E-05	0.001541886	186	3510C_LVI	-0.007285138	0.019686924	0	99th Percentile
oxy-Chlordane	ug/L	0.07	0.3	8081A	0	0	186	3510C_LVI	0	0	0	Min+Max=0
Technical Chlordane	ug/L	0.03	0.2	8081A	0.000378189	0.002792668	190	3510C_LVI	-0.003364406	0.026175715	0.016914366	99th Percentile
Toxaphene	ug/L	0.46	2	8081A	0	0	190	3510C_LVI	0	0	0	Min+Max=0
trans-Chlordane	ug/L	0.003	0.02	8081A	1.38106E-05	7.93191E-05	190	3510C_LVI	0	0.000553797	0.000486259	99th Percentile
trans-Nonachlor	ug/L	0.002	0.02	8081A	0	0	182	3510C_LVI	0	0	0	Min+Max=0

8151A_MS Method Detection Limits

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type
2,4,5-T	ug/Kg	38.2	90	8151A_MS	0	0	7	8151A_SP	0	0	0	Min+Max=0
2,4-D	ug/Kg	39.3	90	8151A_MS	0	0	7	8151A_SP	0	0	0	Min+Max=0
2,4-DB	ug/Kg	21.3	90	8151A_MS	0	0	7	8151A_SP	0	0	0	Min+Max=0
4-Nitrophenol	ug/Kg	31.9	90	8151A_MS	0	0	7	8151A_SP	0	0	0	Min+Max=0
Dalapon	ug/Kg	51.7	160	8151A_MS	0	0	7	8151A_SP	0	0	0	Min+Max=0
Dicamba	ug/Kg	20.6	90	8151A_MS	0	0	7	8151A_SP	0	0	0	Min+Max=0
Dichlorprop	ug/Kg	20.6	90	8151A_MS	0	0	7	8151A_SP	0	0	0	Min+Max=0
Dinoseb	ug/Kg	53.2	160	8151A_MS	0	0	7	8151A_SP	0	0	0	Min+Max=0
MCPA	ug/Kg	20.6	90	8151A_MS	0	0	7	8151A_SP	0	0	0	Min+Max=0
MCPP	ug/Kg	20.6	90	8151A_MS	0	0	7	8151A_SP	0	0	0	Min+Max=0
Pentachlorophenol	ug/Kg	44.5	160	8151A_MS	1.770777698	4.685037416	7	8151A_SP	0	12.39544389	16.49429675	Equation
Silvex (2,4,5-TP)	ug/Kg	22.1	90	8151A_MS	0	0	7	8151A_SP	0	0	0	Min+Max=0

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type	% Blank Hits > MDL
1,1,1,2-Tetrachloroethane	ug/Kg	0.59	3	8260B	0.001640465	0.009982497	182	5035A_FW	0	0.083187362	0.054872006	99th Percentile	0
1,1,1-Trichloroethane	ug/Kg	0.3	2	8260B	0	0	182	5035A_FW	0	0	0	Min+Max=0	0
1,1,2,2-Tetrachloroethane	ug/Kg	0.9	4	8260B	0.004703609	0.012657251	182	5035A_FW	0	0.060297861	0.054511176	99th Percentile	0
1,1,2-Trichloro-1,2,2-trifluoroethane	ug/Kg	0.52	3	8260B	0	0	178	5035A_FW	0	0	0	Min+Max=0	0
1,1,2-Trichloroethane	ug/Kg	0.25	2	8260B	0.001119606	0.005896484	182	5035A_FW	0	0.065087508	0.022256468	99th Percentile	0
1,1-Dichloroethane	ug/Kg	0.19	1	8260B	5.85181E-05	0.000789453	182	5035A_FW	0	0.010650299	0	99th Percentile	0
1,1-Dichloroethene	ug/Kg	1.1	5	8260B	0.025250559	0.121271554	182	5035A_FW	0	0.726469945	0.675151124	99th Percentile	0
1,1-Dichloropropene	ug/Kg	0.3	2	8260B	0.001014085	0.004234728	182	5035A_FW	0	0.02742124	0.020944489	99th Percentile	0
1,2,3-Trichlorobenzene	ug/Kg	0.6	3	8260B	0.197677486	0.265677631	182	5035A_FW	-0.408491544	1.282936734	1.164901161	99th Percentile	6.593406593
1,2,3-Trichloropropane	ug/Kg	1	5	8260B	0.002577428	0.011372424	182	5035A_FW	0	0.07597198	0.068417375	99th Percentile	0
1,2,3-Trimethylbenzene	ug/Kg	1.3	10	8260B	0.032886589	0.040994348	182	5035A_FW	0	0.404864671	0.15066902	99th Percentile	0
1,2,4-Trichlorobenzene	ug/Kg	0.42	2	8260B	0.148270965	0.156115014	182	5035A_FW	-0.221352435	0.744503537	0.677848554	99th Percentile	7.142857143
1,2,4-Trimethylbenzene	ug/Kg	1.2	5	8260B	0.05171925	0.102112959	182	5035A_FW	0	1.033451565	0.399043203	99th Percentile	0
1,2-Dibromo-3-Chloropropane	ug/Kg	1.6	10	8260B	0.044941721	0.109552487	182	5035A_FW	0	0.530758318	0.49320402	99th Percentile	0
1,2-Dichlorobenzene	ug/Kg	1.3	10	8260B	0.053986136	0.046002422	182	5035A_FW	0	0.199411278	0.186597976	99th Percentile	0
1,2-Dichloroethane	ug/Kg	0.2	1	8260B	0.01700956	0.026075469	182	5035A_FW	0	0.0966406	0.087539788	99th Percentile	0
1,2-Dichloropropane	ug/Kg	0.4	2	8260B	0.000173306	0.001688246	182	5035A_FW	0	0.019228331	0.002339543	99th Percentile	0
1,3,5-Trichlorobenzene	ug/Kg	1.4	10	8260B	0.063687788	0.060857045	182	5035A_FW	0	0.320694057	0.252457583	99th Percentile	0
1,3,5-Trimethylbenzene	ug/Kg	0.81	5	8260B	0.025380191	0.037092513	182	5035A_FW	0	0.274166174	0.169038032	99th Percentile	0
1,3-Dichlorobenzene	ug/Kg	1.1	5	8260B	0.046660784	0.051678931	182	5035A_FW	0	0.223523956	0.197337118	99th Percentile	0
1,3-Dichloropropane	ug/Kg	0.23	2	8260B	0.00228944	0.008471897	182	5035A_FW	0	0.077541176	0.034667618	99th Percentile	0
1,3-Dichloropropene, Total	ug/Kg	1.4	10	8260B	0	0	151	5035A_FW	0	0	0	Min+Max=0	0
1,4-Dichlorobenzene	ug/Kg	0.98	5	8260B	0.03918103	0.055607387	182	5035A_FW	0	0.239720081	0.236242818	99th Percentile	0
2,2-Dichloropropane	ug/Kg	0.9	5	8260B	0	0	182	5035A_FW	0	0	0	Min+Max=0	0
2-Butanone (MEK)	ug/Kg	8.9	40	8260B	0.052611004	0.243340143	182	5035A_FW	0	2.187458198	1.331708822	99th Percentile	0
2-Chloro-1,3-butadiene	ug/Kg	0.4	2	8260B	0.000772449	0.004308829	182	5035A_FW	0	0.048918213	0.01221941	99th Percentile	0
2-Chloroethyl vinyl ether	ug/Kg	1.4	10	8260B	0.01919623	0.107857633	182	5035A_FW	0	0.99863266	0.484379085	99th Percentile	0
2-Chlorotoluene	ug/Kg	0.93	5	8260B	0.014667285	0.023054115	182	5035A_FW	0	0.111403278	0.092674844	99th Percentile	0
2-Hexanone	ug/Kg	3.9	20	8260B	0.248598641	0.587388776	182	5035A_FW	-2.655951271	4.671367166	1.976863443	99th Percentile	0.549450549
2-Methyl-2-propanol	ug/Kg	32	500	8260B	0.113870437	0.515837006	182	5035A_FW	0	3.924238442	2.578428017	99th Percentile	0
2-Nitropropane	ug/Kg	2.5	10	8260B	0.081669424	0.248145538	182	5035A_FW	0	1.206373399	1.059031435	99th Percentile	0
3-Chloro-1-propene	ug/Kg	3.9	20	8260B	0.004614761	0.120909983	182	5035A_FW	-1.392730506	0.38083135	0.354296901	99th Percentile	0
4-Chlorotoluene	ug/Kg	1	5	8260B	0.039664281	0.041200361	182	5035A_FW	0	0.194103277	0.179141819	99th Percentile	0
4-Isopropyltoluene	ug/Kg	0.4	2	8260B	0.017949527	0.025465159	182	5035A_FW	0	0.161379665	0.116403218	99th Percentile	0
4-Methyl-2-pentanone (MIBK)	ug/Kg	6	30	8260B	0.053855781	0.13656056	182	5035A_FW	0	0.975035704	0.667712048	99th Percentile	0
Acetone	ug/Kg	26	150	8260B	0.452478805	2.033563122	182	5035A_FW	-7.249337928	11.42016882	8.62489488	99th Percentile	0
Acetonitrile	ug/Kg	9	40	8260B	0	2.420323133	182	5035A_FW	-11.66779576	18.31901576	2.785371767	99th Percentile	0.549450549
Acrolein	ug/Kg	7	30	8260B	0.016730867	0.159485801	182	5035A_FW	0	2.074765812	0.248964467	99th Percentile	0
Acrylonitrile	ug/Kg	7.2	30	8260B	0.025330608	0.12866184	182	5035A_FW	0	1.007159164	0.904784214	99th Percentile	0
Benzene	ug/Kg	0.39	2	8260B	0.029370073	0.026749663	182	5035A_FW	0	0.184307752	0.109071104	99th Percentile	0
Benzyl chloride	ug/Kg	2.7	15	8260B	0.021200018	0.048049853	182	5035A_FW	0	0.284634004	0.217099583	99th Percentile	0
Bromobenzene	ug/Kg	1	10	8260B	0.041432227	0.039734467	182	5035A_FW	0	0.218588914	0.157279725	99th Percentile	0
Bromoform	ug/Kg	0.84	5	8260B	0.005128423	0.013211876	182	5035A_FW	0	0.077738572	0.065232905	99th Percentile	0
Bromomethane	ug/Kg	0.21	1	8260B	0.000116619	0.001573271	182	5035A_FW	0	0.021224591	0	99th Percentile	0
Butadiene	ug/Kg	1.1	5	8260B	0.01609509	0.21733075	182	5035A_FW	-1.908553733	0.992874917	0.991934003	99th Percentile	0
Carbon disulfide	ug/Kg	0.2	1	8260B	0.009616443	0.018557491	182	5035A_FW	0	0.134292503	0.083004017	99th Percentile	0
Carbon tetrachloride	ug/Kg	0.3	2	8260B	0.00024103	0.001868023	182	5035A_FW	0	0.015299434	0.014200097	99th Percentile	0
Chlorobenzene	ug/Kg	0.25	2	8260B	0.006190122	0.020804031	182	5035A_FW	0	0.123566631	0.113138135	99th Percentile	0
Chlorobromomethane	ug/Kg	0.25	2	8260B	0.000581161	0.00397817	182	5035A_FW	0	0.036146494	0.023972635	99th Percentile	0
Chlorodibromomethane	ug/Kg	0.27	1.5	8260B	0.001739645	0.006983514	182	5035A_FW	0	0.042951536	0.041356926	99th Percentile	0
Chloroethane	ug/Kg	1.6	10	8260B	7.7138E-05	0.001040649	182	5035A_FW	0	0.014039124	0	99th Percentile	0
Chloroform	ug/Kg	0.3	2	8260B	0.000862282	0.004587528	182	5035A_FW	0	0.032309376	0.027379551	99th Percentile	0
Chloromethane	ug/Kg	0.93	5	8260B	0.011382324	0.137334091	182	5035A_FW	0	1.852102856	0.044897073	99th Percentile	0.549450549

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type	% Blank Hits > MDL
cis-1,2-Dichloroethene	ug/Kg	0.6	3	8260B	0.002770497	0.009692313	182	5035A_FW	0	0.06170325	0.044200993	99th Percentile	0
cis-1,3-Dichloropropene	ug/Kg	0.2	1	8260B	0.001124832	0.006058073	182	5035A_FW	0	0.065298505	0.024517127	99th Percentile	0
Cyclohexane	ug/Kg	0.3	2	8260B	0.001824547	0.01104982	176	5035A_FW	0	0.07588063	0.0758003	99th Percentile	0
Cyclohexanone	ug/Kg	102	500	8260B	0	0	3	5035A_FW	0	0	0	Min+Max=0	0
Dibromomethane	ug/Kg	0.17	1	8260B	0.002678744	0.027449496	182	5035A_FW	0	0.36609351	0.027136822	99th Percentile	0.549450549
Dichlorobromomethane	ug/Kg	0.18	1	8260B	0.000598883	0.003975549	182	5035A_FW	0	0.042102377	0.018805215	99th Percentile	0
Dichlorodifluoromethane	ug/Kg	0.49	2	8260B	0.026865232	0.151551022	182	5035A_FW	0	0.98687895	0.916445547	99th Percentile	2.747252747
Dichlorofluoromethane	ug/Kg	0.3	2	8260B	0	0.042214399	182	5035A_FW	-0.569378667	0.003714887	0.001597959	99th Percentile	0
Ethanol	ug/Kg	50	50	8260B	0	0	84	5035A_FW	0	0	0	Min+Max=0	0
Ethyl acetate	ug/Kg	4.8	20	8260B	0.007193445	0.033702248	182	5035A_FW	0	0.274809199	0.199084621	99th Percentile	0
Ethyl acrylate	ug/Kg	1.3	10	8260B	0.045685677	0.232545409	182	5035A_FW	0	1.947560832	1.032803709	99th Percentile	0.549450549
Ethyl ether	ug/Kg	0.97	5	8260B	0.000869307	0.004886975	182	5035A_FW	0	0.055035043	0.017595856	99th Percentile	0
Ethyl methacrylate	ug/Kg	0.36	5	8260B	0.014028958	0.057467464	182	5035A_FW	0	0.36081086	0.298050697	99th Percentile	0.549450549
Ethylbenzene	ug/Kg	0.41	2	8260B	0.037607494	0.043289127	182	5035A_FW	0	0.421216988	0.161278746	99th Percentile	0.549450549
Ethylene Dibromide	ug/Kg	0.2	1	8260B	0.003453194	0.013015339	182	5035A_FW	0	0.077820345	0.070838826	99th Percentile	0
Hexachlorobutadiene	ug/Kg	0.6	3	8260B	0.036299513	0.065977846	182	5035A_FW	0	0.424885681	0.277376834	99th Percentile	0
Hexane	ug/Kg	3.9	20	8260B	0.217893492	0.808542228	182	5035A_FW	-0.485033142	9.444512251	1.980276093	99th Percentile	1.098901099
Iodomethane	ug/Kg	2.1	15	8260B	0	0	182	5035A_FW	0	0	0	Min+Max=0	0
Isobutyl alcohol	ug/Kg	41	200	8260B	2.850711819	36.88361271	182	5035A_FW	-1.797528269	497.630525	4.831009006	99th Percentile	0.549450549
Isopropyl alcohol	ug/Kg	84	400	8260B	3.706849593	56.37137761	182	5035A_FW	-18.29631134	757.8677582	13.64198512	99th Percentile	0.549450549
Isopropyl ether	ug/Kg	1.2	10	8260B	0.00063415	0.002249203	182	5035A_FW	0	0.015268588	0.010997181	99th Percentile	0
Isopropylbenzene	ug/Kg	0.46	2	8260B	0.01172774	0.01438883	181	5035A_FW	0	0.058824045	0.053324868	99th Percentile	0
m-Xylene & p-Xylene	ug/Kg	1.7	10	8260B	0.063428854	0.181632382	182	5035A_FW	-0.037399173	2.203623679	0.562748751	99th Percentile	0.549450549
Methacrylonitrile	ug/Kg	3.2	15	8260B	0.052483943	0.167199633	182	5035A_FW	0	1.597499863	0.694273367	99th Percentile	0
Methyl acetate	ug/Kg	1.3	10	8260B	0.003881268	0.032458112	182	5035A_FW	-0.267406643	0.294234421	0.080609783	99th Percentile	0
Methyl methacrylate	ug/Kg	13	100	8260B	0	0.539802143	182	5035A_FW	-3.130900714	2.491531012	1.343518639	99th Percentile	0
Methyl tert-butyl ether	ug/Kg	0.3	2	8260B	0.000429691	0.002364491	182	5035A_FW	0	0.015722815	0.013272242	99th Percentile	0
Methylcyclohexane	ug/Kg	0.42	2	8260B	0.029320481	0.069532513	175	5035A_FW	0	0.382970489	0.332944813	99th Percentile	0
Methylene Chloride	ug/Kg	9.9	40	8260B	0.411651673	1.97239457	182	5035A_FW	-7.470225236	8.876326713	7.296778388	99th Percentile	0
n-Butanol	ug/Kg	150	650	8260B	2.129942141	8.482199461	182	5035A_FW	0	97.29574065	25.91969557	99th Percentile	0
n-Butyl acetate	ug/Kg	4.4	20	8260B	0	0.538707014	182	5035A_FW	-4.482988952	1.164050303	1.062952359	99th Percentile	0
n-Butylbenzene	ug/Kg	0.63	3	8260B	0.040001621	0.041832667	182	5035A_FW	0	0.212216998	0.149264836	99th Percentile	0
n-Heptane	ug/Kg	0.3	2	8260B	0.023387724	0.146635834	179	5035A_FW	0	1.398268228	0.373772759	99th Percentile	1.117318436
N-Propylbenzene	ug/Kg	0.76	5	8260B	0.030011737	0.028099214	182	5035A_FW	0	0.135257309	0.11633044	99th Percentile	0
Naphthalene	ug/Kg	1.8	10	8260B	0.424183221	0.371071693	182	5035A_FW	-0.421164841	2.029835648	1.788753089	99th Percentile	0.549450549
o-Xylene	ug/Kg	0.92	5	8260B	0.032307326	0.050221322	182	5035A_FW	0	0.572017734	0.173513189	99th Percentile	0
Pentachloroethane	ug/Kg	0.2	1	8260B	0	0	2	5035A_FW	0	0	0	Min+Max=0	0
Propionitrile	ug/Kg	31.4	200	8260B	0.025340046	0.371079707	182	5035A_FW	-3.215709596	2.634329798	1.883987191	99th Percentile	0
sec-Butylbenzene	ug/Kg	0.67	3	8260B	0.017861571	0.020527376	182	5035A_FW	0	0.121334714	0.084577692	99th Percentile	0
Styrene	ug/Kg	0.74	3	8260B	0.090100628	0.103019123	182	5035A_FW	-0.325163305	0.438433821	0.411839731	99th Percentile	0
TAH	ug/Kg	1.7	10	8260B	0.084120879	0.986931763	182	5035A_FW	0	13.15	0.4104	99th Percentile	1.098901099
Tert-amyl methyl ether	ug/Kg	3.8	20	8260B	0.001018762	0.004140946	182	5035A_FW	0	0.022770069	0.021292639	99th Percentile	0
Tert-butyl ethyl ether	ug/Kg	2.5	10	8260B	0.000135259	0.001286991	182	5035A_FW	0	0.012558831	0.00229109	99th Percentile	0
tert-Butylbenzene	ug/Kg	0.66	3	8260B	0.010854553	0.01752615	182	5035A_FW	0	0.107316456	0.067731379	99th Percentile	0
Tetrachloroethene	ug/Kg	0.4	2	8260B	0.004569306	0.012511854	182	5035A_FW	0	0.067652904	0.057634949	99th Percentile	0
Tetrahydrofuran	ug/Kg	10	100	8260B	0.03643401	0.258397135	182	5035A_FW	-0.972231518	1.513876163	1.264476345	99th Percentile	0
Toluene	ug/Kg	1.3	10	8260B	0.148815863	0.50943816	181	5035A_FW	0	5.7384801	2.163260341	99th Percentile	2.209944751
trans-1,2-Dichloroethene	ug/Kg	0.4	2	8260B	0.00361105	0.012518195	182	5035A_FW	0	0.081376153	0.064599699	99th Percentile	0
trans-1,3-Dichloropropene	ug/Kg	1.4	10	8260B	0.0036969	0.009990562	182	5035A_FW	0	0.045711137	0.043996294	99th Percentile	0
trans-1,4-Dichloro-2-butene	ug/Kg	16.7	100	8260B	0.010207454	0.030663189	182	5035A_FW	0	0.172829008	0.131480455	99th Percentile	0
Trichloroethene	ug/Kg	0.3	2	8260B	0.007989538	0.0232706	182	5035A_FW	0	0.144198675	0.130509938	99th Percentile	0
Trichlorofluoromethane	ug/Kg	0.3	2	8260B	0.000186847	0.002520706	182	5035A_FW	0	0.034006188	0	99th Percentile	0
Vinyl acetate	ug/Kg	1.5	10	8260B	0.008073905	0.072054269	182	5035A_FW	0	0.860757874	0.144832427	99th Percentile	0

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type	% Blank Hits > MDL
Vinyl chloride	ug/Kg	0.3	2	8260B	0.006388622	0.060149987	182	5035A_FW	0	0.580389168	0.116654706	99th Percentile	1.098901099
Xylenes, Total	ug/Kg	1.7	10	8260B	0	0	182	5035A_FW	0	0	0	Min+Max=0	0

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type	% Blank Hits > MDL
1,1,1,2-Tetrachloroethane	ug/L	0.027	0.3	8260B_LL	0	0	195	5030B_UP	0	0	0	Min+Max=0	0
1,1,1-Trichloroethane	ug/L	0.025	0.2	8260B_LL	0	0	195	5030B_UP	0	0	0	Min+Max=0	0
1,1,2,2-Tetrachloroethane	ug/L	0.056	0.2	8260B_LL	7.352E-06	0.000564511	191	5030B_UP	-0.003647434	0.006678831	0	99th Percentile	0
1,1,2-Trichloro-1,2,2-trifluoroethane	ug/L	0.078	0.5	8260B_LL	0	0	196	5030B_UP	0	0	0	Min+Max=0	0
1,1,2-Trichloroethane	ug/L	0.07	0.2	8260B_LL	0	0	192	5030B_UP	0	0	0	Min+Max=0	0
1,1-Dichloroethane	ug/L	0.025	0.2	8260B_LL	0	0	194	5030B_UP	0	0	0	Min+Max=0	0
1,1-Dichloroethene	ug/L	0.102	0.2	8260B_LL	0	0	193	5030B_UP	0	0	0	Min+Max=0	0
1,1-Dichloropropene	ug/L	0.036	0.2	8260B_LL	0.005843413	0.014719245	191	5030B_UP	0	0.091737825	0.058120601	99th Percentile	5.235602094
1,2,3-Trichlorobenzene	ug/L	0.149	0.5	8260B_LL	0.028534427	0.036241012	195	5030B_UP	-0.041328315	0.15140443	0.14916881	99th Percentile	1.538461538
1,2,3-Trichloropropane	ug/L	0.05	0.2	8260B_LL	0.000143757	0.001449239	191	5030B_UP	0	0.01733742	0.001012012	99th Percentile	0
1,2,4-Trichlorobenzene	ug/L	0.072	0.3	8260B_LL	0.047588804	0.057023368	197	5030B_UP	0	0.187578163	0.172150666	99th Percentile	29.94923858
1,2,4-Trimethylbenzene	ug/L	0.072	0.3	8260B_LL	0.013799411	0.024156344	196	5030B_UP	-0.007969974	0.094237037	0.087461288	99th Percentile	2.551020408
1,2-Dibromo-3-Chloropropane	ug/L	0.44	2	8260B_LL	0.0003431	0.002845056	191	5030B_UP	-0.008339722	0.025920871	0.013912287	99th Percentile	0
1,2-Dichlorobenzene	ug/L	0.05	0.3	8260B_LL	0.004360357	0.006734535	195	5030B_UP	0	0.022766468	0.021844247	99th Percentile	0
1,2-Dichloroethane	ug/L	0.043	0.2	8260B_LL	0.010172272	0.015177362	197	5030B_UP	-0.02594843	0.04997351	0.039937277	99th Percentile	0.507614213
1,2-Dichloropropane	ug/L	0.06	0.2	8260B_LL	0	0	194	5030B_UP	0	0	0	Min+Max=0	0
1,3,5-Trichlorobenzene	ug/L	0.118	0.5	8260B_LL	0.009420533	0.010050321	192	5030B_UP	0	0.041114481	0.03397803	99th Percentile	0
1,3,5-Trimethylbenzene	ug/L	0.152	0.5	8260B_LL	0.048635486	0.068219597	197	5030B_UP	0	0.272662779	0.225312719	99th Percentile	11.16751269
1,3-Dichlorobenzene	ug/L	0.05	0.3	8260B_LL	0.00376763	0.006741025	194	5030B_UP	0	0.026939629	0.024026377	99th Percentile	0
1,3-Dichloropropane	ug/L	0.056	0.2	8260B_LL	0	0	191	5030B_UP	0	0	0	Min+Max=0	0
1,3-Dichloropropene, Total	ug/L	0.092	0.2	8260B_LL	0	0	42	5030B_UP	0	0	0	Min+Max=0	0
1,4-Dichlorobenzene	ug/L	0.05	0.3	8260B_LL	0.001762493	0.005280509	191	5030B_UP	0	0.021391356	0.020755315	99th Percentile	0
2,2-Dichloropropane	ug/L	0.06	0.5	8260B_LL	0	0	195	5030B_UP	0	0	0	Min+Max=0	0
2-Butanone (MEK)	ug/L	2.5	10	8260B_LL	0.032056099	0.107054508	191	5030B_UP	0	0.427679148	0.427611198	99th Percentile	0
2-Chloroethyl vinyl ether	ug/L	0.348	6	8260B_LL	0.000391063	0.002524014	191	5030B_UP	0	0.019810648	0.018212028	99th Percentile	0
2-Chlorotoluene	ug/L	0.116	0.5	8260B_LL	0.003231315	0.009278959	191	5030B_UP	0	0.062783757	0.034386258	99th Percentile	0
2-Hexanone	ug/L	0.944	3	8260B_LL	0.008019968	0.059098069	191	5030B_UP	0	0.545847565	0.372596934	99th Percentile	0
2-Methyl-2-propanol	ug/L	2.26	25	8260B_LL	0.006773558	0.040439487	191	5030B_UP	0	0.431767105	0.157606028	99th Percentile	0
4-Chlorotoluene	ug/L	0.05	0.3	8260B_LL	0.006151389	0.011329477	191	5030B_UP	0	0.057619545	0.051797661	99th Percentile	1.570680628
4-Isopropyltoluene	ug/L	0.05	0.3	8260B_LL	0.032773681	0.042978848	197	5030B_UP	0	0.164485374	0.145767542	99th Percentile	38.07106599
4-Methyl-2-pentanone (MIBK)	ug/L	1.7	5	8260B_LL	0.053562722	0.171961903	191	5030B_UP	0	1.161554938	0.591363372	99th Percentile	0
Acetone	ug/L	3.1	6	8260B_LL	1.040160451	1.596480677	192	5030B_UP	-1.204037049	6.337590216	5.83925001	99th Percentile	15.10416667
Acrolein	ug/L	1.07	15	8260B_LL	0.019024823	0.058042442	191	5030B_UP	0	0.241525405	0.238054662	99th Percentile	0
Acrylonitrile	ug/L	0.78	10	8260B_LL	0.032579675	0.162752747	191	5030B_UP	0	1.247584785	0.822579232	99th Percentile	3.141361257
Benzene	ug/L	0.03	0.2	8260B_LL	0.000545515	0.002402813	191	5030B_UP	0	0.014882094	0.012960473	99th Percentile	0
Bromobenzene	ug/L	0.035	0.2	8260B_LL	0.003015988	0.006573187	191	5030B_UP	0	0.027447703	0.021729566	99th Percentile	0
Bromoform	ug/L	0.157	0.5	8260B_LL	0.001771582	0.008109142	191	5030B_UP	0	0.045517921	0.045226505	99th Percentile	0
Bromomethane	ug/L	0.16	0.5	8260B_LL	0	0	195	5030B_UP	0	0	0	Min+Max=0	0
Carbon disulfide	ug/L	0.083	0.3	8260B_LL	0.011048042	0.02266334	191	5030B_UP	-0.046438523	0.104014527	0.102977998	99th Percentile	4.188481675
Carbon tetrachloride	ug/L	0.025	0.2	8260B_LL	0	0	194	5030B_UP	0	0	0	Min+Max=0	0
Chlorobenzene	ug/L	0.025	0.2	8260B_LL	0.004018704	0.008269134	191	5030B_UP	0	0.044760311	0.034105861	99th Percentile	3.141361257
Chlorobromomethane	ug/L	0.025	0.2	8260B_LL	0.000205018	0.001725224	191	5030B_UP	0	0.019287563	0.008788687	99th Percentile	0
Chlorodibromomethane	ug/L	0.055	0.2	8260B_LL	0.004355982	0.014222716	191	5030B_UP	0	0.053794344	0.053383671	99th Percentile	0
Chloroethane	ug/L	0.096	0.5	8260B_LL	0.000135485	0.001338047	191	5030B_UP	0	0.015042423	0.00108352	99th Percentile	0
Chloroform	ug/L	0.03	0.2	8260B_LL	0	0	196	5030B_UP	0	0	0	Min+Max=0	0
Chloromethane	ug/L	0.154	0.5	8260B_LL	0	0	194	5030B_UP	0	0	0	Min+Max=0	0
cis-1,2-Dichloroethene	ug/L	0.055	0.2	8260B_LL	0.001734306	0.005923151	191	5030B_UP	0	0.034790638	0.029249179	99th Percentile	0
cis-1,3-Dichloropropene	ug/L	0.09	0.2	8260B_LL	0.005964854	0.016612005	191	5030B_UP	0	0.089430862	0.083973873	99th Percentile	0
Dibromomethane	ug/L	0.062	0.2	8260B_LL	0	0	192	5030B_UP	0	0	0	Min+Max=0	0
Dichlorobromomethane	ug/L	0.06	0.2	8260B_LL	0.002307928	0.010098961	191	5030B_UP	0	0.047904039	0.047579475	99th Percentile	0
Dichlorodifluoromethane	ug/L	0.128	0.4	8260B_LL	0	0	196	5030B_UP	0	0	0	Min+Max=0	0
Ethylbenzene	ug/L	0.03	0.2	8260B_LL	0.014767604	0.022971779	196	5030B_UP	0	0.064570967	0.060007545	99th Percentile	25
Ethylene Dibromide	ug/L	0.025	0.1	8260B_LL	0.001045777	0.004245522	191	5030B_UP	0	0.027342422	0.02276863	99th Percentile	1.047120419
Hexachlorobutadiene	ug/L	0.154	0.5	8260B_LL	0.009115779	0.012969946	195	5030B_UP	-0.0253333	0.052626769	0.046302222	99th Percentile	0
Hexane	ug/L	0.06	0.2	8260B_LL	0.035738385	0.048081312	197	5030B_UP	-0.004731378	0.165451431	0.158581611	99th Percentile	33.50253807
Iodomethane	ug/L	0.07	0.5	8260B_LL	6.88337E-06	9.513E-05	191	5030B_UP	0	0.001314723	0	99th Percentile	0
Isopropylbenzene	ug/L	0.187	1	8260B_LL	0.044945056	0.071729951	196	5030B_UP	0	0.286996698	0.286342428	99th Percentile	5.102040816
m-Xylene & p-Xylene	ug/L	0.115	0.5	8260B_LL	0.027341656	0.045059633	196	5030B_UP	-0.007569209	0.136532474	0.126523997	99th Percentile	8.673469388

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type	% Blank Hits > MDL
Methyl tert-butyl ether	ug/L	0.07	0.3	8260B_LL	0	0	194	5030B_UP	0	0	0	Min+Max=0	0
Methylene Chloride	ug/L	0.741	5	8260B_LL	0.080644022	0.294169015	191	5030B_UP	-0.719287008	1.437984466	1.198138366	99th Percentile	4.712041885
n-Butylbenzene	ug/L	0.08	0.5	8260B_LL	0.049793535	0.060141935	197	5030B_UP	0	0.247683626	0.225406302	99th Percentile	27.91878173
N-Propylbenzene	ug/L	0.091	0.3	8260B_LL	0.031422035	0.041697426	197	5030B_UP	0	0.149913152	0.122246654	99th Percentile	14.72081218
Naphthalene	ug/L	0.221	1	8260B_LL	0.108918013	0.101173115	197	5030B_UP	0	0.355193748	0.345083212	99th Percentile	9.644670051
o-Xylene	ug/L	0.147	0.5	8260B_LL	0.047389243	0.048527562	196	5030B_UP	-0.009268663	0.157327099	0.151131967	99th Percentile	4.081632653
sec-Butylbenzene	ug/L	0.168	1	8260B_LL	0.035789582	0.041809582	194	5030B_UP	0	0.153929797	0.117990506	99th Percentile	0
Styrene	ug/L	0.192	0.5	8260B_LL	0.067134117	0.06617277	196	5030B_UP	0	0.21881428	0.216998381	99th Percentile	6.12244898
Tert-amyl methyl ether	ug/L	0.111	0.5	8260B_LL	0	0	191	5030B_UP	0	0	0	Min+Max=0	0
Tert-butyl ethyl ether	ug/L	0.151	0.5	8260B_LL	0	0	192	5030B_UP	0	0	0	Min+Max=0	0
tert-Butylbenzene	ug/L	0.1	0.5	8260B_LL	0.050517641	0.065896169	197	5030B_UP	0	0.258367092	0.257028505	99th Percentile	29.44162437
Tetrachloroethene	ug/L	0.084	0.5	8260B_LL	0.00065122	0.002829973	191	5030B_UP	0	0.015262169	0.014509195	99th Percentile	0
Toluene	ug/L	0.05	0.2	8260B_LL	0.002276635	0.005553161	195	5030B_UP	-0.011101128	0.021136871	0.019780342	99th Percentile	0
trans-1,2-Dichloroethene	ug/L	0.089	0.2	8260B_LL	0.00026962	0.001833016	191	5030B_UP	-0.003798204	0.015917589	0.010587474	99th Percentile	0
trans-1,3-Dichloropropene	ug/L	0.092	0.2	8260B_LL	0.019761511	0.035818197	197	5030B_UP	0	0.13947092	0.132302884	99th Percentile	6.598984772
trans-1,4-Dichloro-2-butene	ug/L	0.489	2	8260B_LL	0.00132547	0.006590803	191	5030B_UP	0	0.058868277	0.031404675	99th Percentile	0
Trichloroethene	ug/L	0.066	0.2	8260B_LL	0.00410791	0.008805827	191	5030B_UP	0	0.047575597	0.041492421	99th Percentile	0
Trichlorofluoromethane	ug/L	0.107	0.5	8260B_LL	0	0	195	5030B_UP	0	0	0	Min+Max=0	0
Vinyl acetate	ug/L	0.443	1.5	8260B_LL	0.009929906	0.066642883	191	5030B_UP	0	0.571189388	0.478927563	99th Percentile	1.570680628
Vinyl chloride	ug/L	0.013	0.02	8260B_LL	0	0	196	5030B_UP	0	0	0	Min+Max=0	0
Xylenes, Total	ug/L	0.147	0.5	8260B_LL	0.005335079	0.025666746	191	5030B_UP	0	0.15	0.1271	99th Percentile	0.523560209

8270C_SIM Method Detection Limits

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type
1-Methylnaphthalene	ug/Kg	0.63	5	8270C_SIM	0.121276792	0.267142187	117	3546	0	1.304228868	1.219712361	99th Percentile
2-Methylnaphthalene	ug/Kg	0.45	5	8270C_SIM	0.212853643	0.430117077	165	3546	0	2.287855279	2.049700954	99th Percentile
Acenaphthene	ug/Kg	0.6	5	8270C_SIM	0.023538009	0.068210279	157	3546	0	0.359200194	0.295021181	99th Percentile
Acenaphthylene	ug/Kg	0.5	5	8270C_SIM	0.016453828	0.065613485	157	3546	0	0.374635288	0.343714443	99th Percentile
Anthracene	ug/Kg	0.6	5	8270C_SIM	0.08619862	0.151267709	158	3546	0	0.662851821	0.589790395	99th Percentile
Benzo[a]anthracene	ug/Kg	0.76	5	8270C_SIM	0.168283999	0.232245832	167	3546	0	0.902019228	0.888000476	99th Percentile
Benzo[a]pyrene	ug/Kg	0.4	5	8270C_SIM	0.021937519	0.088676063	167	3546	0	0.545892681	0.435810654	99th Percentile
Benzo[b]fluoranthene	ug/Kg	0.59	5	8270C_SIM	0.041379949	0.133438713	167	3546	0	0.669648918	0.656218368	99th Percentile
Benzo[g,h,i]perylene	ug/Kg	0.5	5	8270C_SIM	0.032122852	0.128869774	156	3546	0	0.957412065	0.635579871	99th Percentile
Benzo[k]fluoranthene	ug/Kg	0.6	5	8270C_SIM	0.037119718	0.125760224	167	3546	0	0.724832749	0.636988553	99th Percentile
Chrysene	ug/Kg	1.5	5	8270C_SIM	0.101510314	0.166365808	167	3546	-0.009276948	0.867594563	0.741455006	99th Percentile
Dibenz(a,h)anthracene	ug/Kg	0.72	5	8270C_SIM	0.008351697	0.048082037	165	3546	0	0.333119228	0.299362055	99th Percentile
Fluoranthene	ug/Kg	1.4	5	8270C_SIM	0.169694105	0.347842882	158	3546	0	1.556061216	1.333407106	99th Percentile
Fluorene	ug/Kg	0.5	5	8270C_SIM	0.039466176	0.11233667	157	3546	0	0.706902	0.55912969	99th Percentile
Indeno[1,2,3-cd]pyrene	ug/Kg	0.6	5	8270C_SIM	0.01722809	0.085733625	167	3546	0	0.581441763	0.513680469	99th Percentile
Naphthalene	ug/Kg	0.8	5	8270C_SIM	0.172705433	0.325284232	164	3546	0	2.120760902	1.622788773	99th Percentile
Pentachlorophenol	ug/Kg	5	20	8270C_SIM	16.45960697	16.41201503	11	3546	0	44.99660471	61.81863286	Equation
Phenanthrene	ug/Kg	0.69	5	8270C_SIM	0.286259253	0.408359379	159	3546	0	2.198488186	1.631528025	99th Percentile
Pyrene	ug/Kg	0.97	5	8270C_SIM	0.235472149	0.333268771	159	3546	0	1.341086924	1.258010055	99th Percentile

Method: 8290 / 1613	Matrix: Solid

Prep Method: Soxhlet

Date Generated: 3/4/2019

Reviewed by: ERS

Analyte	Units	Current RL	Current MDL	MDLs Evaluation							MDLB Evaluation					
				Spike Conc'n	Mean/MDL	MDL > 10%	%Rec 50-150	Mean Result	Mean %R	Std Dev	Calc MDL	Mean Result	Std Dev	Calc MDLB	MDL	RL/MDL	Update/Remarks
2,3,7,8-TCDD	pg/g	1	0.15	0.4	2.1	Pass	Pass	0.513102907	128	0.103046991	0.248987306	0.028858576	0.114135014	0.599937109	0.5999	1.67	
1,2,3,7,8-PeCDD	pg/g	5	0.3	2	3.6	Pass	Pass	2.125089557	106	0.240883161	0.593059488	0.021455207	0.091952547	0.392595217	0.5931	8.43	
1,2,3,4,7,8-HxCDD	pg/g	5	0.71	2	2.8	Pass	Pass	2.085569373	104	0.298053521	0.733814136	0.133164434	0.1238536	0.557991039	0.7338	6.81	
1,2,3,6,7,8-HxCDD	pg/g	5	0.58	2	3	Pass	Pass	2.069869502	103	0.27683248	0.681567479	0.068120511	0.286606221	0.815401788	0.8154	6.13	
1,2,3,7,8,9-HxCDD	pg/g	5	0.58	2	2.4	Pass	Pass	2.058418942	103	0.342411298	0.843023929	0.078335161	0.267893082	0.872421276	0.8724	5.73	
1,2,3,4,6,7,8-HpCDD	pg/g	5	0.46	2	3.3	Pass	Pass	2.18629949	109	0.26752523	0.65865283	0.286208301	0.477012255	2.45693705	2.4569	2.04	
OCDD	pg/g	10	1.5	4	1.9	Pass	Pass	5.299273597	132	1.121654964	2.76153848	2.767445666	7.822151517	24.73045905	24.7305	0.4	
2,3,7,8-TCDF	pg/g	1	0.11	0.4	2.7	Pass	Pass	0.450241451	113	0.067991868	0.16428536	0.042631029	0.118171672	0.557715243	0.5577	1.79	
1,2,3,7,8-PeCDF	pg/g	5	0.27	2	3.1	Pass	Pass	2.096236104	105	0.275498606	0.678283452	0.060846939	0.121205542	0.510973245	0.6783	7.37	
2,3,4,7,8-PeCDF	pg/g	5	0.29	2	2.6	Pass	Pass	2.058735349	103	0.317254564	0.781087512	0.022578793	0.084872221	0.477067431	0.7811	6.4	
1,2,3,4,7,8-HxCDF	pg/g	5	0.3	2	3	Pass	Pass	2.102071887	105	0.283415588	0.697775232	0.036012854	0.089938759	0.374877515	0.6978	7.17	
1,2,3,6,7,8-HxCDF	pg/g	5	0.38	2	2.8	Pass	Pass	2.088072836	104	0.300498418	0.739833523	0.031589205	0.08750211	0.473884977	0.7398	6.76	
2,3,4,6,7,8-HxCDF	pg/g	5	0.3	2	3.2	Pass	Pass	2.119042996	106	0.268442986	0.660912365	0.030937475	0.089266689	0.491943291	0.6609	7.57	
1,2,3,7,8,9-HxCDF	pg/g	5	0.43	2	2.1	Pass	Pass	2.137176139	107	0.411762389	1.013767798	0.30630781	0.520482946	2.689886079	2.6899	1.86	
1,2,3,4,6,7,8-HpCDF	pg/g	5	0.38	2	3.5	Pass	Pass	2.080016559	104	0.244774009	0.60263884	0.169504139	0.374934459	1.111596139	1.1116	4.5	
1,2,3,4,7,8,9-HpCDF	pg/g	5	0.65	2	2.9	Pass	Pass	2.065154588	103	0.2858932	0.703875164	0.201834982	0.361258459	1.859343538	1.8593	2.69	
OCDF	pg/g	10	1.2	4	3	Pass	Pass	4.23280266	106	0.564697314	1.39029685	0.469525656	0.959294765	4.536610348	4.5366	2.2	

ERS 3/4/2019: Requires evaluation/notification process prior to updating.

Analyte	Spike Conc'n	Units	Current RL	Current MDL	Calc MDL	RL Rule	RL/MDL	Mean/MDL	MDL > 10%
2,3,7,8-TCDD	0.15	pg/g	1	0.15	1.21781739	Fail	0.8	0.4	Pass
2,3,7,8-TCDD	0.2	pg/g	1	0.15	0.245692452	Pass	4.1	1.3	Pass
2,3,7,8-TCDD	0.4	pg/g	1	0.15	0.248987306	Pass	4	2.1	Pass
1,2,3,7,8-PeCDD	0.75	pg/g	5	0.3	0.533921065	Pass	9.4	1.6	Pass
1,2,3,7,8-PeCDD	1	pg/g	5	0.3	0.487527589	Pass	10.3	2.3	Pass
1,2,3,7,8-PeCDD	2	pg/g	5	0.3	0.593059488	Pass	8.4	3.6	Pass
1,2,3,4,7,8-HxCDD	0.75	pg/g	5	0.71	1.569200622	Pass	3.2	0.6	Pass
1,2,3,4,7,8-HxCDD	1	pg/g	5	0.71	0.506004873	Pass	9.9	2.3	Pass
1,2,3,4,7,8-HxCDD	2	pg/g	5	0.71	0.733814136	Pass	6.8	2.8	Pass
1,2,3,6,7,8-HxCDD	0.75	pg/g	5	0.58	1.689087313	Fail	3	0.6	Pass
1,2,3,6,7,8-HxCDD	1	pg/g	5	0.58	0.390126563	Pass	12.8	2.8	Pass
1,2,3,6,7,8-HxCDD	2	pg/g	5	0.58	0.681567479	Pass	7.3	3	Pass
1,2,3,7,8,9-HxCDD	0.75	pg/g	5	0.58	1.798514259	Fail	2.8	0.5	Pass
1,2,3,7,8,9-HxCDD	1	pg/g	5	0.58	0.445286377	Pass	11.2	2.4	Pass
1,2,3,7,8,9-HxCDD	2	pg/g	5	0.58	0.843023929	Pass	5.9	2.4	Pass
1,2,3,4,6,7,8-HpCDD	0.75	pg/g	5	0.46	4.610285299	Fail	1.1	0.3	Pass
1,2,3,4,6,7,8-HpCDD	1	pg/g	5	0.46	0.485246898	Pass	10.3	2.4	Pass
1,2,3,4,6,7,8-HpCDD	2	pg/g	5	0.46	0.65865283	Pass	7.6	3.3	Pass
OCDD	1.5	pg/g	10	1.5	65.79360843	Fail	0.2	0.1	Pass
OCDD	2	pg/g	10	1.5	4.250447189	Fail	2.4	0.7	Pass
OCDD	4	pg/g	10	1.5	2.76153848	Pass	3.6	1.9	Pass
2,3,7,8-TCDF	0.15	pg/g	1	0.11	1.079334358	Fail	0.9	0.3	Pass
2,3,7,8-TCDF	0.2	pg/g	1	0.11	0.179197295	Pass	5.6	1.4	Pass
2,3,7,8-TCDF	0.4	pg/g	1	0.11	0.16428536	Pass	6.1	2.7	Pass
1,2,3,7,8-PeCDF	0.75	pg/g	5	0.27	0.381574771	Pass	13.1	2.2	Pass
1,2,3,7,8-PeCDF	1	pg/g	5	0.27	0.48901373	Pass	10.2	2.3	Pass
1,2,3,7,8-PeCDF	2	pg/g	5	0.27	0.678283452	Pass	7.4	3.1	Pass
2,3,4,7,8-PeCDF	0.75	pg/g	5	0.29	0.559123109	Pass	8.9	1.5	Pass
2,3,4,7,8-PeCDF	1	pg/g	5	0.29	0.483494554	Pass	10.3	2.2	Pass
2,3,4,7,8-PeCDF	2	pg/g	5	0.29	0.781087512	Pass	6.4	2.6	Pass
1,2,3,4,7,8-HxCDF	0.75	pg/g	5	0.3	0.971943208	Pass	5.1	0.9	Pass
1,2,3,4,7,8-HxCDF	1	pg/g	5	0.3	0.438236394	Pass	11.4	2.5	Pass
1,2,3,4,7,8-HxCDF	2	pg/g	5	0.3	0.697775232	Pass	7.2	3	Pass
1,2,3,6,7,8-HxCDF	0.75	pg/g	5	0.38	0.979310863	Pass	5.1	0.9	Pass
1,2,3,6,7,8-HxCDF	1	pg/g	5	0.38	0.497646406	Pass	10	2.2	Pass
1,2,3,6,7,8-HxCDF	2	pg/g	5	0.38	0.739833523	Pass	6.8	2.8	Pass
2,3,4,6,7,8-HxCDF	0.75	pg/g	5	0.3	1.962996	Fail	2.5	0.5	Pass
2,3,4,6,7,8-HxCDF	1	pg/g	5	0.3	0.500561585	Pass	10	2.2	Pass
2,3,4,6,7,8-HxCDF	2	pg/g	5	0.3	0.660912365	Pass	7.6	3.2	Pass

Analyte	Spike Conc'n	%Rec 50-150	Calc MDL/Active	95% Conf	Mean Result	Mean %R	Std Dev	N	Min Val
2,3,7,8-TCDD	0.15	Pass	8.12	>	0.430347362	287	0.491326853	27	0.095572886
2,3,7,8-TCDD	0.2	Pass	1.64	=	0.31041265	155	0.101389359	41	0.155529744
2,3,7,8-TCDD	0.4	Pass	1.66	=	0.513102907	128	0.103046991	44	0.314584606
1,2,3,7,8-PeCDD	0.75	Pass	1.78	=	0.87030436	116	0.216862889	30	0.617762891
1,2,3,7,8-PeCDD	1	Pass	1.63	=	1.12624985	113	0.198019236	30	0.880890667
1,2,3,7,8-PeCDD	2	Pass	1.98	=	2.125089557	106	0.240883161	30	1.756761326
1,2,3,4,7,8-HxCDD	0.75	Pass	2.21	>	0.971098625	129	0.637362717	30	0.657256049
1,2,3,4,7,8-HxCDD	1	Pass	0.71	=	1.144940952	114	0.205524161	30	0.814759057
1,2,3,4,7,8-HxCDD	2	Pass	1.03	=	2.085569373	104	0.298053521	30	1.595926856
1,2,3,6,7,8-HxCDD	0.75	Pass	2.91	>	0.935616929	125	0.686057132	30	0.567263554
1,2,3,6,7,8-HxCDD	1	Pass	0.67	=	1.076046321	108	0.15845783	30	0.828676879
1,2,3,6,7,8-HxCDD	2	Pass	1.18	=	2.069869502	103	0.27683248	30	1.55504854
1,2,3,7,8,9-HxCDD	0.75	Pass	3.1	>	0.935968675	125	0.730503109	30	0.55811854
1,2,3,7,8,9-HxCDD	1	Pass	0.77	=	1.071750042	107	0.180862109	30	0.676692398
1,2,3,7,8,9-HxCDD	2	Pass	1.45	=	2.058418942	103	0.342411298	30	1.430031046
1,2,3,4,6,7,8-HpCDD	0.75	Pass	10.02	>	1.269878253	169	1.872561048	30	0.633165479
1,2,3,4,6,7,8-HpCDD	1	Pass	1.05	=	1.171585681	117	0.197092887	30	0.863234888
1,2,3,4,6,7,8-HpCDD	2	Pass	1.43	=	2.18629949	109	0.26752523	30	1.758309671
OCDD	1.5	Pass	43.86	>	7.56416675	504	26.72341089	30	1.503986702
OCDD	2	Pass	2.83	>	3.121542713	156	1.726405489	30	2.036350165
OCDD	4	Pass	1.84	=	5.299273597	132	1.121654964	30	3.859585216
2,3,7,8-TCDF	0.15	Pass	9.81	>	0.34778032	232	0.436507404	28	0.119549029
2,3,7,8-TCDF	0.2	Pass	1.63	=	0.254630394	127	0.074163388	44	0.159562433
2,3,7,8-TCDF	0.4	Pass	1.49	=	0.450241451	113	0.067991868	44	0.306570265
1,2,3,7,8-PeCDF	0.75	Pass	1.41	=	0.834952481	111	0.154984346	30	0.637398981
1,2,3,7,8-PeCDF	1	Pass	1.81	=	1.112286956	111	0.198622862	30	0.810005452
1,2,3,7,8-PeCDF	2	Pass	2.51	>	2.096236104	105	0.275498606	30	1.681124537
2,3,4,7,8-PeCDF	0.75	Pass	1.93	=	0.822279083	110	0.227099211	30	0.611760417
2,3,4,7,8-PeCDF	1	Pass	1.67	=	1.069288205	107	0.196381137	30	0.804865596
2,3,4,7,8-PeCDF	2	Pass	2.69	>	2.058735349	103	0.317254564	30	1.691010036
1,2,3,4,7,8-HxCDF	0.75	Pass	3.24	>	0.867592888	116	0.394774482	30	0.491316475
1,2,3,4,7,8-HxCDF	1	Pass	1.46	=	1.115122994	112	0.177998616	30	0.830281793
1,2,3,4,7,8-HxCDF	2	Pass	2.33	>	2.102071887	105	0.283415588	30	1.686798518
1,2,3,6,7,8-HxCDF	0.75	Pass	2.58	>	0.904891794	121	0.397767005	30	0.593331767
1,2,3,6,7,8-HxCDF	1	Pass	1.31	=	1.112028272	111	0.202129199	30	0.803746066
1,2,3,6,7,8-HxCDF	2	Pass	1.95	=	2.088072836	104	0.300498418	30	1.703144908
2,3,4,6,7,8-HxCDF	0.75	Pass	6.54	>	0.992807204	132	0.79731071	30	0.635252377
2,3,4,6,7,8-HxCDF	1	Pass	1.67	=	1.112405813	111	0.203313258	30	0.800915621
2,3,4,6,7,8-HxCDF	2	Pass	2.2	>	2.119042996	106	0.268442986	30	1.736552863

Analyte	Spike Conc'n	Max Val	Stud. T	Spike > Calc MDL	Spike < RL
2,3,7,8-TCDD	0.15	1.880079433	2.478629824	Fail	Pass
2,3,7,8-TCDD	0.2	0.674766245	2.423256779	Fail	Pass
2,3,7,8-TCDD	0.4	0.912339015	2.416250129	Pass	Pass
1,2,3,7,8-PeCDD	0.75	1.613775027	2.46202136	Pass	Pass
1,2,3,7,8-PeCDD	1	1.722027	2.46202136	Pass	Pass
1,2,3,7,8-PeCDD	2	2.653558097	2.46202136	Pass	Pass
1,2,3,4,7,8-HxCDD	0.75	4.260167579	2.46202136	Fail	Pass
1,2,3,4,7,8-HxCDD	1	1.70037872	2.46202136	Pass	Pass
1,2,3,4,7,8-HxCDD	2	2.642008085	2.46202136	Pass	Pass
1,2,3,6,7,8-HxCDD	0.75	4.472818313	2.46202136	Fail	Pass
1,2,3,6,7,8-HxCDD	1	1.432043785	2.46202136	Pass	Pass
1,2,3,6,7,8-HxCDD	2	2.710541493	2.46202136	Pass	Pass
1,2,3,7,8,9-HxCDD	0.75	4.721689976	2.46202136	Fail	Pass
1,2,3,7,8,9-HxCDD	1	1.474697171	2.46202136	Pass	Pass
1,2,3,7,8,9-HxCDD	2	2.998091035	2.46202136	Pass	Pass
1,2,3,4,6,7,8-HpCDD	0.75	11.11027331	2.46202136	Fail	Pass
1,2,3,4,6,7,8-HpCDD	1	1.720367331	2.46202136	Pass	Pass
1,2,3,4,6,7,8-HpCDD	2	2.85056061	2.46202136	Pass	Pass
OCDD	1.5	148.832086	2.46202136	Fail	Pass
OCDD	2	11.34510651	2.46202136	Fail	Pass
OCDD	4	8.372576935	2.46202136	Pass	Pass
2,3,7,8-TCDF	0.15	1.639960996	2.472659912	Fail	Pass
2,3,7,8-TCDF	0.2	0.590564032	2.416250129	Pass	Pass
2,3,7,8-TCDF	0.4	0.604126519	2.416250129	Pass	Pass
1,2,3,7,8-PeCDF	0.75	1.24738053	2.46202136	Pass	Pass
1,2,3,7,8-PeCDF	1	1.637524986	2.46202136	Pass	Pass
1,2,3,7,8-PeCDF	2	2.830646975	2.46202136	Pass	Pass
2,3,4,7,8-PeCDF	0.75	1.788409222	2.46202136	Pass	Pass
2,3,4,7,8-PeCDF	1	1.704287549	2.46202136	Pass	Pass
2,3,4,7,8-PeCDF	2	3.011024795	2.46202136	Pass	Pass
1,2,3,4,7,8-HxCDF	0.75	2.818790227	2.46202136	Fail	Pass
1,2,3,4,7,8-HxCDF	1	1.63264718	2.46202136	Pass	Pass
1,2,3,4,7,8-HxCDF	2	2.90157055	2.46202136	Pass	Pass
1,2,3,6,7,8-HxCDF	0.75	2.80671074	2.46202136	Fail	Pass
1,2,3,6,7,8-HxCDF	1	1.805976404	2.46202136	Pass	Pass
1,2,3,6,7,8-HxCDF	2	2.855799249	2.46202136	Pass	Pass
2,3,4,6,7,8-HxCDF	0.75	5.147514944	2.46202136	Fail	Pass
2,3,4,6,7,8-HxCDF	1	1.710760056	2.46202136	Pass	Pass
2,3,4,6,7,8-HxCDF	2	2.758724923	2.46202136	Pass	Pass

Analyte	Spike Conc'n	Units	Current RL	Current MDL	Calc MDL	RL Rule	RL/MDL	Mean/MDL	MDL > 10%
1,2,3,7,8,9-HxCDF	0.75	pg/g	5	0.43	1.556477132	Pass	3.2	0.7	Pass
1,2,3,7,8,9-HxCDF	1	pg/g	5	0.43	0.733308303	Pass	6.8	1.6	Pass
1,2,3,7,8,9-HxCDF	2	pg/g	5	0.43	1.013767798	Pass	4.9	2.1	Pass
1,2,3,4,6,7,8-HpCDF	0.75	pg/g	5	0.38	2.478592897	Fail	2	0.4	Pass
1,2,3,4,6,7,8-HpCDF	1	pg/g	5	0.38	0.404526308	Pass	12.4	2.7	Pass
1,2,3,4,6,7,8-HpCDF	2	pg/g	5	0.38	0.60263884	Pass	8.3	3.5	Pass
1,2,3,4,7,8,9-HpCDF	0.75	pg/g	5	0.65	3.147422039	Fail	1.6	0.3	Pass
1,2,3,4,7,8,9-HpCDF	1	pg/g	5	0.65	0.68858674	Pass	7.3	1.7	Pass
1,2,3,4,7,8,9-HpCDF	2	pg/g	5	0.65	0.703875164	Pass	7.1	2.9	Pass
OCDF	1.5	pg/g	10	1.2	10.14024697	Fail	1	0.2	Pass
OCDF	2	pg/g	10	1.2	1.161907999	Pass	8.6	1.9	Pass
OCDF	4	pg/g	10	1.2	1.39029685	Pass	7.2	3	Pass

Analyte	Spike Conc'n	%Rec 50-150	Calc MDL/Active	95% Conf	Mean Result	Mean %R	Std Dev	N	Min Val
1,2,3,7,8,9-HxCDF	0.75	Pass	3.62	>	1.022668262	136	0.632194813	30	0.59104652
1,2,3,7,8,9-HxCDF	1	Pass	1.71	=	1.192778697	119	0.297848067	30	0.794328102
1,2,3,7,8,9-HxCDF	2	Pass	2.36	>	2.137176139	107	0.411762389	30	1.565622608
1,2,3,4,6,7,8-HpCDF	0.75	Pass	6.52	>	1.092915599	146	1.006730866	30	0.643761734
1,2,3,4,6,7,8-HpCDF	1	Pass	1.06	=	1.098292231	110	0.164306579	30	0.836099863
1,2,3,4,6,7,8-HpCDF	2	Pass	1.59	=	2.080016559	104	0.244774009	30	1.706688926
1,2,3,4,7,8,9-HpCDF	0.75	Pass	4.84	>	1.080604469	144	1.278389412	30	0.597187158
1,2,3,4,7,8,9-HpCDF	1	Pass	1.06	=	1.146345436	115	0.279683495	30	0.813599625
1,2,3,4,7,8,9-HpCDF	2	Pass	1.08	=	2.065154588	103	0.2858932	30	1.700654898
OCDF	1.5	Pass	8.45	>	2.505546681	167	4.118667343	30	1.179318256
OCDF	2	Pass	0.97	=	2.265076097	113	0.471932542	30	1.573740045
OCDF	4	Pass	1.16	=	4.23280266	106	0.564697314	30	3.342364138

Analyte	Spike Conc'n	Max Val	Stud. T	Spike > Calc MDL	Spike < RL
1,2,3,7,8,9-HxCDF	0.75	4.108840182	2.46202136	Fail	Pass
1,2,3,7,8,9-HxCDF	1	1.890716179	2.46202136	Pass	Pass
1,2,3,7,8,9-HxCDF	2	3.153561786	2.46202136	Pass	Pass
1,2,3,4,6,7,8-HpCDF	0.75	6.182243836	2.46202136	Fail	Pass
1,2,3,4,6,7,8-HpCDF	1	1.419588877	2.46202136	Pass	Pass
1,2,3,4,6,7,8-HpCDF	2	2.633962999	2.46202136	Pass	Pass
1,2,3,4,7,8,9-HpCDF	0.75	7.758706964	2.46202136	Fail	Pass
1,2,3,4,7,8,9-HpCDF	1	1.90762507	2.46202136	Pass	Pass
1,2,3,4,7,8,9-HpCDF	2	2.747640519	2.46202136	Pass	Pass
OCDF	1.5	24.24433816	2.46202136	Fail	Pass
OCDF	2	3.68655613	2.46202136	Pass	Pass
OCDF	4	5.691275985	2.46202136	Pass	Pass

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb
2,3,7,8-TCDD	pg/g	0.15	1	8290	0.028858576	0.114135014	300	8290_P_Sox	0	1.141751389	0.599937109
1,2,3,7,8-PeCDD	pg/g	0.3	5	8290	0.021455207	0.091952547	300	8290_P_Sox	0	1.176613048	0.392595217
1,2,3,4,7,8-HxCDD	pg/g	0.71	5	8290	0.133164434	0.1238536	300	8290_P_Sox	0	0.978315777	0.557991039
1,2,3,6,7,8-HxCDD	pg/g	0.58	5	8290	0.068120511	0.286606221	300	8290_P_Sox	0	3.559534542	0.815401788
1,2,3,7,8,9-HxCDD	pg/g	0.58	5	8290	0.078335161	0.267893082	300	8290_P_Sox	0	3.472407759	0.872421276
1,2,3,4,6,7,8-HpCDD	pg/g	0.46	5	8290	0.286208301	0.477012255	300	8290_P_Sox	0	5.106312976	2.45693705
OCDD	pg/g	1.5	10	8290	2.767445666	7.822151517	300	8290_P_Sox	0	105.4992071	24.73045905
2,3,7,8-TCDF	pg/g	0.11	1	8290	0.042631029	0.118171672	300	8290_P_Sox	0	0.940115545	0.557715243
1,2,3,7,8-PeCDF	pg/g	0.27	5	8290	0.060846939	0.121205542	300	8290_P_Sox	0	0.959322235	0.510973245
2,3,4,7,8-PeCDF	pg/g	0.29	5	8290	0.022578793	0.084872221	300	8290_P_Sox	0	0.816499947	0.477067431
1,2,3,4,7,8-HxCDF	pg/g	0.3	5	8290	0.036012854	0.089938759	300	8290_P_Sox	0	0.833257099	0.374877515
1,2,3,6,7,8-HxCDF	pg/g	0.38	5	8290	0.031589205	0.08750211	300	8290_P_Sox	0	0.848153114	0.473884977
2,3,4,6,7,8-HxCDF	pg/g	0.3	5	8290	0.030937475	0.089266689	300	8290_P_Sox	0	0.679088993	0.491943291
1,2,3,7,8,9-HxCDF	pg/g	0.43	5	8290	0.30630781	0.520482946	300	8290_P_Sox	0	3.178826088	2.689886079
1,2,3,4,6,7,8-HpCDF	pg/g	0.38	5	8290	0.169504139	0.374934459	300	8290_P_Sox	0	4.949342127	1.111596139
1,2,3,4,7,8,9-HpCDF	pg/g	0.65	5	8290	0.201834982	0.361258459	300	8290_P_Sox	0	2.027047346	1.859343538
OCDF	pg/g	1.2	10	8290	0.469525656	0.959294765	300	8290_P_Sox	0	10.90878488	4.536610348

Analyte	Calculation Type
2,3,7,8-TCDD	99th Percentile
1,2,3,7,8-PeCDD	99th Percentile
1,2,3,4,7,8-HxCDD	99th Percentile
1,2,3,6,7,8-HxCDD	99th Percentile
1,2,3,7,8,9-HxCDD	99th Percentile
1,2,3,4,6,7,8-HpCDD	99th Percentile
OCDD	99th Percentile
2,3,7,8-TCDF	99th Percentile
1,2,3,7,8-PeCDF	99th Percentile
2,3,4,7,8-PeCDF	99th Percentile
1,2,3,4,7,8-HxCDF	99th Percentile
1,2,3,6,7,8-HxCDF	99th Percentile
2,3,4,6,7,8-HxCDF	99th Percentile
1,2,3,7,8,9-HxCDF	99th Percentile
1,2,3,4,6,7,8-HpCDF	99th Percentile
1,2,3,4,7,8,9-HpCDF	99th Percentile
OCDF	99th Percentile

NWTPH_Dx Method Detection Limits

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type
C10-C24	mg/Kg	12.3	50	NWTPH_Dx	2.385151575	3.732934546	192	3550B	-8.997924281	13.55634731	12.70113953	99th Percentile
C12-C24	mg/Kg	12.3	50	NWTPH_Dx	2.388299059	3.355072699	192	3550B	-7.328788327	11.97072866	11.25226531	99th Percentile
Motor Oil	mg/Kg	17.5	50	NWTPH_Dx	1.918591254	6.492765494	192	3550B	-19.34587035	21.750103	17.70098843	99th Percentile

Analyte	Units	MDL	RL	Method	Mean Result	SD	N	Prep Method	Min Val	Max Val	MDLb	Calculation Type	% Blank Hits > MDL
Gasoline	mg/Kg	2.3	5	NWTPH_Gx	0.904055818	0.789035262	192	5035A_M	-1.563501714	3.503534569	3.075911835	99th Percentile	4.166666667

ATTACHMENT 3

ASSESSMENT CHECKLISTS

DRAFT PRE-FIELD AUDIT CHECKLIST
PRIVILEGED AND CONFIDENTIAL

Audit Date: Click here to enter text.
Auditor: Click here to enter text.
Project Manager: Click here to enter text.
Principal-in-Charge: Click here to enter text.
Task Number & Name: Click here to enter text.
Field Lead: Click here to enter text.

1. General Project Information.

   - Is Integral the prime contractor or a subcontractor on the project? If Integral is teaming, describe our relationship with other consultants that will be working in the field.

     Click here to enter text.

   - Describe the objectives of the field work.

     Click here to enter text.

   - Describe the types of samples and data that will be collected for the project.

     Click here to enter text.

   - Will data on physical parameters be collected? Will any of these involve deployment of sensors?

     Click here to enter text.

   - Who has been assigned as Field Team Leader, Site Safety Officer, and other team member(s) to perform this field work?

     Click here to enter text.

   - How do the qualifications of the Integral personnel selected to perform this field work correspond to the types of data to be collected or other needs of the project?

     Click here to enter text.

- Are certifications, licenses or other credentials (e.g., boat captain license) required of the field team members (including subcontractors)? Has OSHA certification been confirmed for all members of the team?

  Click here to enter text.

- What is the expected frequency of reporting by the Field Team Lead to the PM during the sampling activities? How will reporting be performed (e.g., Email, text, phone)?

  Click here to enter text.

- Who has been assigned as the Laboratory QA Coordinator for the project?

  Click here to enter text.

- Will an Integral laboratory be used on this project?

  ☐ Yes ☐ No

  Click here to enter text.

- Has the lab coordinator initiated or performed the following:

  - Laboratory and data validator subcontracting ☐ Yes ☐ No
  - QAPP preparation or review ☐ Yes ☐ No
  - Definition of EDD format to labs ☐ Yes ☐ No
  - Coordination of sample bottles/supplies shipment ☐ Yes ☐ No
  - Overall coordination with Field Team Leader ☐ Yes ☐ No

- Are you using an Integral FSP and QAPP? ☐ Yes ☐ No

- Do you have a project-specific HSP? ☐ Yes ☐ No

  If no, please explain why not and specify the file path to the field procedural documents reviewed by the team prior to deployment.

  Click here to enter text.

  Please list the SOPs that will be used on this project (PM can send a list cut and pasted from the FSP via email, as available).

  Click here to enter text.

2. What elements of the project require advance planning?

- Access Agreements

  Click here to enter text.

- Sample collection permits (e.g., for fish or shellfish)

  Click here to enter text.

- Subcontracts with field sampling contractor and/or testing laboratories

  Click here to enter text.

- Was Integral's Preferred Vendor list consulted prior to selecting subcontractors?
  ☐ Yes ☐ No

  Click here to enter text.

- Describe the schedule for the field work

  Click here to enter text.

- Have the coordinates of sampling stations been plotted and checked for accuracy on a map?
  ☐ Yes ☐ No

  Click here to enter text.

- Have major obstacles or restrictions been identified based on sample location maps?
  ☐ Yes ☐ No

  Click here to enter text.

  Will a GPS device be used to record field sample locations?
  ☐ Yes ☐ No
  If Yes: Are you using an Integral GPS, GPS rental or other (i.e. boat navigation system),
  Are you pre-loading GPS data and base files? All GPS data files should be in WGS84 coordinate system and pre-QA'd by Integral GIS analyst.
  Does the FSP state the required accuracy for GPS locations? (See GPS capabilities memo on the wiki which outlines horizontal accuracy).
  What level of experience does the field crew have operating GPS equipment?
  Click here to enter text.

- Special sampling requirements and/or health and safety concerns

  Click here to enter text.

- Underground Utility Locator

  Click here to enter text.

- Equipment or Boat Rentals

  Click here to enter text.

- Have EPA, state regulators, Trustees and/or other stakeholders (if applicable) been informed of field schedule prior to field work?

  Click here to enter text.

- Other advanced planning steps

  Click here to enter text.

3. Will calibration of the field equipment be required (per manufacturer specifications and FSP)? ☐ Yes ☐ No ☐ Some, not all

   - What equipment will need calibration (note: GPS equipment can be calibrated to local benchmark if properly planned)?

     Click here to enter text.

   - Which calibration/instrument manuals will be used? **Please specify a file path to the instrument calibration manuals, if available electronically**.

     Click here to enter text.

   - Have you checked that the calibration manual has the same publication date as the date of manufacture/release of the instrument to be calibrated?

     Click here to enter text.

   - How often will calibration be performed?

     ☐ 2x Daily ☐ Once Daily ☐ Other (specify) Click here to enter text.

   - How will calibration records be maintained (e.g., in field notebooks, on forms, other)?

     Click here to enter text.

4. Have the following items received documented QA review prior to implementation of the field work?

   - Will you be using a field checklist to help prepare? **Please provide the file path to the checklist.**

     Click here to enter text.

- Field budget with both Field Team Leader and Project Manager input?

  Click here to enter text.

- FSP?

  Click here to enter text.

- QAPP?

  Click here to enter text.

- HSP?

  Click here to enter text.

- Subcontract SOWs?

  Click here to enter text.

5. Will a Field Sampling Report be prepared for this project? If not, what are plans for consolidation of records?

   Click here to enter text.

6. Conduct Audit Findings Meeting with PM or other project team members

   - Provide PM and project team with audit findings (Auditor complete this section)

     Click here to enter text.

   - Provide general and specific recommendations for improvement to PM (and PIC if appropriate)

     Click here to enter text.

   - Document Action Items, project specific, to be completed by PM and project team (Auditor complete this section). Specify timing for actions to be completed.

     Click here to enter text.

   - Solicit suggestions for improvement of Integral's QA process (PM provide suggestions)

     Click here to enter text.

7. Audit Close-Out

   We agree with the audit findings, and all Action Items have been addressed.

PM Signature	Date
PIC Signature	Date

2008 TNI Version 2003 NELAC Quality Systems Checklist

ID #	Major Topic	Topic	Subject	Category	Citation	Does the laboratory comply with this section?
1	Quality Systems Summary				V1M2 1	***Summary of Quality System Requirements - Checklist responses will determine whether or not these have been met. You may use any of these items for assessment if you want.***
2	Quality Systems Summary	Introduction			V1M2 1	**INTRODUCTION, SCOPE AND APPLICABILITY**
3	Quality Systems Summary	Introduction			V1M2 1.1	Introduction
4	Quality Systems Summary	Introduction	General		V1M2 1.1	Each laboratory shall have a quality system. The laboratory's quality system is the means by which an organization ensures the quality of the products or services it provides and includes a variety of management, technical, and administrative elements such as:
5	Quality Systems Summary	Introduction	General	Quality System Components	V1M2 1.1 a)	policies and objectives,
6	Quality Systems Summary	Introduction	General	Quality System Components	V1M2 1.1 b)	procedures and practices,
7	Quality Systems Summary	Introduction	General	Quality System Components	V1M2 1.1 c)	organizational authority,
8	Quality Systems Summary	Introduction	General	Quality System Components	V1M2 1.1 d)	responsibilities, and
9	Quality Systems Summary	Introduction	General	Quality System Components	V1M2 1.1 e)	performance measures.
10	Quality Systems Summary	Introduction	General	Use and Documentation	V1M2 1.1	The quality system provides the framework for planning, implementing, assessing, and improving work performed by an organization so as to provide the client with data of known and documented quality, sufficient to evaluate the usability of the data to the clients needs. The quality system shall be documented in the laboratory's quality manual and related quality documentation, and shall be referenced in the quality manual.
11	Quality Systems Summary		General	Requirement and Purpose	V1M2 1.1	This Standard contains detailed quality system requirements for consistent and uniform implementation by the laboratories conducting testing and the consistent and uniform evaluation of those laboratories by accreditation bodies. Each laboratory seeking accreditation under this Standard shall ensure that they are implementing their quality system and that all Quality Control procedures specified in this module are being followed. The Quality Assurance policies, which establish quality control procedures, are applicable to environmental laboratories regardless of size and complexity.
12	Quality Systems Summary	Introduction	General		V1M2 1.1	This Standard is consistent with ISO/IEC 17025:2005 requirements that are relevant to the scope of environmental testing services.
13	Quality Systems Summary	Introduction	General	Requirement and Purpose	V1M2 1.1	All items identified in this document shall be available for an on-site assessment.
14	Quality Systems Summary	Scope			V1M2 1.2	Scope
15	Quality Systems Summary	Scope			V1M2 1.2	The requirements in this document give the basis for a laboratory's quality system in order to carry out environmental tests. It covers testing performed using reference methods, non-reference methods, and laboratory-developed methods. This document contains the essential elements required to establish a quality system that produces data of known and documented quality, and demonstrates proficiency through the use of proficiency testing and employee training.

16	Quality Systems Summary	Scope			V1M2 1.2	The general requirements of this document apply to all organizations performing environmental tests, regardless of the number of personnel or the degree of environmental testing activities. When the use of the data requires compliance with the Standards, these Standards shall be followed.
17	Quality Systems Summary	Scope			V1M2 1.2	This document is for use by laboratories, clients, regulatory authorities, and accreditation bodies to ensure the laboratory has appropriate management and technical quality systems to perform environmental testing. This document specifies technical, managerial, and documentation requirements needed for assessment by organizations or accreditation bodies to grant approval.
18	Quality Systems Summary	Scope			V1M2 1.2	This document provides the requirements needed for laboratory accreditation. If the requirements of this document are met, the laboratory operates a quality system in conformance with the applicable clauses of ISO/IEC 17025:2005(E).
19	Definitions	Definitions			V1M2 3	***Make sure you understand all these terms as they relate to the assessment.***
20	Definitions	Definitions			V1M2 3	**TERMS AND DEFINITIONS**

ID	Major Topic	Topic	Subject	Category
20				
21	4.1 Organization	4.1 Organization		
22	4.1 Organization	4.1.1 Legal Status		Requirement
23	4.1 Organization	4.1.2 Laboratory Goals	Responsibility	Requirement
24	4.1 Organization	4.1.2 Laboratory Goals	Standard	Requirement
25	4.1 Organization	4.1.2 Laboratory Goals	Customers	Requirement
26	4.1 Organization	4.1.3 Management System	Scope	Requirement
27	4.1 Organization	4.1.4 Conflict of Interest	Activities	Requirement
28	4.1 Organization	4.1.4 Conflict of Interest	Activities	Note
29	4.1 Organization	4.1.4 Conflict of Interest	Activities	Note
30	4.1 Organization	4.1.5 General Requirements		
31		4.1.5 General Requirements	Personnel	Requirement
32	4.1 Organization	4.1.5 General Requirements	Duties - Management System	Requirement
33	4.1 Organization	4.1.5 General Requirements	Duties- Corrective Actions	Requirement
34	4.1 Organization	4.1.5 General Requirements	Duties - Preventive Actions	Requirement
35	4.1 Organization	4.1.5 General Requirements	Undue Pressures	Procedure
36	4.1 Organization	4.1.5 General Requirements	Confidentiality	Procedure
37	4.1 Organization	4.1.5 General Requirements	Confidence	Procedure
38	4.1 Organization	4.1.5 General Requirements	Organization Structure	
39	4.1 Organization	4.1.5 General Requirements	Organization Structure	

40	4.1 Organization	4.1.5 General Requirements	Organization Structure	
41	4.1 Organization	4.1.5 General Requirements	Technical Manager	Requirement
42				
43	4.1 Organization	4.1.5 General Requirements	Quality Manager	Requirement
44	4.1 Organization	4.1.5 General Requirements	Temporary Appointments	Requirement
45	4.1 Organization	4.1.5 General Requirements	Communication	Requirement
46	4.1 Organization	4.1.5 General Requirements		Note
47	4.1 Organization	4.1.6 Communication	Communication	Requirement
48	4.1 Organization	4.1.7 Additional General Requirements		
49	4.1 Organization	4.1.7.1 Quality Manager	Quality Manager	
50		4.1.7.1 Quality Manager	Quality Manager	
51	4.1 Organization	4.1.7.1 Quality Manager	Responsibility	Requirement
52	4.1 Organization	4.1.7.1 Quality Manager	Responsibility	Requirement
53	4.1 Organization	4.1.7.1 Quality Manager	Responsibility	Requirement
54	4.1 Organization	4.1.7.1 Quality Manager	Experience	Requirement
55	4.1 Organization	4.1.7.1 Quality Manager	Familiarity	Requirement
56	4.1 Organization	4.1.7.1 Quality Manager	Responsibility	Requirement
57	4.1 Organization	4.1.7.1 Quality Manager	Responsibility	Requirement
58	4.1 Organization	4.1.7.1 Quality Manager	Responsibility	Requirement
59	4.1 Organization	4.1.7.1 Quality Manager	Quality Manager	Note
60	4.1 Organization	4.1.7.2 Technical Manager	Technical Manager	
61	4.1 Organization	4.1.7.2 Technical Manager	Duties	Requirement

62	4.1 Organization	4.1.7.2 Technical Manager	Experience	Requirement
63	4.1 Organization	4.1.7.2 Technical Manager	Duties	
64	4.1 Organization	4.1.7.2 Technical Manager	Monitoring Quality	Requirement
65	4.1 Organization	4.1.7.2 Technical Manager	Monitoring Data Validity	Requirement
66	4.1 Organization	4.1.7.2 Technical Manager	Restriction to one lab	Requirement
67	4.1 Organization	4.1.7.2 Technical Manager	Restriction to one lab	AB Considerations
68	4.1 Organization	4.1.7.2 Technical Manager	Restriction to one lab	AB Considerations
69	4.1 Organization	4.1.7.2 Technical Manager	Restriction to one lab	AB Considerations
70	4.1 Organization	4.1.7.2 Technical Manager	Temporary Technical Manager	Requirement
71	4.1 Organization	4.1.7.2 Technical Manager	Temporary Technical Manager	Requirement
72	4.2 Management			
73	4.2 Management	4.2.1 Management System		
74	4.2 Management	4.2.1 Management System	Policies and Procedure	Documentation
75	4.2 Management	4.2.1 Management System	Communication & Implementation	Requirement
76				
77	4.2 Management	4.2.2 Quality Management System	Quality Policy	Requirement
78	4.2 Management	4.2.2 Quality Management System	Quality Policy	Requirement
79	4.2 Management	4.2.2 Quality Management System	Quality Policy	Requirement
80	4.2 Management	4.2.2 Quality Management System	Quality Policy	Requirement
81	4.2 Management	4.2.2 Quality Management System	Quality Policy	Requirement
82	4.2 Management	4.2.2 Quality Management System	Quality Manual	Requirement

83	4.2 Management	4.2.2 Quality Management System	Quality Manual	Requirement
84	4.2 Management	4.2.2 Quality Management System	Quality Manual	Note
85	4.2 Management	4.2.3 Commitment	Management System	Requirement
86	4.2 Management	4.2.4 Communication	Customer Satisfaction	Requirement
87	4.2 Management	4.2.5 Quality Manual	Procedures	Requirement
88	4.2 Management	4.2.6 Quality Manual	Roles & Responsibilities	Requirement
89	4.2 Management	4.2.7 Management System Integrity	Changes	Requirement
90	4.2 Management	4.2.8 Additional Management System Requirements		
91	4.2 Management	4.2.8.1 Data Integrity System	Establishment	Requirement
92	4.2 Management	4.2.8.1 Data Integrity System	Data Integrity	
93	4.2 Management	4.2.8.1 Data Integrity System	Training	
94	4.2 Management	4.2.8.1 Data Integrity System	Documentation	
95	4.2 Management	4.2.8.1 Data Integrity System	Monitoring	Requirement
96	4.2 Management	4.2.8.1 Data Integrity System	Procedure	
97	4.2 Management	4.2.8.1 Data Integrity System	Approval	Requirement
98	4.2 Management	4.2.8.1 Data Integrity System	Investigation	
99	4.2 Management	4.2.8.1 Data Integrity System	Annual Review	Requirement
100	4.2 Management	4.2.8.1 Data Integrity System	Investigation	Procedure
101	4.2 Management	4.2.8.1 Data Integrity System	Investigation	Procedure
102	4.2 Management	4.2.8.2 Quality Manager	Quality Manager	Requirement
103	4.2 Management	4.2.8.3 Quality Manual	Required Contents	
104	4.2 Management	4.2.8.3 Quality Manual	Title	Requirement

105	4.2 Management	4.2.8.3 Quality Manual	Location	Requirement
106	4.2 Management	4.2.8.3 Quality Manual	Responsible Party Location	Requirement
107	4.2 Management	4.2.8.3 Quality Manual	Organization Structure	Requirement
108	4.2 Management	4.2.8.3 Quality Manual	Signatories	Requirement
109	4.2 Management	4.2.8.3 Quality Manual	Signatures	Requirement
110	4.2 Management	4.2.8.3 Quality Manual	Objectives	Requirement
111				
112	4.2 Management	4.2.8.3 Quality Manual	Quality Policy	Requirement
113	4.2 Management	4.2.8.3 Quality Manual	Table of Contents	Requirement
114	4.2 Management	4.2.8.4 Quality Manual	Include or Reference	
115	4.2 Management	4.2.8.4 Quality Manual	Maintenance, calibration & verification	Procedure
116	4.2 Management	4.2.8.4 Quality Manual	Equipment	Requirement
117	4.2 Management	4.2.8.4 Quality Manual	Verification	Procedure
118	4.2 Management	4.2.8.4 Quality Manual	Reporting	Procedure
119				
120	4.2 Management	4.2.8.4 Quality Manual	Organization Structure	Requirement
121				
122	4.2 Management	4.2.8.4 Quality Manual	Records Retention	Procedure
123	4.2 Management	4.2.8.4 Quality Manual	Document Control	Procedure
124				
125	4.2 Management	4.2.8.4 Quality Manual	Job descriptions	Requirement
126	4.2 Management	4.2.8.4 Quality Manual	Measurement Traceability	Procedure
127	4.2 Management	4.2.8.4 Quality Manual	Method List	Requirement
128	4.2 Management	4.2.8.4 Quality Manual	Review of New Work	Procedure
129	4.2 Management	4.2.8.4 Quality Manual	Sample Handling	Procedure
130	4.2 Management	4.2.8.4 Quality Manual	Feedback and Corrective Actions	Procedure

131	4.2 Management	4.2.8.4 Quality Manual	Departure from Policies and Procedure	Policy
132	4.2 Management	4.2.8.4 Quality Manual	Complaint Process	Procedure
133	4.2 Management	4.2.8.4 Quality Manual	Confidentiality	Procedure
134	4.2 Management	4.2.8.4 Quality Manual	Audits and Data Review	Procedure
135	4.2 Management	4.2.8.4 Quality Manual	Adequate Credentials	Procedure
136	4.2 Management	4.2.8.4 Quality Manual	Electronic Signatures	Policy
137	4.2 Management	4.2.8.5 SOPs	Standard Operating Procedures	Requirement
138	4.2 Management	4.2.8.5 SOPs	Standard Operating Procedures	Option
139	4.2 Management	4.2.8.5 SOPs	Written SOP Criteria	Requirement
140	4.2 Management	4.2.8.5 SOPs	SOP Accessibility	Requirement
141	4.2 Management	4.2.8.5 SOPs	Identifying Information	Requirement
142	4.2 Management	4.2.8.5 SOPs	Changes to external documents	Requirement
143	4.2 Management	4.2.8.5 SOPs	Analytical Methods	Requirement
144	4.2 Management	4.2.8.5 SOPs	Analytical Methods	
145	4.2 Management	4.2.8.5 SOPs	Analytical Methods	
145.1	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
146	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
147	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
148	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
149	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
150	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
151	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement

152	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
153	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
154	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
155	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
156	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
157	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
158	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
159	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
160	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
161	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
162	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
163	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
164	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
165	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
166	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
167	4.2 Management	4.2.8.5 SOPs	Analytical Methods - Contents	Requirement
168	4.3 Document Control	Document Control		
169	4.3 Document Control	Document Control		
170	4.3 Document Control	4.3.1 General	General	Procedure
171	4.3 Document Control	4.3.1 General		
172	4.3 Document Control	4.3.1 General		
173	4.3 Document Control	4.3.2 Document Approval and Use		
174	4.3 Document Control	4.3.2 Document Approval and Use	Review and Approval	Requirement

175	4.3 Document Control	4.3.2 Document Approval and Use	Master List	Requirement
176	4.3 Document Control	4.3.2 Document Approval and Use	Procedure	Procedure
177	4.3 Document Control	4.3.2 Document Approval and Use	Revisions	Requirement
178	4.3 Document Control	4.3.2 Document Approval and Use	Periodic Review	Requirement
179	4.3 Document Control	4.3.2 Document Approval and Use	Obsolete Documents	Requirement
180	4.3 Document Control	4.3.2 Document Approval and Use	Obsolete Documents	Requirement
181	4.3 Document Control	4.3.2 Document Approval and Use	Identification	Requirement
182	4.3 Document Control	4.3.2 Document Approval and Use	Identification	Requirement
183	4.3 Document Control	4.3.3 Document Changes		
184	4.3 Document Control	4.3.3 Document Changes	Approval	Requirement
185	4.3 Document Control	4.3.3 Document Changes	Approval	Requirement
186	4.3 Document Control	4.3.3 Document Changes	Change Identification	Requirement
187	4.3 Document Control	4.3.3 Document Changes	Amendments	Procedure
188	4.3 Document Control	4.3.3 Document Changes	Amendments	Requirement
189	4.3 Document Control	4.3.3 Document Changes	Amendments	Requirement
190	4.3 Document Control	4.3.3 Document Changes	Electronic Records	Procedure
191	4.4 Review of Requests, Tenders and Contracts			
192	4.4 Review of Requests, Tenders and Contracts	4.4.1 Procedures for Review		
193	4.4 Review of Requests, Tenders and Contracts	4.4.1 Procedures for Review	Review Objectives	Requirement
194	4.4 Review of Requests, Tenders and Contracts	4.4.1 Procedures for Review	Capacity and Resources	Requirement

195	4.4 Review of Requests, Tenders and Contracts	4.4.1 Procedures for Review	Appropriate Methods	Requirement
196	4.4 Review of Requests, Tenders and Contracts	4.4.1 Procedures for Review	Resolving Differences	Requirement
197	4.4 Review of Requests, Tenders and Contracts	4.4.1 Procedures for Review		
198	4.4 Review of Requests, Tenders and Contracts	4.4.1 Procedures for Review		
199	4.4 Review of Requests, Tenders and Contracts	4.4.1 Procedures for Review		
200	4.4 Review of Requests, Tenders and Contracts	4.4.2 Records Review	Review	Requirement
201	4.4 Review of Requests, Tenders and Contracts	4.4.2 Records Review	Customer Communication	Record
202	4.4 Review of Requests, Tenders and Contracts	Review of Requests, Tenders and Contracts		
203	4.4 Review of Requests, Tenders and Contracts	4.4.3 Subcontracted Laboratory	Review	Requirement
204	4.4 Review of Requests, Tenders and Contracts	4.4.4 Customer Communication	Deviations	Requirement
205	4.4 Review of Requests, Tenders and Contracts	4.4.5 Customer Communication	Amendments	Requirement
206	4.5 Subcontracting tests			

207	4.5 Subcontracting tests	Subcontracting Tests		
208	4.5 Subcontracting tests	Customer Obligation	Communication	Requirement
209	4.5 Subcontracting tests	Customer Obligation	Responsibility	Requirement
210	4.5 Subcontracting tests	Subcontractor use and compliance	Registry	Record
211	4.5 Subcontracting tests	Subcontracted Laboratory	Credentials	Requirement
212	4.5 Subcontracting tests	Subcontracted Laboratory	Identification	Requirement
213	4.5 Subcontracting tests	Subcontracted Laboratory	Final Report	Record
214	4.6 Purchasing Services & Supplies			
215	4.6 Purchasing Services & Supplies	Procedure Requirement	Selection and Purchasing	Procedure
216	4.6 Purchasing Services & Supplies	Procedure Requirement	Reception and Storage	Procedure
217	4.6 Purchasing Services & Supplies	Assessing Purchases	Verification	Requirement
218	4.6 Purchasing Services & Supplies	Assessing Purchases	Specifications	Requirement
219	4.6 Purchasing Services & Supplies	Assessing Purchases	Specifications	Record
220	4.6 Purchasing Services & Supplies	Assessing Purchases	Purchasing Documents	Record
221	4.6 Purchasing Services & Supplies	Assessing Purchases	Review	Requirement
222	4.6 Purchasing Services & Supplies			

223	4.6 Purchasing Services & Supplies	Suppliers	Evaluation	Requirement
224	4.6 Purchasing Services & Supplies	Suppliers	Evaluation	Record
225	4.7 Service to Clients			
226	4.7 Service to Clients	General	Cooperation	Requirement
227	4.7 Service to Clients			
228	4.7 Service to Clients			
229	4.7 Service to Clients			
230	4.7 Service to Clients			
231	4.7 Service to Clients	Customer Communication	Feedback	Requirement
232	4.7 Service to Clients	Customer Communication	Using Feedback	Requirement
233	4.7 Service to Clients			
234	4.8 Complaints	Complaints		
235	4.8 Complaints	General	Complaint Resolution	Procedure
236	4.8 Complaints	General	Complaint Resolution	Record
237	4.9 Control of Noncoforming Work			
238	4.9 Control of Noncoforming Work	Nonconforming Work	Implementation	Procedure
239	4.9 Control of Noncoforming Work	Nonconforming Work	Implementation	Procedure
240	4.9 Control of Noncoforming Work	Implementing Procedures	Responsibility	Procedure
241	4.9 Control of Noncoforming Work	Implementing Procedures	Evaluation	Requirement
242	4.9 Control of Noncoforming Work	Implementing Procedures	Corrective Action	Requirement

243	4.9 Control of Noncoforming Work	Implementing Procedures	Notification	Requirement
244	4.9 Control of Noncoforming Work	Implementing Procedures	Work Resumption	Requirement
245	4.9 Control of Noncoforming Work	Nonconforming Work		
246	4.9 Control of Noncoforming Work	Evaluation Results	Corrective Action	Requirement
247	4.10 Improvement	Improvement		
248	4.10 Improvement	Continuous Improvement	Tools	Requirement
249	4.11 Corrective Actions	Corrective Actions		
250	4.11 Corrective Actions	General		
251	4.11 Corrective Actions	General	Implementing Action	Procedure
252	4.11 Corrective Actions	General	Appropriate Authorities	Requirement
253	4.11 Corrective Actions			
254	4.11 Corrective Actions	Cause Analysis	Cause Analysis	
255	4.11 Corrective Actions	Cause Analysis	Investigation	Procedure
256	4.11 Corrective Actions	Cause Analysis		
257	4.11 Corrective Actions	Selection and Implementation		
258	4.11 Corrective Actions	Selection and Implementation	Identification	Requirement
259	4.11 Corrective Actions	Selection and Implementation	Selection	Requirement
260	4.11 Corrective Actions	Selection and Implementation	Appropriateness	Requirement
261	4.11 Corrective Actions	Selection and Implementation	Changes	Record
262	4.11 Corrective Actions	Monitoring Corrective Actions	Monitoring	

263	4.11 Corrective Actions	Monitoring Corrective Actions	Monitoring	Requirement
264	4.11 Corrective Actions	Additional Audits	Additional Audits	
265	4.11 Corrective Actions	Additional Audits	Audit Scheduling	Requirement
266	4.11 Corrective Actions	Additional Audits	Additional Audits	
267	4.11 Corrective Actions	Documented Procedures	Corrective Action	Procedure
268	4.11 Corrective Actions	Documented Procedures	Implementation	Procedure
269	4.11 Corrective Actions	Documented Procedures	Monitoring	Procedure
270	4.11 Corrective Actions	Documented Procedures	Scheduling	Procedure
271	4.11 Corrective Actions	Documented Procedures	QC Assessment	Requirement
272	4.11 Corrective Actions	Documented Procedures	Initiating CA	Procedure
273	4.11 Corrective Actions	Cause Analysis	Use	Requirement
274	4.12 Preventive Action	Preventive Actions		
275	4.12 Preventive Action	General	Identification	Requirement
276	4.12 Preventive Action	General	Implementation	Requirement
277	4.12 Preventive Action	General	Description	Procedure
278	4.12 Preventive Action	Preventive Actions		
279	4.12 Preventive Action	Preventive Actions		
280	4.13 Control of Records	Control of Records		
281	4.13 Control of Records	General		
282	4.13 Control of Records	General	Scope	Procedure
283	4.13 Control of Records	General	Quality Records	Requirement
284	4.13 Control of Records	General	Storage	Requirement
285	4.13 Control of Records	General	Retention Time	Requirement

286	4.13 Control of Records	General	General	
287	4.13 Control of Records	General	Confidentiality	Requirement
288	4.13 Control of Records	General	Electronic Records	Procedure
289	4.13 Control of Records	General	Unauthorized Access	Procedure
290	4.13 Control of Records	4.13.2 Technical Records	Technical	
291	4.13 Control of Records	4.13.2 Technical Records	Record Identification	Requirement
292	4.13 Control of Records	4.13.2 Technical Records	Historical Reconstruction	Requirement
293	4.13 Control of Records	4.13.2 Technical Records	Personnel Identification	Requirement
294	4.13 Control of Records	4.13.2 Technical Records		
295	4.13 Control of Records	4.13.2 Technical Records		
296	4.13 Control of Records	4.13.2 Technical Records	Recording Data	Requirement
297	4.13 Control of Records	4.13.2 Technical Records	Error Correction	Requirement
298	4.13 Control of Records	4.13.2 Technical Records	Error Correction	Requirement
299	4.13 Control of Records	4.13.2 Technical Records	Error Correction	Requirement
300	4.13 Control of Records	4.13.3 Technical Records Additional Requirements		
301	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Requirement
302	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Requirement
303	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Records Retention	Requirement
304	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Availability	Requirement
305	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Electronic Records	Requirement
306	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Archived Records	Requirement
307	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Requirement
308	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Requirement

309	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
310	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
311	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
312	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
313	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
314	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
315	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
316	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
317	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
318	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
319	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
320	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
321	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
322	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
323	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
324	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
325	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
326	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
327	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
328	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Historical Reconstruction	Record
329	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Legible Records	Requirement
330	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Error Correction	Requirement
331	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Error Correction	Requirement
332	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	Records Transfer	Requirement
333	4.13 Control of Records	4.13.3 Technical Records Additional Requirements	State Requirements	State Requirements

334	4.14 Internal Audits	Internal Audits		
335	4.14 Internal Audits	General	Schedule	Requirement
336	4.14 Internal Audits	General	Scope	Requirement
337	4.14 Internal Audits	General	Scheduling Responsibility	Requirement
338	4.14 Internal Audits	General	Auditor Qualifications	Requirement
339	4.14 Internal Audits	Internal Audits		
340	4.14 Internal Audits	Audit Results	Need for Corrective Actions	Requirement
341	4.14 Internal Audits	Audit Results	Customer Notification	Requirement
342	4.14 Internal Audits	Audit Description	Record Contents	Record
343	4.14 Internal Audits	Corrective Actions	Monitoring	Requirement
344	4.14 Internal Audits	Additional Items		
345	4.14 Internal Audits	Additional Items	Customer Notification	Requirement
346	4.14 Internal Audits	Additional Items	Customer Notification	Requirement
347	4.14 Internal Audits	Additional Items	Schedule	Requirement
348	4.15 Management Reviews			
349	4.15 Management Reviews	General	Schedule	Requirement
350	4.15 Management Reviews	General	Schedule	Requirement
351	4.15 Management Reviews	General	Review Content	Requirement
352	4.15 Management Reviews	General	Review Content	Requirement
353	4.15 Management Reviews	General	Review Content	Requirement

354	4.15 Management Reviews	General	Review Content	Requirement
355	4.15 Management Reviews	General	Review Content	Requirement
356	4.15 Management Reviews	General	Review Content	Requirement
357	4.15 Management Reviews	General	Review Content	Requirement
358	4.15 Management Reviews	General	Review Content	Requirement
359	4.15 Management Reviews	General	Review Content	Requirement
360	4.15 Management Reviews	General	Review Content	Requirement
361	4.15 Management Reviews	General	Review Content	Requirement
362	4.15 Management Reviews	Management Reviews		
363	4.15 Management Reviews	Management Reviews		
364	4.15 Management Reviews	Management Reviews		
365	4.15 Management Reviews	General	Findings	Record
366	4.15 Management Reviews	General	Action Implementation	Requirement
367	4.15 Management Reviews	General	Schedule	Requirement
368	4.16 Data Integrity	Data Integrity		
369	4.16 Data Integrity	Investigation	Confidentiality	Requirement
370	4.16 Data Integrity	Investigation	Investigation	Documentation

Citation	Does the laboratory comply with this section?
V1M2 4	**MANAGEMENT REQUIREMENTS**
V1M2 4.1	*Organization (ISO/IEC 17025:2005(E), Clause 4.1)*
V1M2 4.1.1	*The laboratory or the organization of which it is part shall be an entity that can be held legally responsible.*
V1M2 4.1.2	It is the responsibility of the laboratory to carry out its testing and calibration activities in such a way as
V1M2 4.1.2	*to meet the requirements of this International Standard*
V1M2 4.1.2	*and to satisfy the needs of the customer, the regulatory authorities or organizations providing recognition.*
V1M2 4.1.3	*The management system shall cover work carried out in the laboratory's permanent facilities, at sites away from its permanent facilities, or in associated temporary or mobile facilities.*
V1M2 4.1.4	*If the laboratory is part of an organization performing activities other than testing and/or calibration, the responsibilities of key personnel in the organization that have an involvement or influence on the testing and/or calibration activities of the laboratory shall be defined in order to identify potential conflicts of interest.*
V1M2 4.1.4 N1	*NOTE 1: Where a laboratory is part of a larger organization, the organizational arrangements should be such that departments having conflicting interests, such as production, commercial marketing or financing do not adversely influence the laboratory's compliance with the requirements of this International Standard.*
V1M2 4.1.4 N2	*NOTE 2: If the laboratory wishes to be recognized as a third-party laboratory, it should be able to demonstrate that it is impartial and that it and its personnel are free from any undue commercial, financial and other pressures which might influence their technical judgment. The third-party testing or calibration laboratory should not engage in any activities that may endanger the trust in its independence of judgment and integrity in relation to its testing or calibration activities.*
V1M2 4.1.5	*The laboratory shall:*
4.1.5 a)	*have managerial and technical personnel who, irrespective of other responsibilities, have the authority and resources needed to carry out their duties, including*
V1M2 4.1.5 a)	*have managerial and technical personnel who have the authority and resources needed to carry out the implementation, maintenance and improvement of the management system,*
V1M2 4.1.5 a)	*have managerial and technical personnel who have the authority and resources needed to identify the occurrence of departures from the management system or from the procedures for performing tests and/or calibrations*
V1M2 4.1.5 a)	*have managerial and technical personnel who have the authority and resources needed to initiate actions to prevent or minimize such departures (see also 5.2);*
V1M2 4.1.5 b)	*have arrangements to ensure that its management and personnel are free from any undue internal and external commercial, financial and other pressures and influences that may adversely affect the quality of their work;*
V1M2 4.1.5 c)	*have policies and procedures to ensure the protection of its customers' confidential information and proprietary rights, including procedures for protecting the electronic storage and transmission of results;*
V1M2 4.1.5 d)	*have policies and procedures to avoid involvement in any activities that would diminish confidence in its competence, impartiality, judgment or operational integrity;*
V1M2 4.1.5 e)	define the organization and management structure of the laboratory, its place in any parent organization, and the relationships between quality management, technical operations and support services; ***(V1M2 4.2.8.4 e)***
V1M2 4.1.5 f)	specify the responsibility, authority and interrelationships of all personnel who manage, perform or verify work affecting the quality of the tests and/or calibrations; ***(V1M2 4.2.8.4 e and 5.2.5)***

V1M2 4.1.5 g)	provide adequate supervision of testing and calibration staff, including trainees, by persons familiar with methods and procedures, purpose of each test and/or calibration, and with the assessment of the test or calibration results; ***(see V1M2 4.2.8.4 e and 5.2.1)***
V1M2 4.1.5 h)	*have technical management which has overall responsibility for the technical operations and the provision of the resources needed to ensure the required quality of laboratory operations;*
V1M2 4.1.5 i)	***Note: This is different from the actual qualifications of a Quality Manager. Can be determined from the organizational chart, the description of duties, and any documents relating to the selection qualifications and criteria for the position.***
V1M2 4.1.5 i)	*appoint a member of staff as quality manager (however named) who, irrespective of other duties and responsibilities, shall have defined responsibility and authority for ensuring that the management system related to quality is implemented and followed at all ; the quality manager shall have direct access to the highest level of management at which decisions are made on laboratory policy or resources;*
V1M2 4.1.5 j)	*appoint deputies for key managerial personnel (see Note);*
V1M2 4.1.5 k)	*ensure that its personnel are aware of the relevance and importance of their activities and how they contribute to the achievement of the objectives of the management system.*
V1M2 4.1.5 k) N	*NOTE: Individuals may have more than one function and it may be impractical to appoint deputies for every function.*
V1M2 4.1.6	*Top management shall ensure that appropriate communication processes are established within the laboratory and that communication takes place regarding the effectiveness of the management system.*
V1M2 4.1.7	Additional Requirements for Laboratories
V1M2 4.1.7.1	The laboratory's quality manager and/or his/her designee(s) shall:
	See also 4.1.5 i), 4.2.8.2 and 4.14.1
V1M2 4.1.7.1 a)	serve as the focal point for QA/QC and be responsible for the oversight and/or review of quality control data;
V1M2 4.1.7.1 b)	have functions independent from laboratory operations for which they have quality assurance oversight;
V1M2 4.1.7.1 c)	be able to evaluate data objectively and perform assessments without outside (e.g., managerial) influence;
V1M2 4.1.7.1 d)	have documented training and/or experience in QA/QC procedures and the laboratory's quality system;
V1M2 4.1.7.1 e)	have a general knowledge of the analytical methods for which data review is performed;
V1M2 4.1.7.1 f)	arrange for or conduct internal audits as per Section 4.14 annually;
V1M2 4.1.7.1 g)	notify laboratory management of deficiencies in the quality system; and
V1M2 4.1.7.1 h)	monitor corrective actions.
V1M2 4.1.7.1 h) N	NOTE: Where staffing is limited, the quality manager may also be the technical manager.
V1M2 4.1.7.2	The laboratory's technical manager(s), however named, and/or his/her designee(s) shall:
V1M2 4.1.7.2 a)	be a member of the staff of an environmental laboratory who exercises actual day-to-day supervision of laboratory operations for the appropriate fields of accreditation and reporting of results;

V1M2 4.1.7.2 b)	be experienced in the fields of accreditation for which the laboratory is seeking accreditation;
V1M2 4.1.7.2 c)	The laboratory's technical manager(s), however named, and/or his/her designee(s) shall have duties that include:
V1M2 4.1.7.2 c) i	• monitoring standards of performance in quality control and quality assurance, and
V1M2 4.1.7.2 c) ii	• monitoring the validity of the analyses performed and data generated in the laboratory to assure reliable data.
V1M2 4.1.7.2 d)	not be the technical manager(s) of more than one accredited environmental laboratory without authorization from the primary Accreditation Body. Circumstances to be considered in the decision to grant such authorization shall include:
V1M2 4.1.7.2 d) i	• the extent to which operating hours of the laboratories to be directed overlap,
V1M2 4.1.7.2 d) ii	• adequacy of supervision in each laboratory, and
V1M2 4.1.7.2 d) iii	• the availability of environmental laboratory services in the area served.
V1M2 4.1.7.2 e)	if absent for a period of time exceeding fifteen (15) consecutive calendar days shall designate another full-time staff member meeting the qualifications of the technical manager(s) to temporarily perform this function. If this absence exceeds thirty-five (35) consecutive calendar days, the primary accreditation body shall be notified in writing; and
V1M2 4.1.7.2 f)	meet qualification requirements as specified in Section 5.2.6.1.
V1M2 4.2	Management (ISO/IEC 17025:2005(E), Clause 4.2)
V1M2 4.2.1	*The laboratory shall establish, implement and maintain a management system appropriate to the scope of its activities.*
V1M2 4.2.1	*The laboratory shall document its policies, systems, programmes, procedures and instructions to the extent necessary to assure the quality of the test and/or calibration results.*
V1M2 4.2.1	*The system's documentation shall be communicated to, understood by, available to, and implemented by the appropriate personnel. (see also V1M2 4.1.6)*
V1M2 4.2.2	***(Quality Policy Elements to be included in the Quality Manual - see V1M24.2.8.3 h)***
V1M2 4.2.2	The laboratory's management system policies related to quality, including a quality policy statement, shall be defined in a quality manual (however named). The overall objectives shall be established, and
V1M2 4.2.2	shall be reviewed during management review. The quality policy statement shall be issued under the authority of top management. It shall include at least the following:
V1M2 4.2.2 a)	the laboratory management's commitment to good professional practice and to the quality of its testing and calibration in servicing its customers;
V1M2 4.2.2 b)	the management's statement of the laboratory's standard of service;
V1M2 4.2.2 c)	the purpose of the management system related to quality;
V1M2 4.2.2 d)	*The quality policy statement shall include a requirement that all personnel concerned with testing and calibration activities within the laboratory familiarize themselves with the quality documentation and implement the policies and procedures in their work;*

V1M2 4.2.2 e)	*The quality policy statement shall include the laboratory management's commitment to comply with this International Standard and to continually improve the effectiveness of the management system.*
V1M2 4.2.2 e) N	*NOTE: The quality policy statement should be concise and may include the requirement that tests and/or calibrations shall always be carried out in accordance with stated methods and customers' requirements. When the test and/or calibration laboratory is part of a larger organization, some quality policy elements may be in other documents.*
V1M2 4.2.3	*Top management shall provide evidence of commitment to the development and implementation of the management system and to continually improving its effectiveness.*
V1M2 4.2.4	*Top management shall communicate to the organization the importance of meeting customer requirements as well as statutory and regulatory requirements.*
V1M2 4.2.5	*The quality manual shall include or make reference to the supporting procedures including technical procedures. It shall outline the structure of the documentation used in the management system.*
V1M2 4.2.6	*The roles and responsibilities of technical management and the quality manager, including their responsibility for ensuring compliance with this International Standard, shall be defined in the quality manual.*
V1M2 4.2.7	*Top management shall ensure that the integrity of the management system is maintained when changes to the management system are planned and implemented.*
V1M2 4.2.8	Additional Management System Requirements
V1M2 4.2.8.1	The laboratory shall establish and maintain a documented data integrity system. There are four required elements within a data integrity system.
V1M2 4.2.8.1	These are,
V1M2 4.2.8.1	• Data Integrity training.***(see 5.2.7)***
V1M2 4.2.8.1	• signed data integrity documentation for all laboratory employees,***(see 5.2.7)***
V1M2 4.2.8.1	The laboratory shall have within its data integrity system in-depth, periodic monitoring of data integrity,
V1M2 4.2.8.1	• data integrity procedure documentation **(see remainder of 4.2.8.1)**
V1M2 4.2.8.1	The data integrity procedures shall be signed and dated by top management
V1M2 4.2.8.1	***The requirements for data integrity investigation are listed in Section 4.10. The requirements for data integrity training and documentation are listed in Section 5.2.7***
V1M2 4.2.8.1	Management shall annually review data integrity procedures and update as needed.
V1M2 4.2.8.1 a)	Laboratory management shall provide a procedure for confidential reporting of data integrity issues in their laboratory. A primary element of the procedure is to assure confidentiality and a receptive environment in which all employees may privately discuss ethical issues or report items of ethical concern.
V1M2 4.2.8.1 b)	In instances of ethical concern, the procedure shall include a process whereby laboratory management is to be informed of the need for any further detailed investigation.
V1M2 4.2.8.2	The quality manager shall be responsible for maintaining the currency of the quality manual.
V1M2 4.2.8.3	The quality manual shall contain:
V1M2 4.2.8.3 a)	document title;

V1M2 4.2.8.3 b)	laboratory's full name and address;
V1M2 4.2.8.3 c)	name, address (if different from above), and telephone number of individual(s) responsible for the laboratory;
V1M2 4.2.8.3 d)	identification of all major organizational units which are to be covered by this quality manual and the effective date of the version;
V1M2 4.2.8.3 e)	identification of the laboratory's approved signatories;
V1M2 4.2.8.3 f)	the signed and dated concurrence (with appropriate names and titles), of all responsible parties including the quality manager(s), technical manager(s), and the agent who is in charge of all laboratory activities, such as the laboratory director or laboratory manager;
V1M2 4.2.8.3 g)	the objectives of the quality system and contain or reference the laboratory's policies and procedures;
V1M2 4.2.8.3 h)	***See V1M2 4.2.2, 4.2.2 a), b) and c) for specifics to be included in quality policy***
V1M2 4.2.8.3 h)	the laboratory's official quality policy statement, which shall include quality system objectives and management's commitment to ethical laboratory practices and to upholding the requirements of this Standard; and
V1M2 4.2.8.3 i)	a table of contents, and applicable lists of references, glossaries and appendices.
V1M2 4.2.8.4	The quality manual shall contain **or reference**:
V1M2 4.2.8.4 a)	all maintenance, calibration and verification procedures used by the laboratory in conducting tests;
V1M2 4.2.8.4 b)	major equipment and reference measurement standards used as well as the facilities and services used by the laboratory in conducting tests;
V1M2 4.2.8.4 c)	verification practices, which may include inter-laboratory comparisons, proficiency testing programs, use of reference materials and internal quality control schemes;
V1M2 4.2.8.4 d)	procedures for reporting analytical results;
V1M2 4.2.8.4 e)	***See V1M2 4.1.5 e) , f) and g) for specific requirements to be discussed.***
V1M2 4.2.8.4 e)	the organization and management structure of the laboratory, its place in any parent organization, and relevant organizational charts;
V1M2 4.2.8.4 f)	***See ViM2 4.13 for specifics information to be discussed***
V1M2 4.2.8.4 f)	procedures to ensure that all records required under this Standard are retained,
V1M2 4.2.8.4 f)	procedures for control and maintenance of documentation through a document control system that ensures that all standard operating procedures (SOPs), manuals, or documents clearly indicate the time period during which the procedure or document was in force;
V1M2 4.2.8.4 g)	***See V1M2 4.1.5 e) for additional information***
V1M2 4.2.8.4 g)	job descriptions of key staff and reference to the job descriptions of other laboratory staff;
V1M2 4.2.8.4 h)	procedures for achieving traceability of measurements;
V1M2 4.2.8.4 i)	a list of all methods under which the laboratory performs its accredited testing;
V1M2 4.2.8.4 j)	procedures for ensuring that the laboratory reviews all new work to ensure that it has the appropriate facilities and resources before commencing such work;
V1M2 4.2.8.4 k)	procedures for handling samples;
V1M2 4.2.8.4 l)	procedures to be followed for feedback and corrective action whenever testing discrepancies are detected, or departures from documented policies and procedures occur;

V1M2 4.2.8.4 m)	policy for permitting departures from documented policies and procedures or from standard specifications;
V1M2 4.2.8.4 n)	procedures for dealing with complaints;
V1M2 4.2.8.4 o)	procedures for protecting confidentiality (including national security concerns), and proprietary rights;
V1M2 4.2.8.4 p)	procedures for audits and data review;
V1M2 4.2.8.4 q)	procedures for establishing that personnel are adequately experienced in the duties they are expected to carry out and are receiving any needed training; and
V1M2 4.2.8.4 r)	policy addressing the use of unique electronic signatures, where applicable.
V1M2 4.2.8.5	Laboratories shall maintain SOPs that accurately reflect all phases of current laboratory activities, such as assessing data integrity, corrective actions, handling customer complaints, and all methods.
V1M2 4.2.8.5 a)	These documents, for example, may be equipment manuals provided by the manufacturer, or
V1M2 4.2.8.5 a)	These documents may be internally written documents with adequate detail to allow someone similarly qualified, other than the analyst, to reproduce the procedures used to
V1M2 4.2.8.5 b)	The relevant SOPs shall be readily accessible to all personnel.
V1M2 4.2.8.5 c)	Each SOP shall clearly indicate the effective date of the document, the revision number, and the signature(s) of the approving authority.
V1M2 4.2.8.5 d)	Documents that contain sufficient information to perform the tests, do not need to be supplemented or rewritten as internal procedures if the documents are written in a way that they can be used as written. Any changes, including the use of a selected option, shall be documented and included in the laboratory's method records.
V1M2 4.2.8.5 e)	The laboratory shall have and maintain an SOP for each accredited analyte or method.
V1M2 4.2.8.5 f)	The SOP may be a copy of a published or referenced method or may be written by the laboratory. In cases where modifications to the published method have been made by the laboratory or where the referenced method is ambiguous or provides insufficient detail, these changes or clarifications shall be clearly described. ***(4.2.8.5 d))***
V1M2 4.2.8.5 f)	Each method shall include or reference the following topics where applicable:
V1M2 4.2.8.5 f) i)	identification of the method
V1M2 4.2.8.5 f) ii)	applicable matrix or matrices;
V1M2 4.2.8.5 f) iii)	limits of detection and quantitation ;
V1M2 4.2.8.5 f) iv)	scope and application, including parameters to be analyzed;
V1M2 4.2.8.5 f) v)	summary of the method;
V1M2 4.2.8.5 f) vi)	definitions;
V1M2 4.2.8.5 f) vii)	interferences;

V1M2 4.2.8.5 f) viii)	safety;
V1M2 4.2.8.5 f) ix)	equipment and supplies;
V1M2 4.2.8.5 f) x)	reagents and standards;
V1M2 4.2.8.5 f) xi)	sample collection, preservation, shipment and storage;
V1M2 4.2.8.5 f) xii)	quality control;
V1M2 4.2.8.5 f) xiii)	calibration and standardization;
V1M2 4.2.8.5 f) xiv)	procedure;
V1M2 4.2.8.5 f) xv)	data analysis and calculations;
V1M2 4.2.8.5 f) xvi)	method performance;
V1M2 4.2.8.5 f) xvii)	pollution prevention;
V1M2 4.2.8.5 f) xviii)	data assessment and acceptance criteria for quality control measures;
V1M2 4.2.8.5 f) xix)	corrective actions for out-of-control data;
V1M2 4.2.8.5 f) xx)	contingencies for handling out-of-control or unacceptable data;
V1M2 4.2.8.5 f) xxi)	waste management;
V1M2 4.2.8.5 f) xxii)	references; and
V1M2 4.2.8.5 f) xxiii)	any tables, diagrams, flowcharts and validation data.
V1M2 4.3	Document Control (ISO/IEC 17025:2005(E), Clause 4.3)
V1M2 4.3.1	*General*
V1M2 4.3.1	*The laboratory shall establish and maintain procedures to control all documents that form part of its management system (internally generated or from external sources), such as regulations, standards, other normative documents, test and/or calibration methods, as well as drawings, software, specifications, instructions and manuals.*
V1M2 4.3.1 N1	*NOTE 1: In this context "document" could be policy statements, procedures, specifications, calibration tables, charts, text books, posters, notices, memoranda, software, drawings, plans, etc. These may be on various media, whether hard copy or electronic, and they may be digital, analog, photographic or written.*
V1M2 4.3.1 N2	*NOTE 2: The control of data related to testing and calibration is covered in 5.4.7. The control of records is covered in 4.13.*
V1M2 4.3.2	*Document Approval and Issue*
V1M2 4.3.2.1	*All documents issued to personnel in the laboratory as part of the management system shall be reviewed and approved for use by authorized personnel prior to issue.*

V1M2 4.3.2.1	*A master list or an equivalent document control procedure identifying the current revision status and distribution of documents in the management system shall be established and shall be readily available to preclude the use of invalid and/or obsolete documents.*
V1M2 4.3.2.2	*The document procedure(s) adopted shall ensure that:*
V1M2 4.3.2.2 a)	*authorized editions of appropriate documents are available at all locations where operations essential to the effective functioning of the laboratory are performed;*
V1M2 4.3.2.2 b)	*documents are periodically reviewed and, where necessary, revised to ensure continuing suitability and compliance with applicable requirements;*
V1M2 4.3.2.2 c)	*invalid or obsolete documents are promptly removed from all points of issue or use, or otherwise assured against unintended use;*
V1M2 4.3.2.2 d)	*obsolete documents retained for either legal or knowledge preservation purposes are suitably marked.*
V1M2 4.3.2.3	*Management system documents generated by the laboratory shall be uniquely identified.*
V1M2 4.3.2.3	*Management system document identification shall include the date of issue and/or revision identification, page numbering, the total number of pages or a mark to signify the end of the document, and the issuing authority(ies).*
V1M2 4.3.3	*Document Changes*
V1M2 4.3.3.1	*Changes to documents shall be reviewed and approved by the same function that performed the original review unless specifically designated otherwise.*
V1M2 4.3.3.1	*The designated personnel shall have access to pertinent background information upon which to base their review and approval.*
V1M2 4.3.3.2	*Where practicable, the altered or new text shall be identified in the document or the appropriate attachments.*
V1M2 4.3.3.3	*If the laboratory's document control system allows for the amendment of documents by hand pending the re-issue of the documents, the procedures and authorities for such amendments shall be defined.*
V1M2 4.3.3.3	*Amendments shall be clearly marked, initialled and dated.*
V1M2 4.3.3.3	*A revised document shall be formally re-issued as soon as practicable.*
V1M2 4.3.3.4	*Procedures shall be established to describe how changes in documents maintained in computerized systems are made and controlled.*
V1M2 4.4	Review of Requests, Tenders and Contracts (ISO/IEC 17025:2005(E), Clause 4.4)
V1M2 4.4.1	The laboratory shall establish and maintain procedures for the review of requests, tenders and contracts. ***(4.4.1 a) through c)***
V1M2 4.4.1 a)	*The policies and procedures for the review of requests, tenders and contracts leading to a contract for testing and/or calibration shall ensure that: the requirements, including the methods to be used, are adequately defined, documented and understood (see 5.4.2);*
V1M2 4.4.1 b)	*The policies and procedures for the review of requests, tenders and contracts leading to a contract for testing and/or calibration shall ensure that: the laboratory has the capability and resources to meet the requirements;*

V1M2 4.4.1 c)	*The policies and procedures for he review of requests, tenders and contracts leading to a contract for testing and/or calibration shall ensure that: the appropriate test and/or calibration method is selected and is capable of meeting the customers' requirements (see 5.4.2).*
V1M2 4.4.1 c)	*Any differences between the request or tender and the contract shall be resolved before any work commences. Each contract shall be acceptable both to the laboratory and the customer.*
V1M2 4.4.1 c) N1	*NOTE 1: The request, tender and contract review should be conducted in a practical and efficient manner, and the effect of financial, legal and time schedule aspects should be taken into account. For internal customers, reviews of requests, tenders and contracts can be performed in a simplified way.*
V1M2 4.4.1 c) N2	*NOTE 2: The review of capability should establish that the laboratory possesses the necessary physical, personnel and information resources, and that the laboratory's personnel have the skills and expertise necessary for the performance of the tests and/or calibrations in question. The review may also encompass results of earlier participation in interlaboratory comparisons or proficiency testing and/or the running of trial test or calibration programmes using samples or items of known value in order to determine uncertainties of measurement, limits of detection, confidence limits, etc.*
V1M2 4.4.1 c) N3	*NOTE 3: A contract may be any written or oral agreement to provide a customer with testing and/or calibration services.*
V1M2 4.4.2	*Records of the review of requests, tenders and contracts, including any significant changes, shall be maintained.*
V1M2 4.4.2	*Records shall also be maintained of pertinent discussions with a customer relating to the customer's requirements or the results of the work during the period of execution of the contract.*
V1M2 4.4.2 N	*NOTE: For review of routine and other simple tasks, the date and the identification (e.g. the initials) of the person in the laboratory responsible for carrying out the contracted work are considered adequate. For repetitive routine tasks, the review need be made only at the initial enquiry stage or on granting of the contract for on-going routine work performed under a general agreement with the customer, provided that the customer's requirements remain unchanged. For new, complex or advanced testing and/or calibration tasks, a more comprehensive record should be maintained.*
V1M2 4.4.3	*The review of requests, tenders and contracts shall also cover any work that is subcontracted by the laboratory.*
V1M2 4.4.4	*The customer shall be informed of any deviation from the contract.*
V1M2 4.4.5	*If a contract needs to be amended after work has commenced, the same contract review process shall be repeated and any amendments shall be communicated to all affected personnel.*
V1M2 4.5	Subcontracting of Environmental Tests (ISO/IEC 17025:2005(E), Clause 4.5)

V1M2 4.5.1	*When a laboratory subcontracts work, whether because of unforeseen reasons (e.g. workload, need for further expertise or temporary incapacity) or on a continuing basis (e.g. through permanent subcontracting, agency or franchising arrangements), this work shall be placed with a competent subcontractor. A competent subcontractor is one that, for example, complies with this International Standard for the work in question.*
V1M2 4.5.2	*The laboratory shall advise the customer of the arrangement in writing and, when appropriate, gain the approval of the customer, preferably in writing.*
V1M2 4.5.3	*The laboratory is responsible to the customer for the subcontractor's work, except in the case where the customer or a regulatory authority specifies which subcontractor is to be used.*
V1M2 4.5.4	*The laboratory shall maintain a register of all subcontractors that it uses for tests and/or calibrations and a record of the evidence of compliance with this International Standard for the work in question.*
V1M2 4.5.5	When a laboratory subcontracts work, this work shall be placed with a laboratory accredited to this Standard for the tests to be performed or with a laboratory that meets applicable statutory and regulatory requirements for performing the tests and submitting the results of tests performed.
V1M2 4.5.5	The laboratory performing the subcontracted work shall be indicated in the final report.
V1M2 4.5.5	The laboratory shall make a copy of the subcontractor’s report available to the client when requested.
V1M2 4.6	Purchasing Services and Supplies (ISO/IEC 17025:2005(E), Clause 4.6)
V1M2 4.6.1	*The laboratory shall have a policy and procedure(s) for the selection and purchasing of services and supplies it uses that affect the quality of the tests and/or calibrations.*
V1M2 4.6.1	*Procedures shall exist for the purchase, reception and storage of reagents and laboratory consumable materials relevant for the tests and calibrations.*
V1M2 4.6.2	*The laboratory shall ensure that purchased supplies and reagents and consumable materials that affect the quality of tests and/or calibrations are not used until they have been inspected or otherwise verified as complying with standard specifications or requirements defined in the methods for the tests and/or calibrations concerned.*
V1M2 4.6.2	*These services and supplies used shall comply with specified requirements.*
V1M2 4.6.2	*Records of actions taken to check compliance of services and supplies shall be maintained.*
V1M2 4.6.3	*Purchasing documents for items affecting the quality of laboratory output shall contain data describing the services and supplies ordered.*
V1M2 4.6.3	*These purchasing documents shall be reviewed and approved for technical content prior to release.*
V1M2 4.6.3 N	*NOTE: The description may include type, class, grade, precise identification, specifications, drawings, inspection instructions, other technical data including approval of test results, the quality required and the management system standard under which they were made.*

V1M2 4.6.4	*The laboratory shall evaluate suppliers of critical consumables, supplies and services which affect the quality of testing and calibration,*
V1M2 4.6.4	*The laboratory shall maintain records of the evaluation suppliers of critical consumables, supplies and services and list those approved.*
V1M2 4.7	Service to the Client (ISO/IEC 17025:2005(E), Clause 4.7)
V1M2 4.7.1	*The laboratory shall be willing to cooperate with customers or their representatives in clarifying the customer's request and in monitoring the laboratory's performance in relation to the work performed, provided that the laboratory ensures confidentiality to other customers.*
V1M2 4.7.1 N1	*NOTE 1: Such cooperation may include:*
V1M2 4.7.1 N1 a)	*providing the customer or the customer's representative reasonable access to relevant areas of the laboratory for the witnessing of tests and/or calibrations performed for the customer;*
V1M2 4.7.1 N1 b)	*preparation, packaging, and dispatch of test and/or calibration items needed by the customer for verification purposes.*
V1M2 4.7.1 N2	*NOTE 2: Customers value the maintenance of good communication, advice and guidance in technical matters, and opinions and interpretations based on results. Communication with the customer, especially in large assignments, should be maintained throughout the work. The laboratory should inform the customer of any delays or major deviations in the performance of the tests and/or calibrations.*
V1M2 4.7.2	*The laboratory shall seek feedback, both positive and negative, from its customers.*
V1M2 4.7.2	*The feedback shall be used and analysed to improve the management system, testing and calibration activities and customer service.*
V1M2 4.7.2 N	*NOTE: Examples of the types of feedback include customer satisfaction surveys and review of test or calibration reports with customers.*
V1M2 4.8	Complaints (ISO/IEC 17025:2005(E), Clause 4.8)
V1M2 4.8	*The laboratory shall have a policy and procedure for the resolution of complaints received from customers or other parties.*
V1M2 4.8	*Records shall be maintained of all complaints and of the investigations and corrective actions taken by the laboratory (see also 4.11).*
V1M2 4.9	Control of Nonconforming Environmental Testing Work (ISO/IEC 17025:2005(E), Clause 4.9)
V1M2 4.9.1	*The laboratory shall have a policy and procedures that shall be implemented when any aspect of its testing and/or calibration work, or the results of this work, do not conform to its own procedures or the agreed requirements of the customer. The policy and procedures shall ensure that:*
V1M2 4.9.1	The policy and procedures shall ensure that:
V1M2 4.9.1 a)	*the responsibilities and authorities for the management of nonconforming work are designated and actions (including halting of work and withholding of test reports and calibration certificates, as necessary) are defined and taken when nonconforming work is identified;*
V1M2 4.9.1 b)	*an evaluation of the significance of the nonconforming work is made;*
V1M2 4.9.1 c)	*correction is taken immediately, together with any decision about the acceptability of the nonconforming work;*

V1M2 4.9.1 d)	*where necessary, the customer is notified and work is recalled;*
V1M2 4.9.1 e)	*the responsibility for authorizing the resumption of work is defined.*
V1M2 4.9.1 e) N	*NOTE: Identification of nonconforming work or problems with the management system or with testing and/or calibration activities can occur at various places within the management system and technical operations. Examples are customer complaints, quality control, instrument calibration, checking of consumable materials, staff observations or supervision, test report and calibration certificate checking, management reviews and internal or external audits.*
V1M2 4.9.2	*Where the evaluation indicates that the nonconforming work could recur or that there is doubt about the compliance of the laboratory's operations with its own policies and procedures, the corrective action procedures given in 4.11 shall be promptly followed.*
V1M2 4.1	Improvement (ISO/IEC 17025:2005(E), Clause 4.10)
V1M2 4.1	*The laboratory shall continually improve the effectiveness of its management system through the use of the quality policy, quality objectives, audit results, analysis of data, corrective and preventive actions and management review.*
V1M2 4.11	Corrective Action (ISO/IEC 17025:2005(E), Clause 4.11)
V1M2 4.11.1	*General*
V1M2 4.11.1	*The laboratory shall establish a policy and a procedure for implementing corrective action when nonconforming work or departures from the policies and procedures in the management system or technical operations have been identified.*
V1M2 4.11.1	*The laboratory shall designate appropriate authorities for implementing corrective action when nonconforming work or departures from the policies and procedures in the management system or technical operations have been identified.*
V1M2 4.11.1 N	*NOTE: A problem with the management system or with the technical operations of the laboratory may be identified through a variety of activities, such as control of nonconforming work, internal or external audits, management reviews, feedback from customers and from staff observations.*
V1M2 4.11.2	*Cause Analysis*
V1M2 4.11.2	*The procedure for corrective action shall start with an investigation to determine the root cause(s) of the problem.*
V1M2 4.11.2 N	*NOTE: Cause analysis is the key and sometimes the most difficult part in the corrective action procedure. Often the root cause is not obvious and thus a careful analysis of all potential causes of the problem is required. Potential causes could include customer requirements, the samples, sample specifications, methods and procedures, staff skills and training, consumables, or equipment and its calibration.*
V1M2 4.11.3	*Selection and Implementation of Corrective Actions*
V1M2 4.11.3	*Where corrective action is needed, the laboratory shall identify potential corrective actions*
V1M2 4.11.3	*It shall select and implement the action(s) most likely to eliminate the problem and to prevent recurrence.*
V1M2 4.11.3	*Corrective actions shall be to a degree appropriate to the magnitude and the risk of the problem.*
V1M2 4.11.3	*The laboratory shall document and implement any required changes resulting from corrective action investigations.*
V1M2 4.11.4	*Monitoring of Corrective Actions*

V1M2 4.11.4	*The laboratory shall monitor the results to ensure that the corrective actions taken have been effective.*
V1M2 4.11.5	*Additional Audits*
V1M2 4.11.5	*Where the identification of nonconformities or departures casts doubts on the laboratory's compliance with its own policies and procedures, or on its compliance with this International Standard, the laboratory shall ensure that the appropriate areas of activity are audited in accordance with 4.14 as soon as possible.*
V1M2 4.11.5 N	*NOTE: Such additional audits often follow the implementation of the corrective actions to confirm their effectiveness. An additional audit should be necessary only when a serious issue or risk to the business is identified.*
V1M2 4.11.6	The laboratory shall have documented procedure(s) to address 4.11.1 ***(see 4.11.1)***
V1M2 4.11.6	The laboratory shall have documented procedure(s) to address 4.11.3
V1M2 4.11.6	The laboratory shall have documented procedure(s) to address 4.11.4
V1M2 4.11.6	The laboratory shall have documented procedure(s) to address 4.11.5
V1M2 4.11.6 a)	These procedure(s) shall also include: which individual(s) or positions are responsible for assessing each QC data type; and
V1M2 4.11.6 b)	These procedure(s) shall also include: which individual(s) or positions are responsible for initiating and/or recommending corrective actions.
V1M2 4.11.7	Cause analysis described in 4.11.2 applies to failures that indicate a systematic error.
V1M2 4.12	Preventive Action (ISO/IEC 17025:2005(E), Clause 4.12)
V1M2 4.12.1	*Needed improvements and potential sources of nonconformities, either technical or concerning the management system, shall be identified.*
V1M2 4.12.1	*When improvement opportunities are identified or if preventive action is required, action plans shall be developed, implemented and monitored to reduce the likelihood of the occurrence of such nonconformities and to take advantage of the opportunities for improvement.*
V1M2 4.12.2	*Procedures for preventive actions shall include the initiation of such actions and the application of controls to ensure that they are effective.*
V1M2 4.12.2 N1	*NOTE 1: Preventive action is a pro-active process to identify opportunities for improvement rather than a reaction to the identification of problems or complaints.*
V1M2 4.12.2 N2	*NOTE 2: Apart from the review of the operational procedures, the preventive action might involve analysis of data, including trend and risk analyses and proficiency-testing results.*
V1M2 4.13	Control of Records (ISO/IEC 17025:2005(E), Clause 4.13)
V1M2 4.13.1	*General*
V1M2 4.13.1.1	*The laboratory shall establish and maintain procedures for identification, collection, indexing, access, filing, storage, maintenance and disposal of quality and technical records.*
V1M2 4.13.1.1	*Quality records shall include reports from internal audits and management reviews as well as records of corrective and preventive actions.*
V1M2 4.13.1.2	*All records shall be legible and shall be stored and retained in such a way that they are readily retrievable in facilities that provide a suitable environment to prevent damage or deterioration and to prevent loss.*
V1M2 4.13.1.2	*Retention times of records shall be established.*

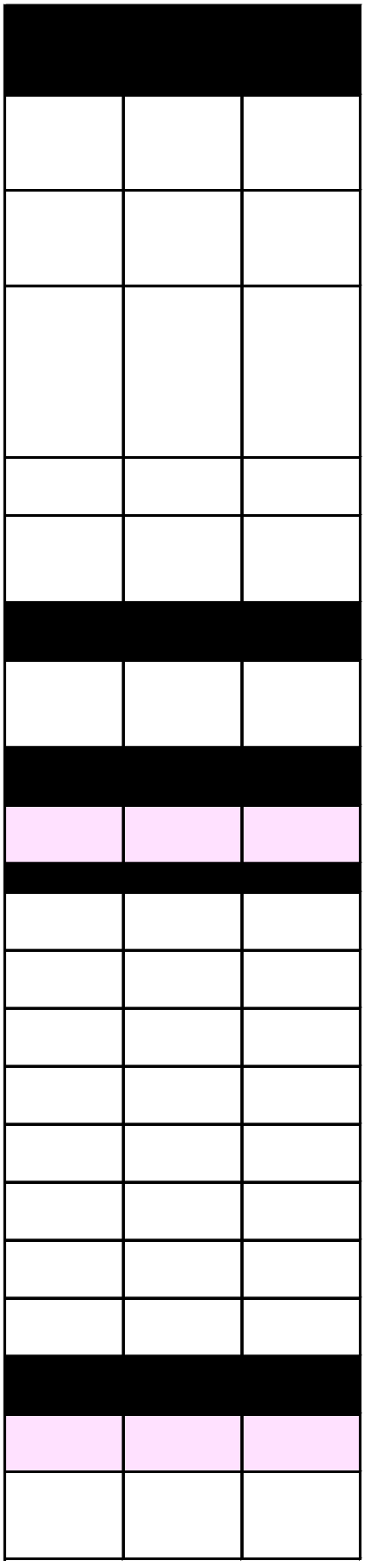
V1M2 4.13.1.2 N	*NOTE: Records may be in any media, such as hard copy or electronic media.*
V1M2 4.13.1.3	*All records shall be held secure and in confidence.*
V1M2 4.13.1.4	*The laboratory shall have procedures to protect and back-up records stored electronically*
V1M2 4.13.1.4	*The laboratory shall have procedures to prevent unauthorized access to or amendment of these records.*
V1M2 4.13.2	*Technical Records*
V1M2 4.13.2.1	*The laboratory shall retain records of original observations, derived data and sufficient information to establish an audit trail, calibration records, staff records and a copy of each test report or calibration certificate issued, for a defined period.*
V1M2 4.13.2.1	The records for each test or calibration shall contain sufficient information to facilitate, if possible, identification of factors affecting the uncertainty and to enable the test or calibration to be repeated under conditions as close as possible to the original.**(4.13.3 f)**
V1M2 4.13.2.1	*The records shall include the identity of personnel responsible for the sampling, performance of each test and/or calibration and checking of results.*
V1M2 4.13.2.1 N1	*NOTE 1: In certain fields it may be impossible or impractical to retain records of all original observations.*
V1M2 4.13.2.1 N2	*NOTE 2: Technical records are accumulations of data (see 5.4.7) and information which result from carrying out tests and/or calibrations and which indicate whether specified quality or process parameters are achieved. They may include forms, contracts, work sheets, work books, check sheets, work notes, control graphs, external and internal test reports and calibration certificates, customers' notes, papers and feedback.*
V1M2 4.13.2.2	*Observations, data and calculations shall be recorded at the time they are made and shall be identifiable to the specific task.*
V1M2 4.13.2.3	*When mistakes occur in records, each mistake shall be crossed out, not erased, made illegible or deleted, and the correct value entered alongside.*
V1M2 4.13.2.3	*All such alterations to records shall be signed or initialled by the person making the correction.*
V1M2 4.13.2.3	*In the case of records stored electronically, equivalent measures shall be taken to avoid loss or change of original data.*
V1M2 4.13.3	Additional Requirements
V1M2 4.13.3 a)	The laboratory shall establish a record keeping system that allows the history of the sample and associated data to be readily understood through the documentation.
V1M2 4.13.3 a)	This system shall produce unequivocal, accurate records that document all laboratory activities such as laboratory facilities, equipment, analytical methods, and related laboratory activities, such as sample receipt, sample preparation, or data verification, and inter-laboratory transfers of samples and/or extracts.
V1M2 4.13.3 b)	The laboratory shall retain all records for a minimum of five years from generation of the last entry in the records.
V1M2 4.13.3 c)	Records shall be available to the accreditation body.
V1M2 4.13.3 d)	Records that are stored only on electronic media shall be supported by the hardware and software necessary for their retrieval.
V1M2 4.13.3 e)	Access to archived information shall be documented with an access log.
V1M2 4.13.3 f)	All information necessary for the historical reconstruction of data shall be maintained by the laboratory.
V1M2 4.13.3 f)	Historical reconstruction information shall include

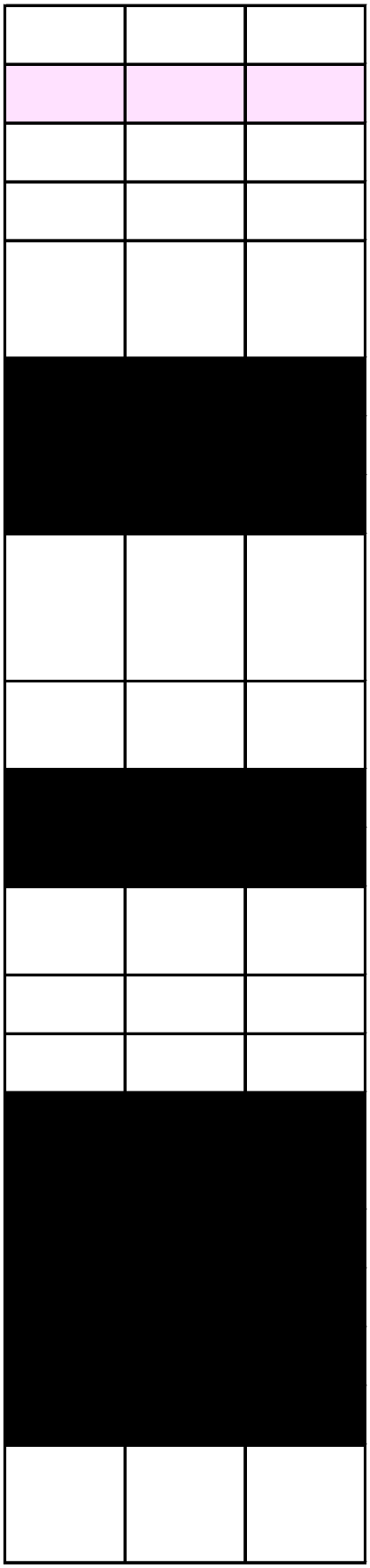
V1M2 4.13.3 f) i	all raw data, whether hard copy or electronic, for calibrations, samples and quality control measures, including analysts' worksheets and data output records (chromatograms, strip charts, and other instrument response readout records);
V1M2 4.13.3 f) ii	a written description or reference to the specific test method used, which includes a description of the specific computational steps used to translate parametric observations into a reportable analytical value;
V1M2 4.13.3 f) iii	laboratory sample ID code;
V1M2 4.13.3 f) iv	date of analysis;
V1M2 4.13.3 f) v	time of analysis is required if the holding time is seventy-two hours or less
V1M2 4.13.3 f) v	time of analysis is required when time critical steps are included in the analysis (e.g., extractions and incubations);
V1M2 4.13.3 f) vi	instrumentation identification and instrument operating conditions/parameters (or reference to such data);
V1M2 4.13.3 f) vii	all manual calculations;
V1M2 4.13.3 f) viii	analyst's or operator's initials/signature or electronic identification;
V1M2 4.13.3 f) ix	sample preparation, including cleanup, separation protocols, incubation periods or subculture, ID codes, volumes, weights, instrument printouts, meter readings, calculations, reagents;
V1M2 4.13.3 f) x	test results;
V1M2 4.13.3 f) xi	standard and reagent origin, receipt, preparation, and use;
V1M2 4.13.3 f) xii	calibration criteria, frequency and acceptance criteria;
V1M2 4.13.3 f) xiii	data and statistical calculations, review, confirmation, interpretation, assessment and reporting conventions;
V1M2 4.13.3 f) xiv	quality control protocols and assessment;
V1M2 4.13.3 f) xv	electronic data security, software documentation and verification, software and hardware audits, backups, and records of any changes to automated data entries;
V1M2 4.13.3 f) xvi	method performance criteria including expected quality control requirements;
V1M2 4.13.3 f) xvii	proficiency test results;
V1M2 4.13.3 f) xviii	records of demonstration of capability for each analyst; and
V1M2 4.13.3 f) xix	a record of names, initials, and signatures for all individuals who are responsible for signing or initialing any laboratory record.
V1M2 4.13.3 g	All generated data, except those that are generated by automated data collection systems, shall be recorded legibly in permanent ink.
V1M2 4.13.3 g i	i. An individual making corrections to records shall date and initial the correction.
V1M2 4.13.3 g ii	ii. Corrections due to reasons other than transcription errors shall specify the reason for the correction.
V1M2 4.13.3 h	The laboratory shall have a plan to ensure that the records are maintained or transferred according to the clients' instructions in the event that a laboratory transfers ownership or goes out of business.
V1M2 4.13.3 h	In addition, appropriate regulatory and state legal requirements concerning laboratory records shall be followed.

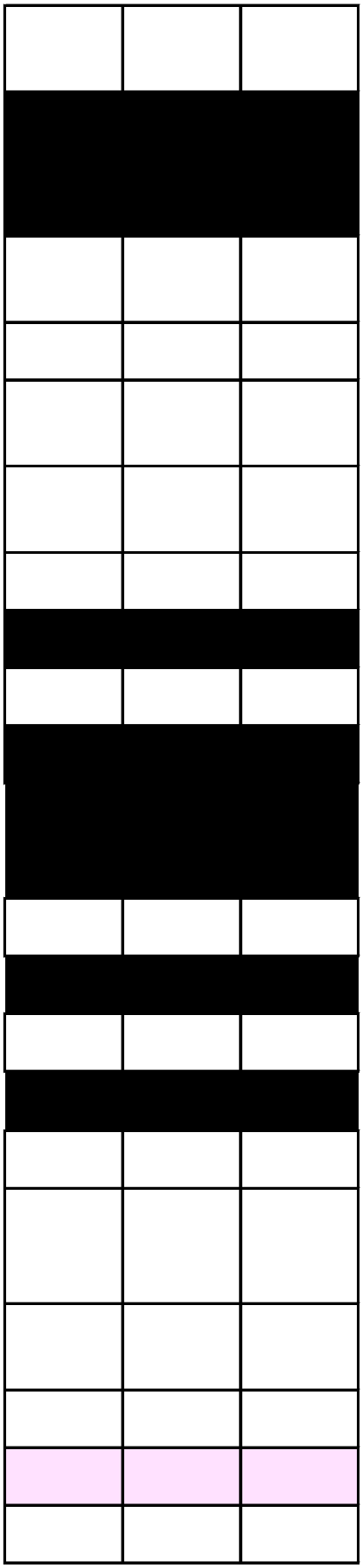
V1M2 4.14	Internal Audits (ISO/IEC 17025:2005(E), Clause 4.14)
V1M2 4.14.1	*The laboratory shall periodically, and in accordance with a predetermined schedule and procedure, conduct internal audits of its activities to verify that its operations continue to comply with the requirements of the management system and this International Standard.*
V1M2 4.14.1	*The internal audit programme shall address all elements of the management system, including the testing and/or calibration activities.*
V1M2 4.14.1	*It is the responsibility of the quality manager to plan and organize audits as required by the schedule and requested by management.*
V1M2 4.14.1	*Such audits shall be carried out by trained and qualified personnel who are, wherever resources permit, independent of the activity to be audited.*
V1M2 4.14.1 N	*NOTE: The cycle for internal auditing should normally be completed in one year.*
V1M2 4.14.2	*When audit findings cast doubt on the effectiveness of the operations or on the correctness or validity of the laboratory's test or calibration results, the laboratory shall take timely corrective action*
V1M2 4.14.2	*When audit findings cast doubt on the effectiveness of the operations or on the correctness or validity of the laboratory's test or calibration results, the laboratory notify customers in writing if investigations show that the laboratory results may have been affected.*
V1M2 4.14.3	*The area of activity audited, the audit findings and corrective actions that arise from them shall be recorded.*
V1M2 4.14.4	*Follow-up audit activities shall verify and record the implementation and effectiveness of the corrective action taken.*
V1M2 4.14.5	Additional Items
V1M2 4.14.5 a)	The laboratory shall have a policy that specifies the time frame for notifying a client of events that cast doubt on the validity of the results.
V1M2 4.14.5 b)	The laboratory management shall ensure that these actions are discharged within the agreed time frame.
V1M2 4.14.5 c)	The Internal audit schedule shall be completed annually,
V1M2 4.15	Management Reviews (ISO/IEC 17025:2005(E), Clause 4.15)
V1M2 4.15.1	*In accordance with a predetermined schedule and procedure, the laboratory's top management shall periodically conduct a review of the laboratory's management system and testing and/or calibration activities to ensure their continuing suitability and effectiveness*
V1M2 4.15.1	*In accordance with a predetermined schedule and procedure, the laboratory's top management shall periodically conduct a review of the laboratory's management system and testing and/or calibration activities to introduce necessary changes or improvements.*
V1M2 4.15.1	*-The management review shall take account of: the suitability of policies and procedures;*
V1M2 4.15.1	*-The management review shall take account of: reports from managerial and supervisory personnel;*
V1M2 4.15.1	*-The management review shall take account of: the outcome of recent internal audits;*

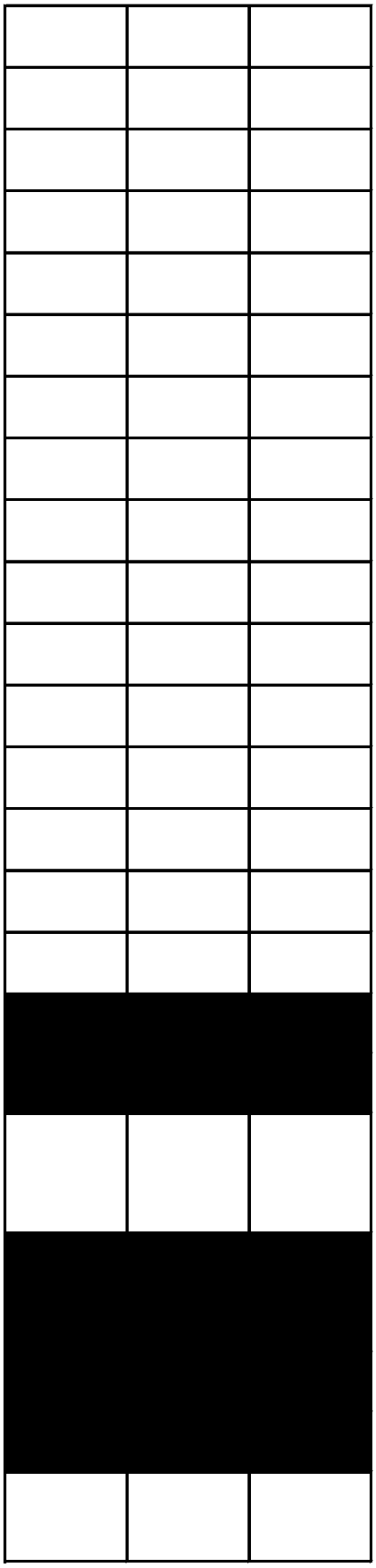
V1M2 4.15.1	*-The management review shall take account of: corrective and preventive actions;*
V1M2 4.15.1	*-The management review shall take account of: assessments by external bodies;*
V1M2 4.15.1	*-The management review shall take account of: the results of interlaboratory comparisons or proficiency tests;*
V1M2 4.15.1	*-The review shall take account of: changes in the volume and type of the work;*
V1M2 4.15.1	*-The management review shall take account of: customer feedback;*
V1M2 4.15.1	*-The management review shall take account of: complaints;*
V1M2 4.15.1	*-The management review shall take account of: recommendations for improvement;*
V1M2 4.15.1	*-The management review shall take account of: other relevant factors, such as quality control activities, resources, and staff training.*
V1M2 4.15.1 N1	*NOTE 1: A typical period for conducting a management review is once every 12 months.*
V1M2 4.15.1 N2	*NOTE 2: Results should feed into the laboratory planning system and should include the goals, objectives and action plans for the coming year.*
V1M2 4.15.1 N3	*NOTE 3: A management review includes consideration of related subjects at regular management meetings.*
V1M2 4.15.2	*Findings from management reviews and the actions that arise from them shall be recorded.*
V1M2 4.15.2	*The management shall ensure that those actions are carried out within an appropriate and agreed timescale.*
V1M2 4.15.3	Management review shall be completed on an annual basis.
V1M2 4.16	Data Integrity Investigations
V1M2 4.16	All investigations resulting from data integrity issues should be conducted in a confidential manner until they are completed.
V1M2 4.16	These investigations shall be documented as well as any notifications made to clients receiving any affected data.

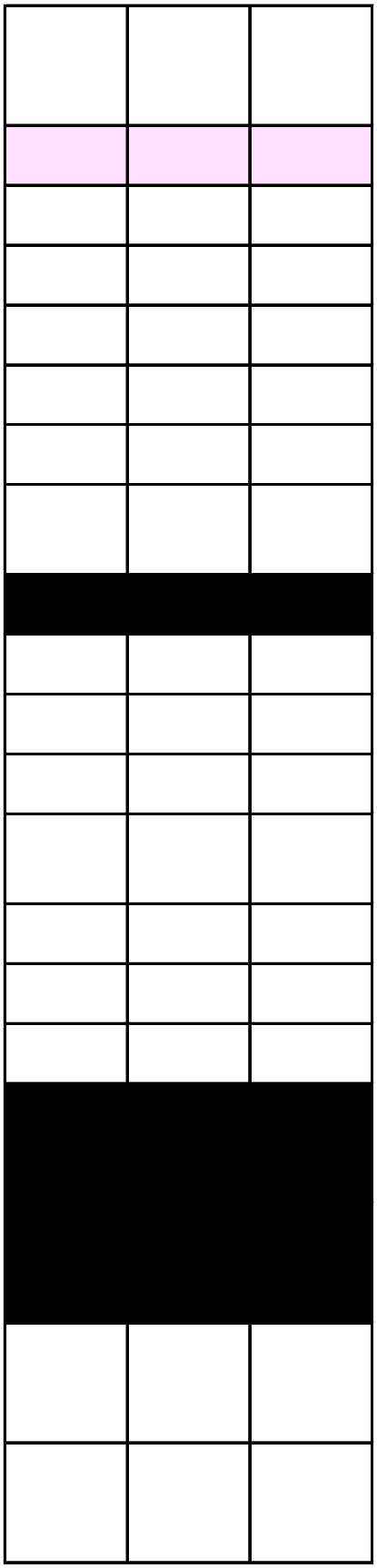
Yes	No	N/A

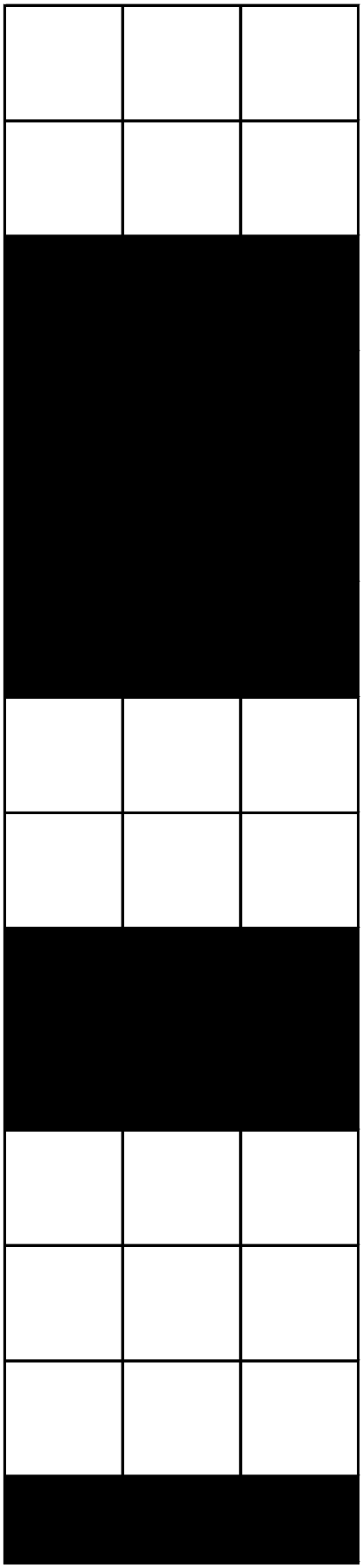


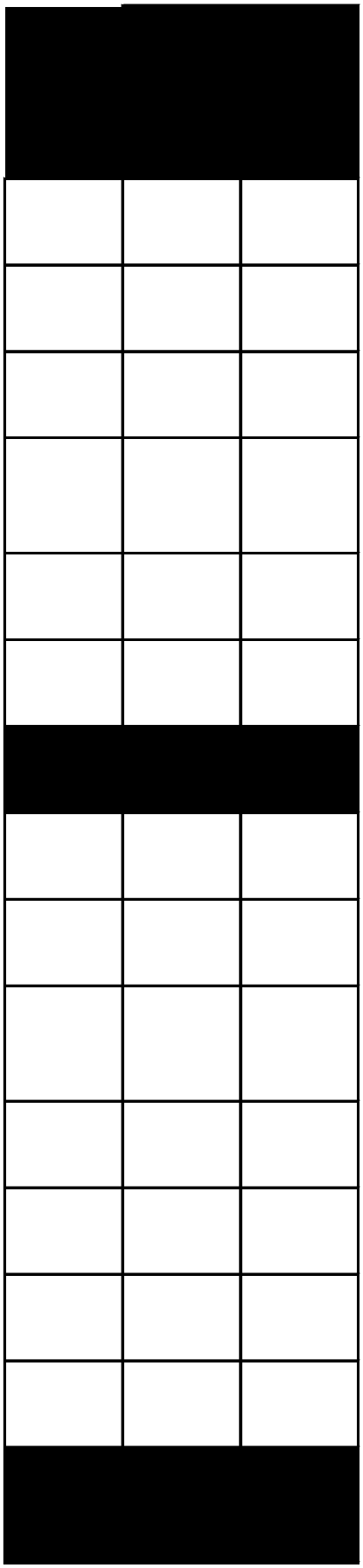


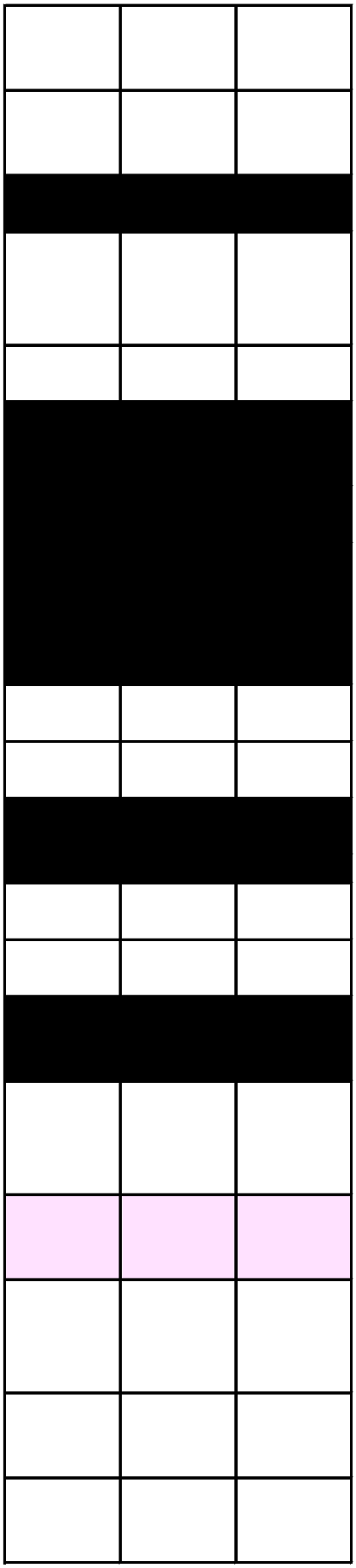


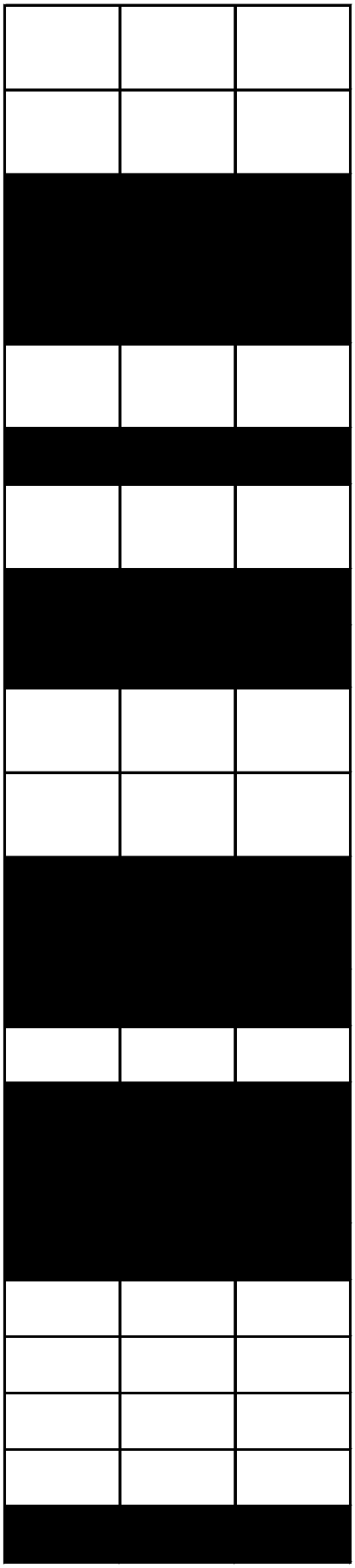


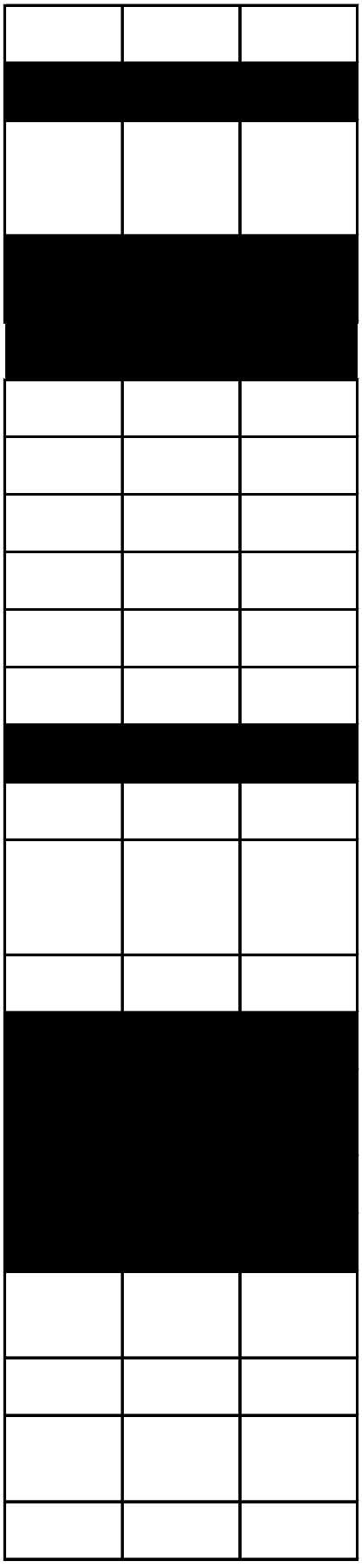


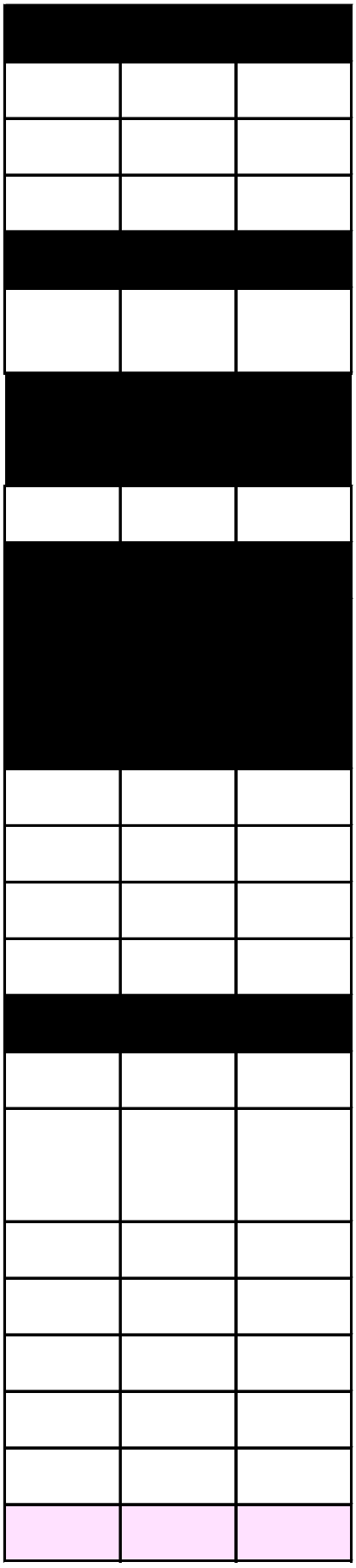


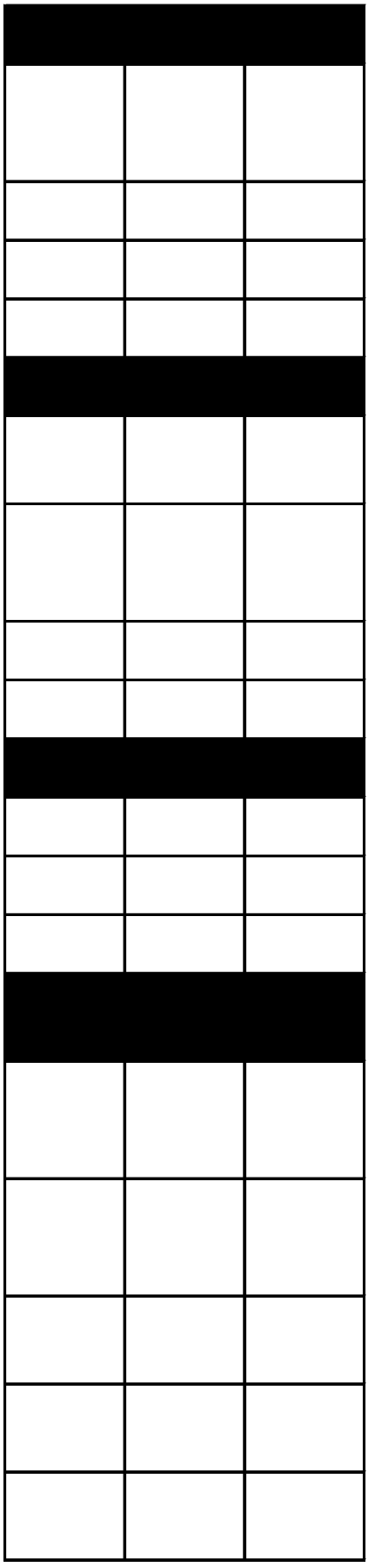


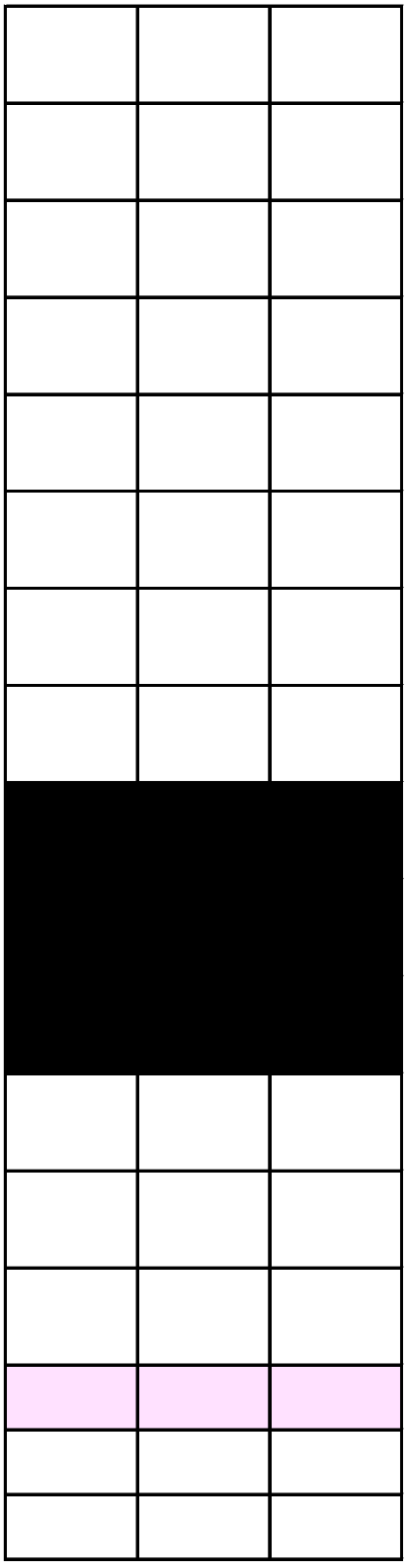












ID	Major Topic	Topic	Subject	Category	Citation
370					V1M2 5
371	5.1 General				V1M2 5.1.1
372	5.1 General	General			V1M2 5.1.1
373	5.1 General	General			V1M2 5.1.1
374	5.1 General	General			V1M2 5.1.1
375	5.1 General	General			V1M2 5.1.1
376	5.1 General	General			V1M2 5.1.1
377	5.1 General	General			V1M2 5.1.1
378	5.1 General	General			V1M2 5.1.1
379	5.1 General	General			V1M2 5.1.1
380	5.1 General	General	Factors	Requirement	V1M2 5.1.2
381	5.1 General	General	Factors	Requirement	V1M2 5.1.2
382	5.2 Personnel	Personnel			V1M2 5.2
383	5.2 Personnel	5.2.1 Management Responsibilities	Competency	Requirement	V1M2 5.2.1
384	5.2 Personnel	5.2.1 Management Responsibilities	Training	Requirement	V1M2 5.2.1
385	5.2 Personnel	5.2.1 Management Responsibilities	Qualifications	Requirement	V1M2 5.2.1
386	5.2 Personnel	5.2.1 Management Responsibilities			V1M2 5.2.1 N1
387	5.2 Personnel	5.2.1 Management Responsibilities			V1M2 5.2.1 N2
388	5.2 Personnel	5.2.1 Management Responsibilities			V1M2 5.2.1 N2
389	5.2 Personnel	5.2.1 Management Responsibilities			V1M2 5.2.1 N2
390	5.2 Personnel	5.2.1 Management Responsibilities			V1M2 5.2.1 N2
391	5.2 Personnel	5.2.2 Training	Goals	Requirement	V1M2 5.2.2
392	5.2 Personnel	5.2.2 Training	Training Needs	Procedure	V1M2 5.2.2
393	5.2 Personnel	5.2.2 Training	Training Program	Requirement	V1M2 5.2.2
394	5.2 Personnel	5.2.2 Training	Effectiveness	Requirement	V1M2 5.2.2

395	5.2 Personnel	5.2.3 Personnel Status	Scope	Requirement	V1M2 5.2.3
396	5.2 Personnel	5.2.3 Personnel Status	Expectations	Requirement	V1M2 5.2.3
397	5.2 Personnel	5.2.4 Job Descriptions	Scope	Record	V1M2 5.2.4
398	5.2 Personnel	5.2.4 Job Descriptions	Job Descriptions		V1M2 5.2.4 N
399	5.2 Personnel	5.2.4 Job Descriptions	Job Descriptions		V1M2 5.2.4 N
400	5.2 Personnel	5.2.4 Job Descriptions	Job Descriptions		V1M2 5.2.4 N
401	5.2 Personnel	5.2.4 Job Descriptions	Job Descriptions		V1M2 5.2.4 N
402	5.2 Personnel	5.2.4 Job Descriptions	Job Descriptions		V1M2 5.2.4 N
403	5.2 Personnel	5.2.4 Job Descriptions	Job Descriptions		V1M2 5.2.4 N
404	5.2 Personnel	5.2.4 Job Descriptions	Job Descriptions		V1M2 5.2.4 N
405	5.2 Personnel	5.2.4 Job Descriptions	Job Descriptions		V1M2 5.2.4 N
406	5.2 Personnel	5.2.5 Management Responsibilities	Delegating Responsibility	Requirement	V1M2 5.2.5
407	5.2 Personnel	5.2.5 Management Responsibilities	Personnel Records	Record	V1M2 5.2.5
408	5.2 Personnel	5.2.5 Management Responsibilities	Record Accessibility	Requirement	V1M2 5.2.5
409	5.2 Personnel	Personnel			V1M2 5.2.5 N
410	5.2 Personnel	5.2.6 Additional Requirements			V1M2 5.2.6
411	5.2 Personnel	5.2.6.1 Technical Manager	Technical Manager		V1M2 5.2.6.1
412	5.2 Personnel	5.2.6.1 Technical Manager	Credentials		V1M2 5.2.6.1
413	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 a)
414	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 a)

415	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 a)
416	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 b)
417	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 b)
418	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 b)
419	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 c)
420	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 c)
421	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 c)
422	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 c)
423	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 c)
424	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 d)
425	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 d)

426	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 d)
427	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 e)
428	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 e) i
429	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 e) i
430	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 e) i
431	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 e) ii
432	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 e) ii
433	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 e) ii
434	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 e) iii
435	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 e) iii
436	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 e) iii
437	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 f)

438	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 f)
439	5.2 Personnel	5.2.6.1 Technical Manager	Credentials	Requirement	V1M2 5.2.6.1 f)
440	5.2 Personnel	5.2.6.1 Technical Manager Exceptions	Technical Manager Exceptions	Exceptions	V1M2 5.2.6.2
441	5.2 Personnel	5.2.6.1 Technical Manager Exceptions	Credentials	Requirement	V1M2 5.2.6.2 a)
442	5.2 Personnel	5.2.6.1 Technical Manager Exceptions	Credentials	Requirement	V1M2 5.2.6.2 a)
443	5.2 Personnel	5.2.6.1 Technical Manager Exceptions	Credentials	Requirement	V1M2 5.2.6.2 a)
444	5.2 Personnel	5.2.6.1 Technical Manager Exceptions	Credentials	Requirement	V1M2 5.2.6.2 b)
445	5.2 Personnel	5.2.6.1 Technical Manager Exceptions	Credentials	Requirement	V1M2 5.2.6.2 b)
446	5.2 Personnel	5.2.6.1 Technical Manager Exceptions	Credentials	Requirement	V1M2 5.2.6.2 c)
447	5.2 Personnel	5.2.6.1 Technical Manager Exceptions	Credentials	Requirement	V1M2 5.2.6.2 c) i
448	5.2 Personnel	5.2.6.1 Technical Manager Exceptions	Credentials	Requirement	V1M2 5.2.6.2 c) i
449	5.2 Personnel	5.2.6.1 Technical Manager Exceptions	Credentials	Requirement	V1M2 5.2.6.2 c) ii
450	5.2 Personnel	5.2.6.1 Technical Manager Exceptions	Grandfather Clause	Exceptions	V1M2 5.2.6.2 c) iii
451	5.2 Personnel	5.2.7 Data Integrity Training			V1M2 5.2.7
452	5.2 Personnel	5.2.7 Data Integrity Training	Frequency	Requirement	V1M2 5.2.7

453	5.2 Personnel	5.2.7 Data Integrity Training	Consequences	Requirement	V1M2 5.2.7
454	5.2 Personnel	5.2.7 Data Integrity Training	Documentation	Record	V1M2 5.2.7
455	5.2 Personnel	5.2.7 Data Integrity Training	Topic	Requirement	V1M2 5.2.7
456	5.2 Personnel	5.2.7 Data Integrity Training	Documentation	Record	V1M2 5.2.7
457	5.2 Personnel	5.2.7 Data Integrity Training	Training		V1M2 5.2.7
458	5.2 Personnel	5.2.7 Data Integrity Training	Topic	Requirement	V1M2 5.2.7.a
459	5.2 Personnel	5.2.7 Data Integrity Training	Topic	Requirement	V1M2 5.2.7.b
460	5.2 Personnel	5.2.7 Data Integrity Training	Topic	Requirement	V1M2 5.2.7.c
461	5.2 Personnel	5.2.7 Data Integrity Training	Topic	Requirement	V1M2 5.2.7.d
462	5.2 Personnel	5.2.7 Data Integrity Training	Topic	Requirement	V1M2 5.2.7.e
463	5.2 Personnel	5.2.7 Data Integrity Training	Topic	Requirement	V1M2 5.2.7
464	5.3 Accommodation & Environmental Conditions				V1M2 5.3
465	5.3 Accommodation & Environmental Conditions	5.3.1 Environmental Conditions	Scope	Requirement	V1M2 5.3.1
466	5.3 Accommodation & Environmental Conditions	5.3.1 Environmental Conditions	Environmental Conditions	Requirement	V1M2 5.3.1
467	5.3 Accommodation & Environmental Conditions	5.3.1 Environmental Conditions	Off-site	Requirement	V1M2 5.3.1
468	5.3 Accommodation & Environmental Conditions	5.3.1 Environmental Conditions	Technical Requirements	Record	V1M2 5.3.1

469	5.3 Accommodation & Environmental Conditions	5.3.2 Monitoring	Scope	Record	V1M2 5.3.2
470	5.3 Accommodation & Environmental Conditions	5.3.2 Monitoring	Specific Conditions	Requirement	V1M2 5.3.2
471	5.3 Accommodation & Environmental Conditions	5.3.2 Monitoring	Unacceptable Conditions	Requirement	V1M2 5.3.2
472	5.3 Accommodation & Environmental Conditions	5.3.3 Floor Plan	Incompatible Activities	Requirement	V1M2 5.3.3
473	5.3 Accommodation & Environmental Conditions	5.3.3 Floor Plan	Cross Contamination	Requirement	V1M2 5.3.3
474	5.3 Accommodation & Environmental Conditions	5.3.4 Accessibility	Controlled Access	Requirement	V1M2 5.3.4
475	5.3 Accommodation & Environmental Conditions	5.3.4 Accessibility	Controlled Access	Requirement	V1M2 5.3.4
476	5.3 Accommodation & Environmental Conditions	5.3.5 Housekeeping	Good Housekeeping	Requirement	V1M2 5.3.5
477	5.3 Accommodation & Environmental Conditions	5.3.5 Housekeeping	Good Housekeeping	Procedure	V1M2 5.3.5
478	5.4 Environmental Test Methods & Method Validation				V1M2 5.4
479	5.4 Environmental Test Methods & Method Validation			Note	V1M2 5.4 N
480	5.4 Environmental Test Methods & Method Validation	5.4.1 General	General		V1M2 5.4.1
481	5.4 Environmental Test Methods & Method Validation	5.4.1 General	Scope	Procedure	V1M2 5.4.1
482	5.4 Environmental Test Methods & Method Validation	5.4.1 General	Scope	Procedure	V1M2 5.4.1

483	5.4 Environmental Test Methods & Method Validation	5.4.1 General	Equipment Use	Procedure	V1M2 5.4.1
484	5.4 Environmental Test Methods & Method Validation	5.4.1 General	Manual	Requirement	V1M2 5.4.1
485	5.4 Environmental Test Methods & Method Validation	5.4.1 General	Deviations	Record	V1M2 5.4.1
486	5.4 Environmental Test Methods & Method Validation	5.4.1 General	General		V1M2 5.4.1 N
487	5.4 Environmental Test Methods & Method Validation	5.4.2 Method Selection	Method Selection		V1M2 5.4.2
488	5.4 Environmental Test Methods & Method Validation	5.4.2 Method Selection	Scope	Requirement	V1M2 5.4.2
489	5.4 Environmental Test Methods & Method Validation	5.4.2 Method Selection	Method Sources	Requirement	V1M2 5.4.2
490	5.4 Environmental Test Methods & Method Validation	5.4.2 Method Selection	Method Edition	Requirement	V1M2 5.4.2
491	5.4 Environmental Test Methods & Method Validation	5.4.2 Method Selection	Supplemental Information	Documentation	V1M2 5.4.2
492	5.4 Environmental Test Methods & Method Validation	5.4.2 Method Selection	Appropriate Methods	Requirement	V1M2 5.4.2
493	5.4 Environmental Test Methods & Method Validation	5.4.2 Method Selection	Laboratory Method	Requirement	V1M2 5.4.2
494	5.4 Environmental Test Methods & Method Validation	5.4.2 Method Selection	Customer Communication	Requirement	V1M2 5.4.2
495	5.4 Environmental Test Methods & Method Validation	5.4.2 Method Selection	Method Verification	Requirement	V1M2 5.4.2
496	5.4 Environmental Test Methods & Method Validation	5.4.2 Method Selection	Method reverification	Requirement	V1M2 5.4.2
497	5.4 Environmental Test Methods & Method Validation	5.4.2 Method Selection	Out-of date Methods	Requirement	V1M2 5.4.2
498	5.4 Environmental Test Methods & Method Validation	5.4.3 Laboratory-Developed Methods	Lab Developed Methods		V1M2 5.4.3

499	5.4 Environmental Test Methods & Method Validation	5.4.3 Laboratory-Developed Methods	Planned Activity	Requirement	V1M2 5.4.3
500	5.4 Environmental Test Methods & Method Validation	5.4.3 Laboratory-Developed Methods	Communication	Requirement	V1M2 5.4.3
501	5.4 Environmental Test Methods & Method Validation	5.4.4 Non-Standard Methods	Lab Developed Methods		V1M2 5.4.4
502	5.4 Environmental Test Methods & Method Validation	5.4.4 Test Methods C144 Validation	Lab Developed Methods		V1M2 5.4.5
503	5.4 Environmental Test Methods & Method Validation	5.4.6 Estimation of Uncertainty	Uncertainty		V1M2 5.4.6
504	5.4 Environmental Test Methods & Method Validation	5.4.6 Estimation of Uncertainty	Analytical Uncertainty	Procedure	V1M2 5.4.6
505	5.4 Environmental Test Methods & Method Validation	5.4.6 Estimation of Uncertainty	Analytical Uncertainty	Procedure	V1M2 5.4.6
506	5.4 Environmental Test Methods & Method Validation	5.4.6 Estimation of Uncertainty	Analytical Uncertainty	Option	V1M2 5.4.6
507	5.4 Environmental Test Methods & Method Validation	5.4.7 Control of Data	Control of Data		V1M2 5.4.7
508	5.4 Environmental Test Methods & Method Validation	5.4.7 Control of Data	Systematic Review	Requirement	V1M2 5.4.7.1
509	5.4 Environmental Test Methods & Method Validation	5.4.7 Control of Data Computers & Automated Equipment	Computer Requirements		V1M2 5.4.7.2
510	5.4 Environmental Test Methods & Method Validation	5.4.7 Control of Data Computers & Automated Equipment	Computer software	Documentation	V1M2 5.4.7.2.a
511	5.4 Environmental Test Methods & Method Validation	5.4.7 Control of Data Computers & Automated Equipment	Software Validation	Requirement	V1M2 5.4.7.2.a
512	5.4 Environmental Test Methods & Method Validation	5.4.7 Control of Data Computers & Automated Equipment	Data Protection	Procedure	V1M2 5.4.7.2.b
513	5.4 Environmental Test Methods & Method Validation	5.4.7 Control of Data Computers & Automated Equipment	Data Protection	Procedure	V1M2 5.4.7.2.b
514	5.4 Environmental Test Methods & Method Validation	5.4.7 Control of Data Computers & Automated Equipment	Computer maintenance	Requirement	V1M2 5.4.7.2.c

515	5.4 Environmental Test Methods & Method Validation	5.4.7 Control of Data Computers & Automated Equipment	Computer operating conditions	Requirement	V1M2 5.4.7.2.c
516	5.4 Environmental Test Methods & Method Validation	5.4.7 Control of Data Computers & Automated Equipment	Control of Data		V1M2 5.4.7.2 N
517	5.5 Calibration Requirements	Calibration			V1M2 5.5
518	5.5 Calibration Requirements	5.5.1 Scope	Equipment	Requirement	V1M2 5.5.1
519	5.5 Calibration Requirements	5.5.1 Scope	Rental Equipment	Requirement	V1M2 5.5.1
520	5.5 Calibration Requirements	5.5.2 Equipment Requirements	Specifications	Requirement	V1M2 5.5.2
521	5.5 Calibration Requirements	5.5.2 Equipment Requirements	Calibration Programs	Requirement	V1M2 5.5.2
522	5.5 Calibration Requirements	5.5.2 Equipment Requirements	Initial Check	Requirement	V1M2 5.5.2
523	5.5 Calibration Requirements	5.5.2 Equipment Requirements	Calibration before Use	Requirement	V1M2 5.5.2
524	5.5 Calibration Requirements	5.5.3 Equipment Operation	Personnel	Requirement	V1M2 5.5.3
525	5.5 Calibration Requirements	5.5.3 Equipment Operation	SOPs/Manuals	Requirement	V1M2 5.5.3
526	5.5 Calibration Requirements	5.5.4 Identification	Unique Identifiers	Requirement	V1M2 5.5.4
527	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5
528	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5
529	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.a
530	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.a
531	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.b
532	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.b
533	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.b

534	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.c
535	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.d
536	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.e
537	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.f
538	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.f
539	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.f
540	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.f
541	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.g
542	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.g
543	5.5 Calibration Requirements	5.5.5 Records	Equipment	Record	V1M2 5.5.5.h
544	5.5 Calibration Requirements	5.5.6 Maintenance	Planned Maintenance	Requirement	V1M2 5.5.6
545	5.5 Calibration Requirements	5.5.6 Maintenance			V1M2 5.5.6 N
546	5.5 Calibration Requirements	5.5.7 Defective Equipment	Removal from Service	Requirement	V1M2 5.5.7
547	5.5 Calibration Requirements	5.5.7 Defective Equipment	Identification	Requirement	V1M2 5.5.7
548	5.5 Calibration Requirements	5.5.7 Defective Equipment	Examining Consequences	Requirement	V1M2 5.5.7
549	5.5 Calibration Requirements	5.5.8 Calibration Status	Calibration Status	Requirement	V1M2 5.5.8
550	5.5 Calibration Requirements	5.5.8 Calibration Status	Calibration Date	Requirement	V1M2 5.5.8
551	5.5 Calibration Requirements	5.5.8 Calibration Status	Expiration	Requirement	V1M2 5.5.8
552	5.5 Calibration Requirements	5.5.9 After Equipment Returns	Function and Calibration	Record	V1M2 5.5.9
553	5.5 Calibration Requirements	5.5.10 Intermediate Checks	Frequency	Procedure	V1M2 5.5.10
554	5.5 Calibration Requirements	5.5.11 Correction Factors	Updates	Procedure	V1M2 5.5.11

555	5.5 Calibration Requirements	5.5.12 Inadvertent Adjustments	Protection	Requirement	V1M2 5.5.12
556	5.5 Calibration Requirements	Calibration			V1M2 5.5.12 N
557	5.5 Calibration Requirements	5.5.13 Additional Requirements			V1M2 5.5.13
558	5.5 Calibration Requirements	5.5.13 Additional Requirements			V1M2 5.5.13
559	5.5 Calibration Requirements	5.5.13 Additional Requirements Support Equipment			V1M2 5.5.13.1
560	5.5 Calibration Requirements	5.5.13 Additional Requirements Support Equipment	Scope		V1M2 5.5.13.1
561	5.5 Calibration Requirements	5.5.13 Additional Requirements Support Equipment	Maintenance	Requirement	V1M2 5.5.13.1.a
562	5.5 Calibration Requirements	5.5.13 Additional Requirements Support Equipment	Maintenance	Record	V1M2 5.5.13.1.a
563	5.5 Calibration Requirements	5.5.13 Additional Requirements Support Equipment	Annual Calibration/verification	Requirement	V1M2 5.5.13.1.b
564	5.5 Calibration Requirements	5.5.13 Additional Requirements Support Equipment	Calibration/verification Results	Requirement	V1M2 5.5.13.1.b
565	5.5 Calibration Requirements	5.5.13 Additional Requirements Support Equipment	Calibration/verification Results	Option	V1M2 5.5.13.1.b.i
566	5.5 Calibration Requirements	5.5.13 Additional Requirements Support Equipment	Calibration/verification Results	Option	V1M2 5.5.13.1.b.ii
567	5.5 Calibration Requirements	5.5.13 Additional Requirements Support Equipment	Raw Data	Record	V1M2 5.5.13.1.c
568	5.5 Calibration Requirements	5.5.13 Additional Requirements Support Equipment	Daily Checks	Documentation	V1M2 5.5.13.1.d
569	5.5 Calibration Requirements	5.5.13 Additional Requirements Support Equipment	Daily Checks	Requirement	V1M2 5.5.13.1.d
570	5.5 Calibration Requirements	5.5.13 Additional Requirements Support Equipment	Volumetric Devices	Requirement	V1M2 5.5.13.1.e
571	5.6 Measurement Traceability	Measurement Traceability			V1M2 5.6

572	5.6 Measurement Traceability	Measurement Traceability	General		V1M2 5.6.1
573	5.6 Measurement Traceability	Measurement Traceability	General		V1M2 5.6.2
574	5.6 Measurement Traceability	5.6.3 Reference Standards & Materials			V1M2 5.6.3
575	5.6 Measurement Traceability	5.6.3.1 Reference Standards	Reference Standard		V1M2 5.6.3.1
576	5.6 Measurement Traceability	5.6.3.1 Reference Standards	Reference Standard	Procedure	V1M2 5.6.3.1
577	5.6 Measurement Traceability	5.6.3.1 Reference Standards	Calibration	Requirement	V1M2 5.6.3.1
578	5.6 Measurement Traceability	5.6.3.1 Reference Standards	Use	Requirement	V1M2 5.6.3.1
579	5.6 Measurement Traceability	5.6.3.1 Reference Standards	Calibration	Requirement	V1M2 5.6.3.1
580	5.6 Measurement Traceability	5.6.3 Materials	Reference Materials		V1M2 5.6.3.2
581	5.6 Measurement Traceability	5.6.3 Materials	Traceability	Requirement	V1M2 5.6.3.2
582	5.6 Measurement Traceability	5.6.3 Materials	Checks	Requirement	V1M2 5.6.3.2
583	5.6 Measurement Traceability	5.6.3 Reference Standards & Materials	Intermediate checks		V1M2 5.6.3.3
584	5.6 Measurement Traceability	5.6.3 Reference Standards & Materials	Intermediate checks	Requirement	V1M2 5.6.3.3
585	5.6 Measurement Traceability	5.6.3 Reference Standards & Materials	Transport and Storage		V1M2 5.6.3.4
586	5.6 Measurement Traceability	5.6.3 Reference Standards & Materials	Transport and Storage	Procedure	V1M2 5.6.3.4
587	5.6 Measurement Traceability	5.6.3 Reference Standards & Materials			V1M2 5.6.3.4 N
588	5.6 Measurement Traceability	5.6.4 Additional Requirements	Additional Requirements		V1M2 5.6.4
589	5.6 Measurement Traceability	5.6.4.1 Reference Standards and Reference Materials	Reference Standards & Materials		V1M2 5.6.4.1
590	5.6 Measurement Traceability	5.6.4.1 Reference Standards and Reference Materials	Reference Standards & Materials	Requirement	V1M2 5.6.4.1
591	5.6 Measurement Traceability	5.6.4.1 Reference Standards	Reference Standards		V1M2 5.6.4.1.a
592	5.6 Measurement Traceability	5.6.4.1 Reference Standards	Reference Standard Traceability	Requirement	V1M2 5.6.4.1.a

593	5.6 Measurement Traceability	5.6.4.1 Reference Materials	Reference Materials		V1M2 5.6.4.1.b
594	5.6 Measurement Traceability	5.6.4.1 Reference Materials	Reference Material Traceability	Requirement	V1M2 5.6.4.1.b
595	5.6 Measurement Traceability	5.6.4.1 Reference Materials	Reference Material Checks	Requirement	V1M2 5.6.4.1.b
596	5.6 Measurement Traceability	5.6.4.2 Standards, Reagents and Reference Materials (SRRM)			V1M2 5.6.4.2
597	5.6 Measurement Traceability	5.6.4.2 (SRRM)	Purchase, receipt and storage	Procedure	V1M2 5.6.4.2
598	5.6 Measurement Traceability	5.6.4.2 (SRRM)	Manufacturer	Record	V1M2 5.6.4.2.a
599	5.6 Measurement Traceability	5.6.4.2 (SRRM)	Certificate of Analysis	Record	V1M2 5.6.4.2.a
600	5.6 Measurement Traceability	5.6.4.2 (SRRM)	Receipt Date	Record	V1M2 5.6.4.2.a
601	5.6 Measurement Traceability	5.6.4.2 (SRRM)	Storage	Record	V1M2 5.6.4.2.a
602	5.6 Measurement Traceability	5.6.4.2 (SRRM)	Expiration Date	Record	V1M2 5.6.4.2.b
603	5.6 Measurement Traceability	5.6.4.2 (SRRM)	Preparation	Record	V1M2 5.6.4.2.c
604	5.6 Measurement Traceability	5.6.4.2 (SRRM)	Identification	Requirement	V1M2 5.6.4.2.d
605	5.6 Measurement Traceability	5.6.4.2 (SRRM)	Expiration Date Prepared materials	Requirement	V1M2 5.6.4.2.d
606	5.6 Measurement Traceability	5.6.4.2 (SRRM)	Reagent Suitability	Procedure	V1M2 5.6.4.2.e
607	5.6 Measurement Traceability	5.6.4.2 (SRRM)	Use after Expiration Date	Requirement	V1M2 5.6.4.2.f
608	5.7 Collection of Samples	Sample Collection			V1M2 5.7
609	5.7 Collection of Samples	5.7.1 Sampling Plans	Strategy	Procedure	V1M2 5.7.1
610	5.7 Collection of Samples	5.7.1 Sampling Plans	Availability	Requirement	V1M2 5.7.1
611	5.7 Collection of Samples	5.7.1 Sampling Plans	Statistical Methods	Requirement	V1M2 5.7.1
612	5.7 Collection of Samples	5.7.1 Sampling Plans	Controlling Factors	Requirement	V1M2 5.7.1

613	5.7 Collection of Samples	5.7.1 Sampling Plans			V1M2 5.7.1 N1
614	5.7 Collection of Samples	5.7.1 Sampling Plans			V1M2 5.7.1 N2
615	5.7 Collection of Samples	5.7.2 Customer Requirements	Requested Deviations	Record	V1M2 5.7.2
616	5.7 Collection of Samples	5.7.2 Customer Requirements	Requested Deviations	Report	V1M2 5.7.2
617	5.7 Collection of Samples	5.7.2 Customer Requirements	Requested Deviations	Requirement	V1M2 5.7.2
618	5.7 Collection of Samples	5.7.3 Sampling Records	Sampling and/or Testing Event Records	Procedure	V1M2 5.7.3
619	5.7 Collection of Samples	5.7.3 Sampling Records	Details to Record	Record	V1M2 5.7.3
620	5.7 Collection of Samples	5.7.4 Additional Requirements			V1M2 5.7.4
621	5.7 Collection of Samples	5.7.4 Additional Requirements	Sampling Date	Record	V1M2 5.7.4.a
622	5.7 Collection of Samples	5.7.4 Additional Requirements	Sampling Time	Record	V1M2 5.7.4.a
623	5.7 Collection of Samples	5.7.4 Additional Requirements	Deviations	Record	V1M2 5.7.4.b
624	5.8 Handling Samples & Test Items	Handling Samples & Test Items			V1M2 5.8
625	5.8 Handling Samples & Test Items	5.8.1 Procedures for		Procedure	V1M2 5.8.1
626	5.8 Handling Samples & Test Items	5.8.2 Identification	Process	Requirement	V1M2 5.8.2
627	5.8 Handling Samples & Test Items	5.8.2 Identification	Retention	Requirement	V1M2 5.8.2
628	5.8 Handling Samples & Test Items	5.8.2 Identification	Unique Identifiers	Requirement	V1M2 5.8.2
629	5.8 Handling Samples & Test Items	5.8.2 Identification	Sub-groups	Requirement	V1M2 5.8.2

630	5.8 Handling Samples & Test Items	5.8.3 Receipt Procedures	Departures	Record	V1M2 5.8.3
631	5.8 Handling Samples & Test Items	5.8.3 Receipt Procedures	Departures communication	Requirement	V1M2 5.8.3
632	5.8 Handling Samples & Test Items	5.8.4 Storage	Storage Conditions	Procedure	V1M2 5.8.4
633	5.8 Handling Samples & Test Items	5.8.4 Storage	Instructions	Requirement	V1M2 5.8.4
634	5.8 Handling Samples & Test Items	5.8.4 Storage	Specific Conditions	Record	V1M2 5.8.4
635	5.8 Handling Samples & Test Items	5.8.4 Storage	Security	Requirement	V1M2 5.8.4
636	5.8 Handling Samples & Test Items	5.8.4 Storage			V1M2 5.8.4 N1
637	5.8 Handling Samples & Test Items	5.8.4 Storage			V1M2 5.8.4 N2
638	5.8 Handling Samples & Test Items	5.8.4 Storage			V1M2 5.8.4 N3
639	5.8 Handling Samples & Test Items	5.8.5 Additional Requirements			V1M2 5.8.5
640	5.8 Handling Samples & Test Items	5.8.5 Additional Requirements			V1M2 5.8.5
641	5.8 Handling Samples & Test Items	5.8.5 Additional Requirements Documentation	Unique Identifiers	Procedure	V1M2 5.8.5.a
642	5.8 Handling Samples & Test Items	5.8.5 Additional Requirements Documentation	Identifying Subsamples	Procedure	V1M2 5.8.5.a
643	5.8 Handling Samples & Test Items	5.8.5 Additional Requirements Documentation	Link to Field ID	Requirement	V1M2 5.8.5.b
644	5.8 Handling Samples & Test Items	5.8.5 Additional Requirements Documentation	ID Placement	Requirement	V1M2 5.8.5.c
645	5.8 Handling Samples & Test Items	5.8.5 Additional Requirements Documentation	ID Records	Record	V1M2 5.8.5.d
646	5.8 Handling Samples & Test Items	5.8.5 Additional Requirements Documentation	ID Relationships	Requirement	V1M2 5.8.5.d

647	5.8 Handling Samples & Test Items	5.8.5 Additional Requirements Documentation	ID/Field ID		V1M2 5.8.5.e
648	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy			V1M2 5.8.6
649	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Policy	Requirement	V1M2 5.8.6
650	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Sample Id	Requirement	V1M2 5.8.6.a
651	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Sample Location	Requirement	V1M2 5.8.6.a
652	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Collection Date	Requirement	V1M2 5.8.6.a
653	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Collection Time	Requirement	V1M2 5.8.6.a
654	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Collector's Name	Requirement	V1M2 5.8.6.a
655	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Preservation	Requirement	V1M2 5.8.6.a
656	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Sample Type	Requirement	V1M2 5.8.6.a
657	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Special Remarks	Requirement	V1M2 5.8.6.a
658	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Sample Labeling	Requirement	V1M2 5.8.6.b
659	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Sample Labeling	Requirement	V1M2 5.8.6.b
660	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Sample Containers	Requirement	V1M2 5.8.6.c

661	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Holding Times	Requirement	V1M2 5.8.6.d
662	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Sample Volume	Requirement	V1M2 5.8.6.e
663	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Sample Deviations	Procedure	V1M2 5.8.6.f
664	5.8 Handling Samples & Test Items	5.8.6 Additional Requirements Sample Acceptance Policy	Data Qualifications	Requirement	V1M2 5.8.6.g
665	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures			V1M2 5.8.7
666	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Preservation	Procedure	V1M2 5.8.7.1
667	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Deviations		V1M2 5.8.7.2
668	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Deviations	Record	V1M2 5.8.7.2.a
669	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Deviations	Record	V1M2 5.8.7.2.b
670	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Deviations	Requirement	V1M2 5.8.7.2.i
671	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Deviations	Requirement	V1M2 5.8.7.2.ii
672	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Sample Receipt Log	Record	V1M2 5.8.7.3
673	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Sample Receipt Log	Record	V1M2 5.8.7.3.a

674	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Sample Receipt Log Contents	Requirement	V1M2 5.8.7.3.a.i
675	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Sample Receipt Log Contents	Requirement	V1M2 5.8.7.3.a.ii
676	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Sample Receipt Log Contents	Requirement	V1M2 5.8.7.3.a.iii
677	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Sample Receipt Log Contents	Requirement	V1M2 5.8.7.3.a.iv
678	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Supplemental Information	Requirement	V1M2 5.8.7.3.b
679	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Supplemental Information Availability	Requirement	V1M2 5.8.7.3.b
680	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Supplemental Information Items	Requirement	V1M2 5.8.7.3.b N
681	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Supplemental Information Items	Requirement	V1M2 5.8.7.3.b.i
682	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Supplemental Information Items	Requirement	V1M2 5.8.7.3.b.ii
683	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Supplemental Information Items	Requirement	V1M2 5.8.7.3.b.iii
684	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Supplemental Information Items	Requirement	V1M2 5.8.7.3.b.iv
685	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Records Retention	Record	V1M2 5.8.7.4
686	5.8 Handling Samples & Test Items	5.8.7 Additional Requirements Sample Receipt Procedures	Chain of Custody	Record	V1M2 5.8.7.5
687	5.8 Handling Samples & Test Items	5.8.8 Additional Requirements Legal Chain of Custody			V1M2 5.8.8

688	5.8 Handling Samples & Test Items	5.8.8 Additional Requirements Legal Chain of Custody			V1M2 5.8.8
689	5.8 Handling Samples & Test Items	5.8.8 Additional Requirements Legal Chain of Custody	Client Request	Requirement	V1M2 5.8.8
690	5.8 Handling Samples & Test Items	5.8.9 Additional Requirements Sample Storage and Disposal			V1M2 5.8.9
691	5.8 Handling Samples & Test Items	5.8.9 Additional Requirements Sample Storage and Disposal	Storage Conditions	Requirement	V1M2 5.8.9.a
692	5.8 Handling Samples & Test Items	5.8.9 Additional Requirements Sample Storage and Disposal	Temperature	Requirement	V1M2 5.8.9.a.i
693	5.8 Handling Samples & Test Items	5.8.9 Additional Requirements Sample Storage and Disposal	Temperature	Requirement	V1M2 5.8.9.a.i
694	5.8 Handling Samples & Test Items	5.8.9 Additional Requirements Sample Storage and Disposal	Storage Conditions	Requirement	V1M2 5.8.9.a.ii
695	5.8 Handling Samples & Test Items	5.8.9 Additional Requirements Sample Storage and Disposal	Storage Conditions for fractions	Requirement	V1M2 5.8.9.b
696	5.8 Handling Samples & Test Items	5.8.9 Additional Requirements Sample Storage and Disposal	Sample Disposal	Procedure	V1M2 5.8.9.c
697	5.9 QA	5.9 QA			V1M2 5.9
698	5.9 QA	5.9.1 Quality Control	Quality Control	Requirement	V1M2 5.9.1
699	5.9 QA	5.9.1 Quality Control	Criteria for Records	Record	V1M2 5.9.1
700	5.9 QA	5.9.1 Quality Control	Monitoring Program Elements	Requirement	V1M2 5.9.1
701	5.9 QA	5.9.1 Quality Control	Monitoring Program Elements	Option	V1M2 5.9.1.a
702	5.9 QA	5.9.1 Quality Control	Monitoring Program Elements	Option	V1M2 5.9.1.b
703	5.9 QA	5.9.1 Quality Control	Monitoring Program Elements	Option	V1M2 5.9.1.c

704	5.9 QA	5.9.1 Quality Control	Monitoring Program Elements	Option	5.9.1.d
705	5.9 QA	5.9.1 Quality Control	Monitoring Program Elements	Option	V1M2 5.9.1.e
706	5.9 QA	5.9.1 Quality Control			V1M2 5.9.1.e N
707	5.9 QA	5.9.2 Quality Control	Planned Actions	Requirement	V1M2 5.9.2
708	5.9 QA	5.9.3 Essential QC Procedures			V1M2 5.9.3
709	5.9 QA	5.9.3 Essential QC Procedures			V1M2 5.9.3
710	5.9 QA	5.9.3 Essential QC Procedures	Procedure	Requirement	V1M2 5.9.3.a
711					V1M2
712	5.9 QA	5.9.3 Essential QC Procedures	Positive & Negative Controls	Requirement	V1M2 5.9.3.a.i
713	5.9 QA	5.9.3 Essential QC Procedures	Variability	Requirement	V1M2 5.9.3.a.ii
714	5.9 QA	5.9.3 Essential QC Procedures	Accuracy	Requirement	V1M2 5.9.3.a.iii
715	5.9 QA	5.9.3 Essential QC Procedures	Method Capability	Requirement	V1M2 5.9.3.a.iv
716	5.9 QA	5.9.3 Essential QC Procedures	Data Reduction	Requirement	V1M2 5.9.3.a.v
717	5.9 QA	5.9.3 Essential QC Procedures	Reagents and Standards	Requirement	V1M2 5.9.3.a.vi
718	5.9 QA	5.9.3 Essential QC Procedures	Selectivity	Requirement	V1M2 5.9.3.a.vii
719	5.9 QA	5.9.3 Essential QC Procedures	Constant Test Conditions	Requirement	V1M2 5.9.3.a.viii
720	5.9 QA	5.9.3 Essential QC Procedures	Assessment	Requirement	V1M2 5.9.3.b
721	5.9 QA	5.9.3 Essential QC Procedures	Acceptance Criteria	Procedure	V1M2 5.9.3.c
722	5.9 QA	5.9.3 Essential QC Procedures	SOP Procedures	Requirement	V1M2 5.9.3.c
723	5.9 QA	5.9.3 Essential QC Procedures	Procedures in Technical Modules/Methods	Requirement	V1M2 5.9.3.c
724	5.9 QA	5.9.3 Essential QC Procedures	Stringency	Requirement	V1M2 5.9.3.c

725	5.10 Reporting Results				V1M2 5.1
726	5.10 Reporting Results				V1M2 5.10 N
727	5.10 Reporting Results	5.10.1 General			V1M2 5.10.1
728	5.10 Reporting Results	5.10.1 General	Performance Measures	Requirement	V1M2 5.10.1
729	5.10 Reporting Results	5.10.1 General	Performance Measures	Requirement	V1M2 5.10.1
730	5.10 Reporting Results	5.10.1 General	Internal Customers	Exemption	V1M2 5.10.1
731	5.10 Reporting Results	5.10.1 General	Internal Customers	Requirement	V1M2 5.10.1
732	5.10 Reporting Results	5.10.1 General			V1M2 5.10.1 N1
733	5.10 Reporting Results	5.10.1 General			V1M2 5.10.1 N2
734	5.10 Reporting Results	5.10.2 Test Report			V1M2 5.10.2
735	5.10 Reporting Results	5.10.2 Test Report	Contents	Requirement	V1M2 5.10.2
736	5.10 Reporting Results	5.10.2 Test Report	Contents	Requirement	V1M2 5.10.2.a
737	5.10 Reporting Results	5.10.2 Test Report	Contents	Requirement	V1M2 5.10.2.b
738	5.10 Reporting Results	5.10.2 Test Report	Contents	Requirement	V1M2 5.10.2.c
739	5.10 Reporting Results	5.10.2 Test Report	Contents	Requirement	V1M2 5.10.2.d
740	5.10 Reporting Results	5.10.2 Test Report	Contents	Requirement	V1M2 5.10.2.e
741	5.10 Reporting Results	5.10.2 Test Report	Contents	Requirement	V1M2 5.10.2.f
742	5.10 Reporting Results	5.10.2 Test Report	Contents	Requirement	V1M2 5.10.2.g
743	5.10 Reporting Results	5.10.2 Test Report	Contents	Requirement	V1M2 5.10.2.h
744	5.10 Reporting Results	5.10.2 Test Report	Contents	Requirement	V1M2 5.10.2.i

745	5.10 Reporting Results	5.10.2 Test Report	Contents	Requirement	V1M2 5.10.2.j
746	5.10 Reporting Results	5.10.2 Test Report	Contents	Requirement	V1M2 5.10.2.k
747	5.10 Reporting Results	5.10.2 Test Report	Contents	Requirement	V1M2 5.10.2 N1
748	5.10 Reporting Results	5.10.2 Test Report	Contents	Requirement	V1M2 5.10.2 N2
749	5.10 Reporting Results	5.10.3 Test Report			V1M2 5.10.3
750	5.10 Reporting Results	5.10.3 Test Report	Additional Items	Requirement	V1M2 5.10.3.1
751	5.10 Reporting Results	5.10.3 Test Report	Additional Items	Requirement	V1M2 5.10.3.1.a
752	5.10 Reporting Results	5.10.3 Test Report	Additional Items	Requirement	V1M2 5.10.3.1.b
753	5.10 Reporting Results	5.10.3 Test Report	Additional Items	Requirement	V1M2 5.10.3.1.c
754	5.10 Reporting Results	5.10.3 Test Report	Additional Items	Requirement	V1M2 5.10.3.1.d
755	5.10 Reporting Results	5.10.3 Test Report	Additional Items	Requirement	V1M2 5.10.3.1.e
756	5.10 Reporting Results	5.10.3 Test Report	Additional Items	Requirement	V1M2 5.10.3.2
757	5.10 Reporting Results	5.10.3 Test Report	Additional Items	Requirement	V1M2 5.10.3.2.a
758	5.10 Reporting Results	5.10.3 Test Report	Additional Items	Requirement	V1M2 5.10.3.2.b
759	5.10 Reporting Results	5.10.3 Test Report	Additional Items	Requirement	V1M2 5.10.3.2.c
760	5.10 Reporting Results	5.10.3 Test Report	Additional Items	Requirement	V1M2 5.10.3.2.d
761	5.10 Reporting Results	5.10.3 Test Report	Additional Items	Requirement	V1M2 5.10.3.2.e
762	5.10 Reporting Results	5.10.3 Test Report	Additional Items	Requirement	V1M2 5.10.3.2.f
763	5.10 Reporting Results				V1M2 5.10.4
764	5.10 Reporting Results	5.10.4 Opinions and Interpretations			V1M2 5.10.5
765	5.10 Reporting Results	5.10.4 Opinions and Interpretations	Basis of Interpretations	Requirement	V1M2 5.10.5
766	5.10 Reporting Results	5.10.4 Opinions and Interpretations			V1M2 5.10.5 N1

767	5.10 Reporting Results	5.10.4 Opinions and Interpretations			V1M2 5.10.5 N2
768	5.10 Reporting Results	5.10.4 Opinions and Interpretations			V1M2 5.10.5
769	5.10 Reporting Results	5.10.4 Opinions and Interpretations			V1M2 5.10.5
770	5.10 Reporting Results	5.10.4 Opinions and Interpretations			V1M2 5.10.5
771	5.10 Reporting Results	5.10.4 Opinions and Interpretations			V1M2 5.10.5
772	5.10 Reporting Results	5.10.4 Opinions and Interpretations			V1M2 5.10.5 N3
773	5.10 Reporting Results	5.10.6 Subcontractor Results			V1M2 5.10.6
774	5.10 Reporting Results	5.10.6 Subcontractor Results	Identification	Requirement	V1M2 5.10.6
775	5.10 Reporting Results	5.10.6 Subcontractor Results	Result Submission	Requirement	V1M2 5.10.6
776	5.10 Reporting Results	5.10.7 Electronic Submission			V1M2 5.10.7
777	5.10 Reporting Results	5.10.7 Electronic Submission	Meeting Same Standard	Requirement	V1M2 5.10.7
778	5.10 Reporting Results	5.10.8 Report Format			V1M2 5.10.8
779	5.10 Reporting Results	5.10.8 Report Format	Performance Measures	Requirement	V1M2 5.10.8
780	5.10 Reporting Results	5.10.8 Report Format			V1M2 5.10.8 N1
781	5.10 Reporting Results	5.10.8 Report Format			V1M2 5.10.8 N2
782	5.10 Reporting Results	5.10.9 Amendments			V1M2 5.10.9
783	5.10 Reporting Results	5.10.9 Amendments	Supplemental Reports	Requirement	V1M2 5.10.9
784	5.10 Reporting Results	5.10.9 Amendments	Performance Measures	Requirement	V1M2 5.10.9
785	5.10 Reporting Results	5.10.9 Amendments	Unique Identifiers	Requirement	V1M2 5.10.9
786	5.10 Reporting Results	5.10.10 Exceptions			V1M2 5.10.10
787	5.10 Reporting Results	5.10.10 Exceptions	Regulatory Reports	Requirement	V1M2 5.10.10

788	5.10 Reporting Results	5.10.10 Exceptions	In-house Labs	Requirement	V1M2 5.10.10
789	5.10 Reporting Results	5.10.10 Exceptions	In-house Labs	Requirement	V1M2 5.10.10
790	5.10 Reporting Results	5.10.10 Exceptions	In-house Labs	Requirement	V1M2 5.10.10.a
791	5.10 Reporting Results	5.10.10 Exceptions	In-house Labs	Requirement	5.10.10.b
792	5.10 Reporting Results	5.10.10 Exceptions			5.10.10.c
793	5.10 Reporting Results	5.10.11 Additional Requirements			5.10.11
794	5.10 Reporting Results	5.10.11 Additional Requirements	Time	Requirement	5.10.11.a
795	5.10 Reporting Results	5.10.11 Additional Requirements	Reporting Units	Requirement	5.10.11.b
796	5.10 Reporting Results	5.10.11 Additional Requirements	Non-accredited Work	Requirement	5.10.11.c
797	5.10 Reporting Results	5.10.11 Additional Requirements	Results outside calibration range	Requirement	5.10.11.d

Does the laboratory comply with this section?	Yes	No	N/A
TECHNICAL REQUIREMENTS			
General (ISO/IEC 17025:2005(E), Clause 5.1)			
Many factors determine the correctness and reliability of the tests and/or calibrations performed by a laboratory. These factors include contributions from:			
- human factors (5.2);			
- accommodation and environmental conditions (5.3);			
- test and calibration methods and method validation (5.4);			
- equipment (5.5);			
- measurement traceability (5.6);			
- sampling (5.7);			
- the handling of test and calibration items (5.8).			
The extent to which the factors contribute to the total uncertainty of measurement differs considerably between (types of) tests and between (types of) calibrations.			
The laboratory shall take account of these factors (V1M2 5.1.1) in developing test and calibration methods and procedures, in the training and qualification of personnel, and in the selection and calibration of the equipment it uses.			
Personnel (ISO/IEC 17025:2005(E), Clause 5.2)			
The laboratory management shall ensure the competence of all who operate specific equipment, perform tests and/or calibrations, evaluate results, and sign test reports and calibration certificates. ***(See Section 1.6 of the technical modules)***			
When using staff who are undergoing training, appropriate supervision shall be provided.			
Personnel performing specific tasks shall be qualified on the basis of appropriate education, training, experience and/or demonstrated skills, as required.			
NOTE 1: In some technical areas (e.g. non-destructive testing) it may be required that the personnel performing certain tasks hold personnel certification. The laboratory is responsible for fulfilling specified personnel certification requirements. The requirements for personnel certification might be regulatory, included in the standards for the specific technical field, or required by the customer.			
NOTE 2: The personnel responsible for the opinions and interpretation included in test reports should, in addition to the appropriate qualifications, training, experience and satisfactory knowledge of the testing carried out, also have:			
— relevant knowledge of the technology used for the manufacturing of the items, materials, products, etc. tested, or the way they are used or intended to be used, and of the defects or degradations which may occur during or in service;			
— knowledge of the general requirements expressed in the legislation and standards; and			
— an understanding of the significance of deviations found with regard to the normal use of the items, materials, products, etc. concerned.			
The management of the laboratory shall formulate the goals with respect to the education, training and skills of the laboratory personnel.			
The laboratory shall have a policy and procedures for identifying training needs and providing training of personnel.			
The training programme shall be relevant to the present and anticipated tasks of the laboratory.			
The effectiveness of the training actions taken shall be evaluated.			

The laboratory shall use personnel who are employed by, or under contract to, the laboratory.			
Where contracted and additional technical and key support personnel are used, the laboratory shall ensure that such personnel are supervised and competent and that they work in accordance with the laboratory's management system.			
The laboratory shall maintain current job descriptions for managerial, technical and key support personnel involved in tests and/or calibrations.			
NOTE: Job descriptions can be defined in many ways. As a minimum, the following should be defined:			
— the responsibilities with respect to performing tests and/or calibrations;			
— the responsibilities with respect to the planning of tests and/or calibrations and evaluation of results;			
— the responsibilities for reporting opinions and interpretations;			
— the responsibilities with respect to method modification and development and validation of new methods;			
— expertise and experience required;			
— qualifications and training programmes;			
— managerial duties.			
The management shall authorize specific personnel to perform particular types of sampling, test and/or calibration, to issue test reports and calibration certificates, to give opinions and interpretations and to operate particular types of equipment.			
The laboratory shall maintain records of the relevant authorization(s), competence, educational and professional qualifications, training, skills and experience of all technical personnel, including contracted personnel.			
This information shall be readily available and shall include the date on which authorization and/or competence is confirmed.			
NOTE: All references to Calibration Certificates in ISO/IEC 17025:2005(E) are not applicable to environmental testing.			
Additional Personnel Requirements			
Technical Manager Qualifications			
The applicable requirements for technical managers are given below.			
Any technical manager of an accredited environmental laboratory engaged in chemical analysis shall be a person with a bachelor’s degree in the chemical, environmental, biological sciences, physical sciences or engineering,			
Any technical manager of an accredited environmental laboratory engaged in chemical analysis shall have at least twenty-four college (24) semester credit hours in chemistry			

Any technical manager of an accredited environmental laboratory engaged in chemical analysis shall have at least two (2) years of experience in the environmental analysis of representative inorganic and organic analytes for which the laboratory seeks or maintains accreditation. A master's or doctoral degree in one of the above disciplines may be substituted for one year of experience.			
Any technical manager of an accredited environmental laboratory limited to inorganic chemical analysis, other than metals analysis, shall be a person with at least an earned associate's degree in the chemical, physical or environmental sciences, or two (2) years of equivalent and successful college education,			
Any technical manager of an accredited environmental laboratory limited to inorganic chemical analysis, other than metals analysis, shall have a minimum of sixteen (16) college semester credit hours in chemistry.			
Any technical manager of an accredited environmental laboratory limited to inorganic chemical analysis, other than metals analysis, shall have at least two (2) years of experience performing such analysis.			
Any technical manager of an accredited environmental laboratory engaged in microbiological or biological analysis shall be a person with a bachelor's degree in microbiology, biology, chemistry, environmental sciences, physical sciences or engineering			
Any technical manager of an accredited environmental laboratory engaged in microbiological or biological analysis shall have a minimum of sixteen college semester credit hours in general microbiology and biology			
Any technical manager of an accredited environmental laboratory engaged in microbiological or biological analysis shall have at least two (2) years of experience in the environmental analysis of representative analytes for which the laboratory seeks or maintains accreditation. A master's or doctoral degree in one of the above disciplines may be substituted for one (1) year of experience.			
A person with an associate's degree in an appropriate field of the sciences or applied sciences, with a minimum of four (4) college semester credit hours in general microbiology may be the technical manager(s) of a laboratory engaged in microbiological analysis limited to fecal coliform, total coliform, E. coli, and standard plate count. Two (2) years of equivalent and successful college education, including the microbiology requirement, may be substituted for the associate's degree.			
the technical manager(s) of a laboratory engaged in microbiological analysis limited to fecal coliform, total coliform, E. coli, and standard plate count shall have one (1) year of experience in microbiological analyses.			
Any technical manager of an accredited environmental laboratory engaged in radiological analysis shall be a person with a bachelor's degree in chemistry, environmental, biological sciences, physical sciences or engineering			
Any technical manager of an accredited environmental laboratory engaged in radiological analysis shall have twenty-four (24) college semester credit hours of chemistry			

Any technical manager of an accredited environmental laboratory engaged in radiological analysis shall have two (2) or more years of experience in the radiological analysis of environmental samples. A master’s or doctoral degree in one of the above disciplines may be substituted for one (1) year experience.			
The technical manager(s) of an accredited environmental laboratory engaged in microscopic examination of asbestos and/or airborne fibers shall meet the following requirements:			
The technical manager(s) of an accredited environmental laboratory engaged in microscopic examination of asbestos and/or airborne fibers requiring the use of a transmission electron microscope shall have a bachelor's degree			
The technical manager(s) of an accredited environmental laboratory engaged in microscopic examination of asbestos and/or airborne fibers requiring the use of a transmission electron microscope shall have successfully completed of courses in the use of the instrument			
The technical manager(s) of an accredited environmental laboratory engaged in microscopic examination of asbestos and/or airborne fibers requiring the use of a transmission electron microscope shall have one (1) year of experience, under supervision, in the use of the instrument. Such experience shall include the identification of minerals.			
The technical manager(s) of an accredited environmental laboratory engaged in microscopic examination of asbestos and/or airborne fibers requiring the use of a polarized light microscope, shall have an associate's degree or two (2) years of college study			
The technical manager(s) of an accredited environmental laboratory engaged in microscopic examination of asbestos and/or airborne fibers requiring the use of a polarized light microscope, shall have successfully completed formal coursework in polarized light microscopy			
The technical manager(s) of an accredited environmental laboratory engaged in microscopic examination of asbestos and/or airborne fibers requiring the use of a polarized light microscope, shall have one year of experience, under supervision, in the use of the instrument. Such experience shall include the identification of minerals.			
The technical manager(s) of an accredited environmental laboratory engaged in microscopic examination of asbestos and/or airborne fibers requiring the use of a phase contrast microscope, as in the determination of airborne fibers, shall have an associate's degree or two (2) years of college study			
The technical manager(s) of an accredited environmental laboratory engaged in microscopic examination of asbestos and/or airborne fibers requiring the use of a phase contrast microscope, as in the determination of airborne fibers, shall have documentation of successful completion of formal coursework in phase contrast microscopy			
The technical manager(s) of an accredited environmental laboratory engaged in microscopic examination of asbestos and/or airborne fibers requiring the use of a phase contrast microscope, as in the determination of airborne fibers, shall have one (1) year of experience, under supervision, in the use of the instrument.			
Any technical manager of an accredited environmental laboratory engaged in the examination of radon in air shall have at least an associate’s degree or two (2) years of college			

Any technical manager of an accredited environmental laboratory engaged in the examination of radon in air shall have at least one (1) year of experience in radiation measurements			
Any technical manager of an accredited environmental laboratory engaged in the examination of radon in air shall have at least one (1) year of experience in the measurement of radon and/or radon progeny.			
Technical Manager Qualification Exceptions			
Notwithstanding any other provision of this Section, a full-time employee of a drinking water or sewage treatment facility who holds a valid treatment plant operator's certificate appropriate to the nature and size of such facility shall be deemed to meet the educational requirements as the technical manager.			
A technical manager shall have two (2) year testing experience devoted exclusively to the testing of environmental samples specified in the scope of the facility's regulatory permit.			
Such accreditation for a water treatment facility and/or a sewage treatment facility shall be limited to the scope of that facility's regulatory permit.			
A full-time employee of an industrial waste treatment facility with a minimum of two (2) years of experience under supervision in testing of environmental samples taken within such facility for the scope of that facility's regulatory permit shall be deemed to meet the requirements for serving as the technical manager of an accredited laboratory.			
Such accreditation for an industrial waste treatment facility shall be limited to the scope of that facility's regulatory permit.			
Persons who do not meet the education credential requirements but possess the requisite experience of 5.2.6.1 shall qualify as technical manager(s) subject to the following conditions.			
Persons who do not meet the education credential requirements but possess the requisite experience of 5.2.6.1 shall qualify as technical manager(s) if the person shall be a technical manager of the laboratory on the date the laboratory applies for accreditation and/or becomes subject to accreditation under this Standard			
Persons who do not meet the education credential requirements but possess the requisite experience of 5.2.6.1 shall qualify as technical manager(s) if the person shall have been a technical manager in that laboratory continuously for the previous twelve (12) months or more.			
Persons who do not meet the education credential requirements but possess the requisite experience of 5.2.6.1 shall be approved as a technical manager for only those fields of accreditation for which he/she has been technical manager in that laboratory for the previous twelve (12) months or more.			
A person who is admitted as a technical manager under these conditions, and leaves the laboratory, will be eligible for hire as a technical manager for the same fields of accreditation in another accredited laboratory.			
Data Integrity Training			
Data integrity training shall be provided as a formal part of new employee orientation and shall also be provided on an annual basis for all current employees.			

Employees are required to understand that any infractions of the laboratory data integrity procedures shall result in a detailed investigation that could lead to very serious consequences including immediate termination, debarment or civil/criminal prosecution.			
The initial data integrity training and the annual refresher training shall have a signature attendance sheet or other form of documentation that demonstrates all staff have participated and understand their obligations related to data integrity.			
Data integrity training requires emphasis on the importance of proper written narration on the part of the analyst with respect to those cases where analytical data may be useful, but are in one sense or another partially deficient			
The topics covered in such training shall be documented in writing (such as an agenda) and provided to all trainees.			
At a minimum, the following topics and activities shall be included:			
organizational mission and its relationship to the critical need for honesty and full disclosure in all analytical reporting, how and when to report data integrity issues, and record keeping;			
training, including discussion regarding all data integrity procedures;			
data integrity training documentation;			
in-depth data monitoring and data integrity procedure documentation; and			
specific examples of breaches of ethical behavior such as improper data manipulations, adjustments of instrument time clocks, and inappropriate changes in concentrations of standards.			
The data integrity procedures may also include written ethics agreements, examples of improper practices, examples of improper chromatographic manipulations, requirements for external ethics program training, and any external resources available to employees.			
Accommodation and Environmental Conditions (ISO/IEC 17025:2005(E), Clause 5.3)			
Laboratory facilities for testing and/or calibration, including but not limited to energy sources, lighting and environmental conditions, shall be such as to facilitate correct performance of the tests and/or calibrations.			
The laboratory shall ensure that the environmental conditions do not invalidate the results or adversely affect the required quality of any measurement.			
Particular care shall be taken when sampling and tests and/or calibrations are undertaken at sites other than a permanent laboratory facility.			
The technical requirements for accommodation and environmental conditions that can affect the results of tests and calibrations shall be documented.			

The laboratory shall monitor, control and record environmental conditions as required by the relevant specifications, methods and procedures or where they influence the quality of the results.			
Due attention shall be paid, for example, to biological sterility, dust, electromagnetic disturbances, radiation, humidity, electrical supply, temperature, and sound and vibration levels, as appropriate to the technical activities concerned.			
Tests and calibrations shall be stopped when the environmental conditions jeopardize the results of the tests and/or calibrations.			
There shall be effective separation between neighbouring areas in which there are incompatible activities.			
Measures shall be taken to prevent cross-contamination.			
Access to and use of areas affecting the quality of the tests and/or calibrations shall be controlled.			
The laboratory shall determine the extent of control based on its particular circumstances.			
Measures shall be taken to ensure good housekeeping in the laboratory.			
Special procedures shall be prepared where necessary.			
Environmental Test Methods and Method Validation			
NOTE: All references to Calibration Laboratories and Calibration Methods in ISO/IEC 17025:2005(E) in these Clauses are not applicable to environmental testing.			
General (ISO/IEC 17025:2005(E), Clause 5.4.1)			
The laboratory shall use appropriate methods and procedures for all tests and/or calibrations within its scope.			
These include sampling, handling, transport, storage and preparation of items to be tested and/or calibrated, and, where appropriate, an estimation of the measurement uncertainty as well as statistical techniques for analysis of test and/or calibration data.			

The laboratory shall have instructions on the use and operation of all relevant equipment, and on the handling and preparation of items for testing and/or calibration, or both, where the absence of such instructions could jeopardize the results of tests and/or calibrations.			
All instructions, standards, manuals and reference data relevant to the work of the laboratory shall be kept up to date and shall be made readily available to personnel (see 4.3).			
Deviation from test and calibration methods shall occur only if the deviation has been documented, technically justified, authorized, and accepted by the customer.			
NOTE: International, regional or national standards or other recognized specifications that contain sufficient and concise information on how to perform the tests and/or calibrations do not need to be supplemented or rewritten as internal procedures if these standards are written in a way that they can be used as published by the operating staff in a laboratory. It may be necessary to provide additional documentation for optional steps in the method or additional details.			
Selection of Methods (ISO/IEC 17025:2005(E), Clause 5.4.2)			
The laboratory shall use test and/or calibration methods, including methods for sampling, which meet the needs of the customer and which are appropriate for the tests and/or calibrations it undertakes.			
Methods published in international, regional or national standards shall preferably be used.			
The laboratory shall ensure that it uses the latest valid edition of a standard unless it is not appropriate or possible to do so.			
When necessary, the standard shall be supplemented with additional details to ensure consistent application.			
When the customer does not specify the method to be used, the laboratory shall select appropriate methods that have been published either in international, regional or national standards, or by reputable technical organizations, or in relevant scientific texts or journals, or as specified by the manufacturer of the equipment.			
Laboratory-developed methods or methods adopted by the laboratory may also be used if they are appropriate for the intended use and if they are validated.			
The customer shall be informed as to the method chosen.			
The laboratory shall confirm that it can properly operate standard methods before introducing the tests or calibrations.			
If the standard method changes, the confirmation shall be repeated.			
The laboratory shall inform the customer when the method proposed by the customer is considered to be inappropriate or out of date.			
Laboratory-Developed Methods (ISO/IEC 17025:2005(E), Clause 5.4.3)			

The introduction of test and calibration methods developed by the laboratory for its own use shall be a planned activity and shall be assigned to qualified personnel equipped with adequate resources.			
Plans shall be updated as development proceeds and effective communication amongst all personnel involved shall be ensured.			
Non-Standard Methods (ISO/IEC 17025:2005(E), Clause 5.4.4) is not applicable in this module and is addressed in specific technical modules based on technology.			
Validation of Methods (ISO/IEC 17025:2005(E), Clause 5.4.5) is not applicable in this module and is addressed in specific technical modules based on technology.			
Estimation of Analytical Uncertainty			
Clause 5.4.6 of the ISO/IEC/IEC 17025:2005(E) concerning calibration testing does not apply. The following requirement replaces the ISO/IEC Clause.			
Environmental testing laboratories shall have a procedure(s) for estimating analytical uncertainty.			
Quality control measurement data may be used to determine analytical uncertainty.			
Control of Data (ISO/IEC 17025:2005(E), Clause 5.4.7)			
Calculations and data transfers shall be subject to appropriate checks in a systematic manner.			
When computers or automated equipment are used for the acquisition, processing, recording, reporting, storage or retrieval of test or calibration data, the laboratory shall ensure that:			
computer software developed by the user is documented in sufficient detail			
computer software developed by the user is suitably validated as being adequate for use;			
procedures are established and implemented for protecting the data;			
such procedures shall include, but not be limited to, integrity and confidentiality of data entry or collection, data storage, data transmission and data processing;			
computers and automated equipment are maintained to ensure proper functioning			

computers and automated equipment are provided with the environmental and operating conditions necessary to maintain the integrity of test and calibration data.			
NOTE: Commercial off-the-shelf software (e.g. word processing, database and statistical programmes) in general use within their designed application range may be considered to be sufficiently validated. However, laboratory software configuration/modifications should be validated as in 5.4.7.2 a).			
Calibration Requirements (ISO/IEC 17025:2005(E), Clause 5.5)			
The laboratory shall be furnished with all items of sampling, measurement and test equipment required for the correct performance of the tests and/or calibrations (including sampling, preparation of test and/or calibration items, processing and analysis of test and/or calibration data).			
In those cases where the laboratory needs to use equipment outside its permanent control, it shall ensure that the requirements of this International Standard are met.			
Equipment and its software used for testing, calibration and sampling shall be capable of achieving the accuracy required and shall comply with specifications relevant to the tests and/or calibrations concerned.			
Calibration programmes shall be established for key quantities or values of the instruments where these properties have a significant effect on the results.			
Before being placed into service, equipment (including that used for sampling) shall be calibrated or checked to establish that it meets the laboratory's specification requirements and complies with the relevant standard specifications.			
It (equipment) shall be checked and/or calibrated before use (see 5.6).			
Equipment shall be operated by authorized personnel.			
Up-to-date instructions on the use and maintenance of equipment (including any relevant manuals provided by the manufacturer of the equipment) shall be readily available for use by the appropriate laboratory personnel.			
Each item of equipment and its software used for testing and calibration and significant to the result shall, when practicable, be uniquely identified.			
Records shall be maintained of each item of equipment and its software significant to the tests and/or calibrations performed.			
The records shall include at least the following:			
the identity of the item of equipment			
the identity of the software;			
the manufacturer's name			
type identification			
and serial number or other unique identification;			

checks that equipment complies with the specification (see 5.5.2);			
the current location, where appropriate;			
the manufacturer's instructions, if available, or reference to their location;			
dates, results and copies of reports and certificates of all calibrations			
dates, results and copies of reports and certificates of all adjustments			
dates, results and copies of reports and certificates of all acceptance criteria			
the due date of next calibration;			
the maintenance plan, where appropriate			
and maintenance carried out to date;			
any damage, malfunction, modification or repair to the equipment.			
The laboratory shall have procedures for safe handling, transport, storage, use and planned maintenance of measuring equipment to ensure proper functioning and in order to prevent contamination or deterioration.			
NOTE: Additional procedures may be necessary when measuring equipment is used outside the permanent laboratory for tests, calibrations or sampling.			
Equipment that has been subjected to overloading or mishandling, gives suspect results, or has been shown to be defective or outside specified limits, shall be taken out of service			
It (equipment) shall be isolated to prevent its use or clearly labelled or marked as being out of service until it has been repaired and shown by calibration or test to perform correctly.			
The laboratory shall examine the effect of the defect or departure from specified limits on previous tests and/or calibrations and shall institute the "Control of nonconforming work" procedure (see 4.9).			
Whenever practicable, all equipment under the control of the laboratory and requiring calibration shall be labelled, coded or otherwise identified to indicate the status of calibration			
Whenever practicable, all equipment under the control of the laboratory and requiring calibration shall be labelled, coded or otherwise identified to indicate the date when last calibrated			
Whenever practicable, all equipment under the control of the laboratory and requiring calibration shall be labelled, coded or otherwise identified to indicate the date or expiration criteria when recalibration is due.			
When, for whatever reason, equipment goes outside the direct control of the laboratory, the laboratory shall ensure that the function and calibration status of the equipment are checked and shown to be satisfactory before the equipment is returned to service.			
When intermediate checks are needed to maintain confidence in the calibration status of the equipment, these checks shall be carried out according to a defined procedure.			
Where calibrations give rise to a set of correction factors, the laboratory shall have procedures to ensure that copies (e.g. in computer software) are correctly updated.			

Test and calibration equipment, including both hardware and software, shall be safeguarded from adjustments which would invalidate the test and/or calibration results.			
NOTE: ISO/IEC Clauses 5.5.1 to 5.5.12 apply with respect to equipment in environmental testing laboratories.			
Additional Requirements and Clarifications			
Calibration requirements for analytical support equipment are included in this Section while requirements for instrument (testing) calibration are included in technical modules (i.e., Asbestos, Chemistry, Microbiology, Radiochemistry and Toxicology).			
Support Equipment			
This Standard applies to all devices that may not be the actual test instrument, but are necessary to support laboratory operations. These include, but are not limited to: balances, ovens, refrigerators, freezers, incubators, water baths, temperature measuring devices (including thermometers and thermistors), thermal/pressure sample preparation devices and volumetric dispensing devices (such as Eppendorf® or automatic dilutor/dispensing devices), if quantitative results are dependent on their accuracy, as in standard preparation and dispensing or dilution into a specified volume.			
All support equipment shall be maintained in proper working order.			
The records of all repair and maintenance activities, including service calls, shall be kept.			
All support equipment shall be calibrated or verified at least annually, using a recognized National Metrology Institute, such as NIST, traceable references when available, bracketing the range of use.			
The results of such calibration or verification shall be within the specifications required of the application for which this equipment is used or:			
i. the equipment shall be removed from service until repaired; or			
ii. the laboratory shall maintain records of established correction factors to correct all measurements.			
Raw data records shall be retained to document equipment performance.			
On each day the equipment is used, balances, ovens, refrigerators, freezers and water baths shall be checked and documented.			
The acceptability for use or continued use shall be according to the needs of the analysis or application for which the equipment is being used.			
Volumetric dispensing devices (except Class A glassware and Glass microliter syringes) shall be checked for accuracy on a quarterly basis.			
Measurement Traceability			

General (ISO/IEC 17025:2005(E), Clause 5.6.1) is not applicable to environmental testing.			
Specific Requirements (ISO/IEC 17025:2005(E), Clause 5.6.2) is not applicable to environmental testing.			
Reference Standards and Reference Materials (ISO/IEC 17025:2005(E), Clause 5.6.3)			
Reference Standards			
The laboratory shall have a programme and procedure for the calibration of its reference standards.			
Reference standards shall be calibrated by a body that can provide traceability as described in 5.6.2.1.			
Such reference standards of measurement held by the laboratory shall be used for calibration only and for no other purpose, unless it can be shown that their performance as reference standards would not be invalidated.			
Reference standards shall be calibrated before and after any adjustment.			
Reference Materials			
Reference materials shall, where possible, be traceable to SI units of measurement, or to certified reference materials			
Internal reference materials shall be checked as far as is technically and economically practicable.			
Intermediate Checks			
Checks needed to maintain confidence in the calibration status of reference, primary, transfer or working standards and reference materials shall be carried out according to defined procedures and schedules.			
Transport and Storage			
The laboratory shall have procedures for safe handling, transport, storage and use of reference standards and reference materials in order to prevent contamination or deterioration and in order to protect their integrity.			
NOTE: Additional procedures may be necessary when reference standards and reference materials are used outside the permanent laboratory for tests, calibrations or sampling.			
Additional Requirements and Clarifications			
Reference Standards and Reference Materials			
The laboratory shall provide satisfactory evidence of correlation of results, for example, by participation in a suitable program of inter-laboratory comparisons, proficiency testing, or independent analysis.			
Reference Standards			
Where commercially available, this traceability shall be to a national standard of measurement.			

Reference Materials			
Where possible, traceability shall be to national or international standards of measurement or to national or international standard reference materials.			
Internal reference materials shall be checked as far as is technically and economically practicable.			
Documentation and Labeling of Standards, Reagents, and Reference Materials			
Documented procedures shall exist for the purchase, receipt and storage of consumable materials used for the technical operations of the laboratory.			
The laboratory shall retain records for all standards, reagents, reference materials, and media, including the manufacturer/vendor			
The laboratory shall retain records for all standards, reagents, reference materials, and media, including the manufacturer's Certificate of Analysis or purity (if available)			
The laboratory shall retain records for all standards, reagents, reference materials, and media, including the date of receipt			
The laboratory shall retain records for all standards, reagents, reference materials, and media, including recommended storage conditions.			
For original containers, if an expiration date is provided by the manufacturer or vendor it shall be recorded on the container. If an expiration date is not provided by the manufacturer or vendor it is not required.			
Records shall be maintained on standard, reference material, and reagent preparation. These records shall indicate traceability to purchased stocks or neat compounds, reference to the method of preparation, date of preparation, expiration date and preparer's initials			
All containers of prepared standards, reference materials, and reagents shall bear a unique identifier			
All containers of prepared standards, reference materials, and reagents shall bear an expiration date.			
Procedures shall be in place to ensure prepared reagents meet the requirements of the method.			
Standards, reference materials, and reagents shall not be used after their expiration dates unless their reliability is verified by the laboratory.			
Collection of Samples (ISO/IEC 17025:2005(E), Clause 5.7)			
The laboratory shall have a sampling plan and procedures for sampling when it carries out sampling of substances, materials or products for subsequent testing or calibration.			
The sampling plan as well as the sampling procedure shall be available at the location where sampling is undertaken.			
Sampling plans shall, whenever reasonable, be based on appropriate statistical methods.			
The sampling process shall address the factors to be controlled to ensure the validity of the test and calibration results.			

NOTE 1: Sampling is a defined procedure whereby a part of a substance, material or product is taken to provide for testing or calibration of a representative sample of the whole. Sampling may also be required by the appropriate specification for which the substance, material or product is to be tested or calibrated. In certain cases (e.g. forensic analysis), the sample may not be representative but is determined by availability.			
NOTE 2: Sampling procedures should describe the selection, sampling plan, withdrawal and preparation of a sample or samples from a substance, material or product to yield the required information.			
Where the customer requires deviations, additions or exclusions from the documented sampling procedure, these shall be recorded in detail with the appropriate sampling data			
Where the customer requires deviations, additions or exclusions from the documented sampling procedure, these shall be included in all documents containing test and/or calibration results			
Where the customer requires deviations, additions or exclusions from the documented sampling procedure, these shall be communicated to the appropriate personnel.			
The laboratory shall have procedures for recording relevant data and operations relating to sampling that forms part of the testing or calibration that is undertaken.			
These records shall include the sampling procedure used, the identification of the sampler, environmental conditions (if relevant) and diagrams or other equivalent means to identify the sampling location as necessary and, if appropriate, the statistics the sampling procedures are based upon.			
Additional Requirements			
Documentation shall include the date of sampling.			
Documentation shall include the time of sampling.			
Any deviations from sampling procedures shall be documented.			
Handling Samples and Test Items (ISO/IEC 17025:2005(E), Clause 5.8)			
The laboratory shall have procedures for the transportation, receipt, handling, protection, storage, retention and/or disposal of test and/or calibration items, including all provisions necessary to protect the integrity of the test or calibration item, and to protect the interests of the laboratory and the customer.			
The laboratory shall have a system for identifying test and/or calibration items.			
The identification shall be retained throughout the life of the item in the laboratory.			
The system shall be designed and operated so as to ensure that items cannot be confused physically or when referred to in records or other documents.			
The system shall, if appropriate, accommodate a sub-division of groups of items and the transfer of items within and from the laboratory.			

Upon receipt of the test or calibration item, abnormalities or departures from normal or specified conditions, as described in the test or calibration method, shall be recorded			
When there is doubt as to the suitability of an item for test or calibration, or when an item does not conform to the description provided, or the test or calibration required is not specified in sufficient detail, the laboratory shall consult the customer for further instructions before proceeding and shall record the discussion.			
The laboratory shall have procedures and appropriate facilities for avoiding deterioration, loss or damage to the test or calibration item during storage, handling and preparation.			
Handling instructions provided with the item shall be followed.			
When items have to be stored or conditioned under specified environmental conditions, these conditions shall be maintained, monitored and recorded.			
Where a test or calibration item or a portion of an item is to be held secure, the laboratory shall have arrangements for storage and security that protect the condition and integrity of the secured items or portions concerned.			
NOTE 1: Where test items are to be returned into service after testing, special care is required to ensure that they are not damaged or injured during the handling, testing or storing/waiting processes.			
NOTE 2: A sampling procedure and information on storage and transport of samples, including information on sampling factors influencing the test or calibration result, should be provided to those responsible for taking and transporting the samples.			
NOTE 3: Reasons for keeping a test or calibration item secure can be for reasons of record, safety or value, or to enable complementary tests and/or calibrations to be performed later.			
Additional Requirements - Documentation			
The following are essential to ensure the validity of the laboratory's data.			
The laboratory shall have a documented system for uniquely identifying the samples to be tested, to ensure that there can be no confusion regarding the identity of such samples at any time.			
This system shall include identification for all samples, sub-samples, preservations, sample containers, tests, and subsequent extracts and/or digestates.			
This laboratory code shall maintain an unequivocal link with the unique field ID code assigned to each sample.			
The laboratory ID code shall be placed as a durable mark on the sample container.			
The laboratory ID code shall be entered into the laboratory records			
The laboratory ID code shall be the link that associates the sample with related laboratory activities such as sample preparation.			

In cases where the sample collector and analyst are the same individual, or the laboratory pre-assigns numbers to sample containers, the laboratory ID code may be the same as the field ID code.			
Additional Requirements - Sample Acceptance Policy			
The laboratory shall have a written sample acceptance policy that includes the following:			
proper, full, and complete documentation, which shall include sample identification			
proper, full, and complete documentation, which shall include the location of collection			
proper, full, and complete documentation, which shall include the date of collection			
proper, full, and complete documentation, which shall include the time of collection			
proper, full, and complete documentation, which shall include collector's name			
proper, full, and complete documentation, which shall include preservation type			
proper, full, and complete documentation, which shall include sample type			
proper, full, and complete documentation, which shall include any special remarks concerning the sample;			
proper sample labeling to include unique identification			
proper sample labeling to include a labeling system for the samples with requirements concerning the durability of the labels (water resistant) and the use of indelible ink;			
use of appropriate sample containers;			

adherence to specified holding times;			
sufficient sample volume to perform the necessary tests;			
procedures to be used when samples show signs of damage, contamination or inadequate preservation; and			
qualification of any data that do not meet the above requirements.			
Additional Requirements - Sample Receipt Protocols			
The laboratory shall implement procedures for verifying and documenting preservation.			
If the sample does not meet the sample receipt acceptance criteria listed in this Standard, the laboratory shall either:			
retain correspondence and/or records of conversations concerning the final disposition of rejected samples; or			
fully document any decision to proceed with the analysis of samples not meeting acceptance criteria.			
The condition of these samples shall be noted on the chain of custody or transmittal form and laboratory receipt documents.			
The analysis data shall be appropriately qualified on the final report.			
The laboratory shall utilize a permanent chronological record such as a logbook or electronic database to document receipt of all sample containers.			
This sample receipt log shall record the following:			

client/project name,			
date and time of laboratory receipt,			
unique laboratory ID code, and			
signature or initials of the person making the entries.			
During the login process, the following information shall be unequivocally linked to the log record or included as a part of the log.			
If such information is recorded/documented elsewhere, the records shall be part of the laboratory's permanent records, easily retrievable upon request and readily available to individuals who will process the sample.			
NOTE: The placement of the laboratory ID number on the sample container is not considered a permanent record.			
The field ID code, which identifies each sample, shall be linked to the laboratory ID code in the sample receipt log.			
The date and time of sample collection shall be linked to the sample and to the date and time of receipt in the laboratory.			
The requested analyses (including applicable approved method numbers) shall be linked to the laboratory ID code.			
Any comments resulting from inspection for sample rejection shall be linked to the laboratory ID code.			
All documentation, such as memos, chain of custody, or transmittal forms that are transmitted to the laboratory by the sample transmitter, shall be retained.			
A complete chain of custody record form, if utilized, shall be maintained.			
Additional Requirements - Legal Chain of Custody Protocols			

Legal chain of custody procedures are used for evidentiary or legal purposes.			
If a client specifies that a sample is to be used for evidentiary purposes, then a laboratory shall have a written SOP for how that laboratory will carry out legal chain of custody.			
Additional Requirements - Sample Storage and Disposal			
Samples shall be stored according to the conditions specified by preservation protocols.			
Samples that require thermal preservation shall be stored under refrigeration that is +/-2°C of the specified preservation temperature unless regulatory or method specific criteria exist.			
For samples with a specified storage temperature of 4°C, storage at a temperature above the freezing point of water to 6°C shall be acceptable.			
Samples shall be stored away from all standards, reagents, and food. Samples shall be stored in such a manner to prevent cross contamination.			
Sample fractions, extracts, leachates and other sample preparation products shall be stored according to Section 5.8.9 a) above or according to specifications in the method.			
The laboratory shall have SOPs for the disposal of samples, digestates, leachates and extracts or other sample preparation products.			
Quality Assurance for Environmental Testing (ISO/IEC 17025:2005(E), Clause 5.9)			
The laboratory shall have quality control procedures for monitoring the validity of tests and calibrations undertaken.			
The resulting data shall be recorded in such a way that trends are detectable and, where practicable, statistical techniques shall be applied to the reviewing of the results.			
This monitoring shall be planned and reviewed and may include, but not be limited to, the following:			
regular use of certified reference materials and/or internal quality control using secondary reference materials;			
participation in interlaboratory comparison or proficiency-testing programmes;			
replicate tests or calibrations using the same or different methods;			

retesting or recalibration of retained items;			
correlation of results for different characteristics of an item.			
NOTE: The selected methods should be appropriate for the type and volume of the work undertaken.			
Quality control data shall be analysed and, where they are found to be outside pre-defined criteria, planned action shall be taken to correct the problem and to prevent incorrect results from being reported.			
Essential Quality Control Procedures			
These general quality control principles shall apply, where applicable, to all testing laboratories. The manner in which they are implemented is dependent on the types of tests performed by the laboratory (i.e., asbestos, chemical, microbiological, radiological, toxicity) and are further described in Technical Modules. The standards for any given test type shall assure that the applicable principles are addressed:			
All laboratories shall have detailed written protocols in place to monitor the following quality controls:			
i. through viii are specified for the technologies identified in the technical modules. These should be used if the laboratory is using a technology other than those specified in Modules 3 through 7			
positive and negative controls (see technical modules), chemical or microbiological as applicable to the test type, to monitor tests such as blanks, matrix spikes, reference toxicants;			
tests to define the variability and/or repeatability of the laboratory results such as replicates;			
measures to assure the accuracy of the method including calibration and/or continuing calibrations, use of certified reference materials, proficiency test samples, or other measures;			
measures to evaluate method capability, such as limit of detection and limit of quantitation or range of applicability such as linearity;			
selection of appropriate formulae to reduce raw data to final results such as regression analysis, comparison to internal/external standard calculations, and statistical analyses;			
selection and use of reagents and standards of appropriate quality;			
measures to assure the selectivity of the test for its intended purpose; and			
measures to assure constant and consistent test conditions (both instrumental and environmental) where required by the method such as temperature, humidity, light or specific instrument conditions.			
All quality control measures shall be assessed and evaluated on an on-going basis and quality control acceptance criteria shall be used.			
The laboratory shall have procedures for the development of acceptance/rejection criteria where no method or regulatory criteria exist.			
The quality control protocols specified by the laboratory's SOP shall be followed (see Section 4.2.8.5 in this Standard).			
The laboratory shall ensure that the essential standards outlined in Technical Modules or mandated methods or regulations (whichever are more stringent) are incorporated into their method manuals.			
When it is not apparent which is more stringent, the QC in the mandated method or regulations is to be followed.			

Reporting the Results			
NOTE: All references to Calibration Certificates in ISO/IEC 17025:2005 are not applicable to environmental testing.			
General (ISO/IEC 17025:2005(E), Clause 5.10.1)			
The results of each test, calibration, or series of tests or calibrations carried out by the laboratory shall be reported accurately, clearly, unambiguously and objectively, and in accordance with any specific instructions in the test or calibration methods.			
The results shall be reported, usually in a test report or a calibration certificate (see Note 1), and shall include all the information requested by the customer and necessary for the interpretation of the test or calibration results and all information required by the method used. This information is normally that required by 5.10.2, and 5.10.3 or 5.10.4.			
In the case of tests or calibrations performed for internal customers, or in the case of a written agreement with the customer, the results may be reported in a simplified way.			
Any information listed in 5.10.2 to 5.10.4 which is not reported to the customer shall be readily available in the laboratory which carried out the tests and/or calibrations.			
NOTE 1: Test reports and calibration certificates are sometimes called test certificates and calibration reports respectively.			
NOTE 2: The test reports or calibration certificates may be issued as hard copy or by electronic data transfer provided that the requirements of this International Standard are met.			
Test Reports and Calibration Certificates (ISO/IEC 17025:2005(E), Clause 5.10.2)			
Each test report or calibration certificate shall include at least the following information, unless the laboratory has valid reasons for not doing so:			
a title (e.g. "Test Report" or "Calibration Certificate");			
the name and address of the laboratory, and the location where the tests and/or calibrations were carried out, if different from the address of the laboratory;			
unique identification of the test report or calibration certificate (such as the serial number), and on each page an identification in order to ensure that the page is recognized as a part of the test report or calibration certificate, and a clear identification of the end of the test report or calibration certificate;			
the name and address of the customer;			
identification of the method used;			
a description of, the condition of, and unambiguous identification of the item(s) tested or calibrated;			
the date of receipt of the test or calibration item(s) where this is critical to the validity and application of the results, and the date(s) of performance of the test or calibration;			
reference to the sampling plan and procedures used by the laboratory or other bodies where these are relevant to the validity or application of the results;			
the test or calibration results with, where appropriate, the units of measurement;			

the name(s), function(s) and signature(s) or equivalent identification of person(s) authorizing the test report or calibration certificate;			
where relevant, a statement to the effect that the results relate only to the items tested or calibrated.			
NOTE 1: Hard copies of test reports and calibration certificates should also include the page number and total number of pages.			
NOTE 2: It is recommended that laboratories include a statement specifying that the test report or calibration certificate shall not be reproduced except in full, without written approval of the laboratory.			
Test Reports (ISO/IEC 17025:2005(E), Clause 5.10.3)			
In addition to the requirements listed in 5.10.2, test reports shall, where necessary for the interpretation of the test results, include the following:			
deviations from, additions to, or exclusions from the test method, and information on specific test conditions, such as environmental conditions;			
where relevant, a statement of compliance/non-compliance with requirements and/or specifications;			
where applicable, a statement on the estimated uncertainty of measurement; information on uncertainty is needed in test reports when it is relevant to the validity or application of the test results, when a customer's instruction so requires, or when the uncertainty affects compliance to a specification limit;			
where appropriate and needed, opinions and interpretations (see 5.10.5);			
additional information which may be required by specific methods, customers or groups of customers.			
In addition to the requirements listed in 5.10.2 and 5.10.3.1, test reports containing the results of sampling shall include the following, where necessary for the interpretation of test results:			
the date of sampling;			
unambiguous identification of the substance, material or product sampled (including the name of the manufacturer, the model or type of designation and serial numbers as appropriate);			
the location of sampling, including any diagrams, sketches or photographs;			
a reference to the sampling plan and procedures used;			
details of any environmental conditions during sampling that may affect the interpretation of the test results;			
any standard or other specification for the sampling method or procedure, and deviations, additions to or exclusions from the specification concerned.			
Calibration Certificates (ISO/IEC 17025:2005(E), Clause 5.10.4) does not apply to environmental testing activities.			
Opinions and interpretations			
When opinions and interpretations are included, the laboratory shall document the basis upon which the opinions and interpretations have been made. Opinions and interpretations shall be clearly marked as such in a test report.			
NOTE 1: Opinions and interpretations should not be confused with inspections and product certifications as intended in ISO/IEC 17020 and ISO/IEC Guide 65.			

NOTE 2: Opinions and interpretations included in a test report may comprise, but not be limited to, the following:			
• an opinion on the statement of compliance/noncompliance of the results with requirements;			
• fulfilment of contractual requirements;			
• recommendations on how to use the results;			
• guidance to be used for improvements.			
NOTE 3: In many cases it might be appropriate to communicate the opinions and interpretations by direct dialogue with the customer. Such dialogue should be written down.			
Testing and calibration results obtained from subcontractors			
When the test report contains results of tests performed by subcontractors, these results shall be clearly identified.			
The subcontractor shall report the results in writing or electronically. When a calibration has been subcontracted, the laboratory performing the work shall issue the calibration certificate to the contracting laboratory.			
Electronic transmission of results			
In the case of transmission of test or calibration results by telephone, telex, facsimile or other electronic or electromagnetic means, the requirements of this International Standard shall be met (see also 5.4.7).			
Format of reports and certificates			
The format shall be designed to accommodate each type of test or calibration carried out and to minimize the possibility of misunderstanding or misuse.			
NOTE 1: Attention should be given to the lay-out of the test report or calibration certificate, especially with regard to the presentation of the test or calibration data and ease of assimilation by the reader.			
NOTE 2: The headings should be standardized as far as possible.			
Amendments to test reports and calibration certificates			
Material amendments to a test report or calibration certificate after issue shall be made only in the form of a further document, or data transfer, which includes the statement: "Supplement to Test Report [or Calibration Certificate], serial number... [or as otherwise identified]", or an equivalent form of wording.			
Such amendments shall meet all the requirements of this International Standard.			
When it is necessary to issue a complete new test report or calibration certificate, this shall be uniquely identified and shall contain a reference to the original that it replaces.			
Exceptions			
Some regulatory reporting requirements or formats, such as monthly operating reports, may not require all items listed below; however, the laboratory shall provide all the required information to their client for use in preparing such regulatory reports.			

Laboratories operated solely to provide data for compliance purposes (in-house or captive laboratories) shall have all applicable information specified in Section 5.10 readily available for review by the accreditation body.			
However, formal reports detailing the information are not required if:			
the in-house laboratory is itself responsible for preparing the regulatory reports; or			
the laboratory provides information to another individual within the organization for preparation of regulatory reports. The facility management shall ensure that the appropriate report items are in the report to the regulatory authority, if such information is required; or			
see Section 5.10.1, paragraph 3.			
Additional Requirements			
Time of sample preparation and/or analysis if the required holding time for either activity is less than or equal to seventy-two hours.			
Results that are reported on a basis other than as received (e. g., dry weight).			
Any non-accredited tests shall be clearly identified as such to the client when claims of accreditation to this Standard are made in the analytical report or in the supporting electronic or hardcopy deliverables.			
Clear identification of numerical results with values outside the calibration range.			

ID	Major Topic	Topic	Subject	Category	Citation
798	1.0 Asbestos				V1M3 1
799	1.1 Introduction				V1M3 1.1
800					V1M3 1.1
801	1.2 Scope				V1M3 1.2
802					V1M3 1.2
803	1.3 Terms & Definitions				V1M3 1.3
804					V1M3 1.3
805	1.4 Method Selection				V1M3 1.4
806	1.4 Method Selection	Reference Method	Regulatory		V1M3 1.4
807	1.4 Method Selection	Reference Method	Regulatory		V1M3 1.4
808	1.4 Method Selection	Reference Method	QC	Requirement	V1M3 1.4
809	1.4 Method Selection	Added Analytes	Identification	Requirement	V1M3 1.4
810	1.4 Method Selection	Non Reference Methods	Customer Communication	Requirement	V1M3 1.4
811	1.4 Method Selection	Non Reference Methods	Validation	Requirement	V1M3 1.4
812	1.5 Method Validation				V1M3 1.5
813	1.5 Method Validation	General	Performance Measures	Requirement	V1M3 1.5
814	1.5 Method Validation	General	Scope	Requirement	V1M3 1.5
815	1.5 Method Validation	General	Extent	Requirement	V1M3 1.5
816	1.5 Method Validation	General	Documentation	Record	V1M3 1.5

817	1.5 Method Validation	General	PT Program	Requirement	V1M3 1.5
818	1.6 Demonstration of Capability				V1M3 1.6
819	1.6 Demonstration of Capability	1.6.1 General			V1M3 1.6.1
820	1.6 Demonstration of Capability	1.6.1 General	IDOC	Requirement	V1M3 1.6.1
821	1.6 Demonstration of Capability	1.6.1 General	Ongoing DOC	Requirement	V1M3 1.6.1
822	1.6 Demonstration of Capability	1.6.1 General	IDOC	Exemption	V1M3 1.6.1
823	1.6 Demonstration of Capability	1.6.1 General	IDOC	Record	V1M3 1.6.1
824	1.6 Demonstration of Capability	1.6.1 General	Frequency	Requirement	V1M3 1.6.1
825	1.6 Demonstration of Capability	1.6.1 General	Documentation	Record	V1M3 1.6.1
826	1.6 Demonstration of Capability	1.6.2 Initial DOC			V1M3 1.6.2
827	1.6 Demonstration of Capability	1.6.2 Initial DOC	Frequency	Requirement	V1M3 1.6.2
828	1.6 Demonstration of Capability	1.6.2 Initial DOC	Documentation	Record	V1M3 1.6.2.1
829	1.6 Demonstration of Capability	1.6.2 Initial DOC	Documentation Details	Requirement	V1M3 1.6.2.1.a
830	1.6 Demonstration of Capability	1.6.2 Initial DOC	Documentation Details	Requirement	V1M3 1.6.2.1.b
831	1.6 Demonstration of Capability	1.6.2 Initial DOC	Documentation Details	Requirement	V1M3 1.6.2.1.c
832	1.6 Demonstration of Capability	1.6.2 Initial DOC	Documentation Details	Requirement	V1M3 1.6.2.1.d
833	1.6 Demonstration of Capability	1.6.2 Initial DOC	Documentation Details	Requirement	V1M3 1.6.2.1.e
834	1.6 Demonstration of Capability	1.6.2 Initial DOC	Documentation Details	Requirement	V1M3 1.6.2.1.f
835	1.6 Demonstration of Capability	1.6.2 Initial DOC	Documentation Details	Requirement	V1M3 1.6.2.1.g
836	1.6 Demonstration of Capability	1.6.2 Initial DOC	Use of Procedure	Requirement	V1M3 1.6.2.2
837	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure Details	Option	V1M3 1.6.2.2.a
838	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure Details	Option	V1M3 1.6.2.2.b

839	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure Details	Option	V1M3 1.6.2.2.c
840	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure Details	Option	V1M3 1.6.2.2.d
841	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure Details	Option	V1M3 1.6.2.2.e
842	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure Details	Option	V1M3 1.6.2.2.e.i
843	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure Details	Option	V1M3 1.6.2.2.e.ii
844	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure Details	Option	V1M3 1.6.2.2.f
845	1.6 Demonstration of Capability	1.6.3 On-Going DOC			V1M3 1.6.3
846	1.6 Demonstration of Capability	1.6.3 On-Going DOC	Use of Procedure	Requirement	V1M3 1.6.3.1
847	1.6 Demonstration of Capability	1.6.3 On-Going DOC	Procedure		V1M3 1.6.3.2
848	1.6 Demonstration of Capability	1.6.3 On-Going DOC	Procedure	Option	V1M3 1.6.3.2.a
849	1.6 Demonstration of Capability	1.6.3 On-Going DOC	Procedure	Option	V1M3 1.6.3.2.a N
850	1.6 Demonstration of Capability	1.6.3 On-Going DOC	Procedure	Option	V1M3 1.6.3.2.b
851	1.6 Demonstration of Capability	1.6.3 On-Going DOC	Procedure	Option	V1M3 1.6.3.2.c
852	1.6 Demonstration of Capability	1.6.3 On-Going DOC	Procedure	Option	V1M3 1.6.3.2.d
853	1.6 Demonstration of Capability	1.6.3 On-Going DOC	Procedure	Option	V1M3 1.6.3.2.e
854	1.7 Technical Requirements				V1M3 1.7
855	1.7.1 Technical Requirements Calibration	1.7.1 Calibration			V1M3 1.7.1

856	1.7.1 Technical Requirements Calibration	1.7.1 Calibration			V1M3 1.7.1
857	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM			V1M3 1.7.1.1
858	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM			V1M3 1.7.1.1
859	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM			V1M3 1.7.1.1.1
860	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	Conditions for Calibration	Requirement	V1M3 1.7.1.1.1
861	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	Magnification	Requirement	V1M3 1.7.1.1.1.a
862	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	Camera Constant	Requirement	V1M3 1.7.1.1.1.b
863	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	Frequency	Requirement	V1M3 1.7.1.1.1.b
864	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	Spot Size	Requirement	V1M3 1.7.1.1.1.c
865	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	Beam Dose	Requirement	V1M3 1.7.1.1.1.d
866	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	EDXA		V1M3 1.7.1.1.1.e

867	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	EDXA	Requirement	V1M3 1.7.1.1.1.e.i
868	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	Performance Measures	Requirement	V1M3 1.7.1.1.1.e.ii
869	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	K Factor	Requirement	V1M3 1.7.1.1.1.e.iii
870	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	K Factor	Requirement	V1M3 1.7.1.1.1.e.iii
871	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	Detector Resolution	Requirement	V1M3 1.7.1.1.1.e.iv
872	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	Abnormal X-Ray Area	Requirement	V1M3 1.7.1.1.1.e.v
873	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	Sensitivity	Requirement	V1M3 1.7.1.1.1.e.vi
874	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	Low Temperature Asher	Requirement	V1M3 1.7.1.1.1.f
875	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Water and Wastewater	Grid Openings	Requirement	V1M3 1.7.1.1.1.g
876	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Air			V1M3 1.7.1.1.2
877	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Air	Calibration	Procedure	V1M3 1.7.1.1.2
878	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Air	Magnification	Requirement	V1M3 1.7.1.1.2

879	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Air	Calibration	Record	V1M3 1.7.1.1.2
880	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Air	Calibration	Requirement	V1M3 1.7.1.1.2
881	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Air			V1M3 1.7.1.1.3
882	1.7.1 Technical Requirements Calibration	1.7.1.1 Transmission EM Bulk Samples	Calibration	Procedure	V1M3 1.7.1.1.3
883	1.7.1 Technical Requirements Calibration	1.7.1.2 Phase Contrast			V1M3 1.7.1.2
884	1.7.1 Technical Requirements Calibration	1.7.1.2 Phase Contrast	Phase Rings	Requirement	V1M3 1.7.1.2.1
885	1.7.1 Technical Requirements Calibration	1.7.1.2 Phase Contrast	Phase-shift detection Limit	Requirement	V1M3 1.7.1.2.2
886	1.7.1 Technical Requirements Calibration	1.7.1.2 Phase Contrast	Counting Area	Requirement	V1M3 1.7.1.2.3
887	1.7.1 Technical Requirements Calibration	1.7.1.2 Phase Contrast	Field Diameter	Requirement	V1M3 1.7.1.2.3
888	1.7.1 Technical Requirements Calibration	1.7.1.3 Polarized Light			V1M3 1.7.1.3
889	1.7.1 Technical Requirements Calibration	1.7.1.3 Polarized Light	Microscope Alignment	Requirement	V1M3 1.7.1.3.1
890	1.7.1 Technical Requirements Calibration	1.7.1.3 Polarized Light	Refractive Index Liquids	Requirement	V1M3 1.7.1.3.2
891	1.7.2 Technical Requirements QC	1.7.2 Quality Control			V1M3 1.7.2
892	1.7.2 Technical Requirements QC	1.7.2.1 Negative Control			V1M3 1.7.2.1

893	1.7.2 Technical Requirements QC	1.7.2.1.1 Negative Control Transmission EM			V1M3 1.7.2.1.1
894	1.7.2 Technical Requirements QC	1.7.2.1.1 Negative Control Transmission EM			V1M3 1.7.2.1.1.a
895	1.7.2 Technical Requirements QC	1.7.2.1.1 Negative Control Transmission EM Water & WW	Frequency	Requirement	V1M3 1.7.2.1.1.a.i
896	1.7.2 Technical Requirements QC	1.7.2.1.1 Negative Control Transmission EM Water & WW	Process Blank	Requirement	V1M3 1.7.2.1.1.a.ii
897	1.7.2 Technical Requirements QC	1.7.2.1.1 Negative Control Transmission EM Air			V1M3 1.7.2.1.1.b
898	1.7.2 Technical Requirements QC	1.7.2.1.1 Negative Control Transmission EM Air	Frequency	Requirement	V1M3 1.7.2.1.1.b.i
899	1.7.2 Technical Requirements QC	1.7.2.1.1 Negative Control Transmission EM Air	Acceptance Limits	Requirement	V1M3 1.7.2.1.1.b.ii
900	1.7.2 Technical Requirements QC	1.7.2.1.1 Negative Control Transmission EM Bulk Samples			V1M3 1.7.2.1.1.c
901	1.7.2 Technical Requirements QC	1.7.2.1.1 Negative Control Transmission EM Bulk Samples	Frequency	Requirement	V1M3 1.7.2.1.1.c.i
902	1.7.2 Technical Requirements QC	1.7.2.1.1 Negative Control Transmission EM Bulk Samples	Reference Collection	Requirement	V1M3 1.7.2.1.1.c.ii
903	1.7.2 Technical Requirements QC	1.7.2.1.1 Negative Control Transmission EM Bulk Samples	Reference Collection	Requirement	V1M3 1.7.2.1.1.c.iii
904	1.7.2 Technical Requirements QC	1.7.2.1.2 Negative Control Phase Contrast			V1M3 1.7.2.1.2
905	1.7.2 Technical Requirements QC	1.7.2.1.2 Negative Control Phase Contrast	Field Blanks	Requirement	V1M3 1.7.2.1.2

906	1.7.2 Technical Requirements QC	1.7.2.1.2 Negative Control Phase Contrast	Blank Cassette	Requirement	V1M3 1.7.2.1.2
907	1.7.2 Technical Requirements QC	1.7.2.1 Negative Control Transmission EM Bulk Samples	Field Blank Results	Requirement	V1M3 1.7.2.1.2
908	1.7.2 Technical Requirements QC	1.7.2.1.2 Negative Control Phase Contrast	Blind Sample	Requirement	V1M3 1.7.2.1.2
909	1.7.2 Technical Requirements QC	1.7.2.1.2 Negative Control Phase Contrast	Field Blank Acceptance Limits	Requirement	V1M3 1.7.2.1.2
910	1.7.2 Technical Requirements QC	1.7.2.1.3 Negative Control Polarized Light			V1M3 1.7.2.1.3
911	1.7.2 Technical Requirements QC	1.7.2.1.3 Negative Control Polarized Light	Frequency	Requirement	V1M3 1.7.2.1.3.a
912	1.7.2 Technical Requirements QC	1.7.2.1.3 Negative Control Polarized Light	Extent of Scanning	Requirement	V1M3 1.7.2.1.3.a
913	1.7.2 Technical Requirements QC	1.7.2.1.3 Negative Control Polarized Light	Frequency	Requirement	V1M3 1.7.2.1.3.a
914	1.7.2 Technical Requirements QC	1.7.2.1.3 Negative Control Polarized Light	Verified non-ACM	Requirement	V1M3 1.7.2.1.3.a
915	1.7.2 Technical Requirements QC	1.7.2.1.3 Negative Control Polarized Light	Frequency	Requirement	V1M3 1.7.2.1.3.b
916	1.7.3 Technical Requirements Test Variability				V1M3 1.7.3
917	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM			V1M3 1.7.3.1
918	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM	Frequency	Requirement	V1M3 1.7.3.1

919	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Water & WW			V1M3 1.7.3.1.1
920	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Water & WW	Relocator Grids	Requirement	V1M3 1.7.3.1.1
921	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Water & WW	Frequency	Requirement	V1M3 1.7.3.1.1
922	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Water & WW	Replicate Frequency	Requirement	V1M3 1.7.3.1.1.a
923	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Water & WW	Duplicate Frequency	Requirement	V1M3 1.7.3.1.1.b
924	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Water & WW	Verified Analysis	Requirement	V1M3 1.7.3.1.1.c
925	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Air			V1M3 1.7.3.1.2
926	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Air	Relocator Grids	Requirement	V1M3 1.7.3.1.2.a
927	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Air	Frequency	Requirement	V1M3 1.7.3.1.2.b
928	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Air	Acceptance Limits	Requirement	V1M3 1.7.3.1.2.c
929	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Air	Interlaboratory Analysis	Requirement	V1M3 1.7.3.1.2.d
930	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Air	Multiple Instruments	Requirement	V1M3 1.7.3.1.2.e
931	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Air	Replicate Frequency	Requirement	V1M3 1.7.3.1.2.e.i

932	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Air	Duplicate Frequency	Requirement	V1M3 1.7.3.1.2.e.ii
933	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Air	Verified Analysis	Requirement	V1M3 1.7.3.1.2.e.iii
934	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Bulk Samples			V1M3 1.7.3.1.3
935	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Bulk Samples	Concentration (% Asbestos)	Requirement	V1M3 1.7.3.1.3
936	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Bulk Samples	Intra-Analyst Frequency	Requirement	V1M3 1.7.3.1.3.a
937	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Bulk Samples	Inter-Analyst Frequency	Requirement	V1M3 1.7.3.1.3.b
938	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Bulk Samples	Inter-Laboratory Frequency	Requirement	V1M3 1.7.3.1.3.c
939	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Bulk Samples	Sample Type	Requirement	V1M3 1.7.3.1.3.c
940	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Bulk Samples	Assessment	Requirement	V1M3 1.7.3.1.3.c
941	1.7.3 Technical Requirements Test Variability	1.7.3.1 Transmission EM Bulk Samples	Misclassifications or misidentification	Requirement	V1M3 1.7.3.1.3.c
942	1.7.3 Technical Requirements Test Variability	1.7.3.2 Phase Contrast			V1M3 1.7.3.2
943	1.7.3 Technical Requirements Test Variability	1.7.3.2 Phase Contrast	Interlaboratory Analysis	Requirement	V1M3 1.7.3.2.a
944	1.7.3 Technical Requirements Test Variability	1.7.3.2 Phase Contrast	Sample Type	Requirement	V1M3 1.7.3.2.a
945	1.7.3 Technical Requirements Test Variability	1.7.3.2 Phase Contrast	Statistical Analysis	Requirement	V1M3 1.7.3.2.a
946	1.7.3 Technical Requirements Test Variability	1.7.3.2 Phase Contrast	Results	Requirement	V1M3 1.7.3.2.a

947	1.7.3 Technical Requirements Test Variability	1.7.3.2 Phase Contrast	Intra and Inter Analyst	Requirement	V1M3 1.7.3.2.b
948	1.7.3 Technical Requirements Test Variability	1.7.3.3 Polarized Light			V1M3 1.7.3.3
949	1.7.3 Technical Requirements Test Variability	1.7.3.3 Polarized Light	Procedure	Requirement	V1M3 1.7.3.3
950	1.7.4 Technical Requirements Other QC Measures				V1M3 1.7.4
951	1.7.4 Technical Requirements Other QC Measures	1.7.4.1 Transmission EM			V1M3 1.7.4.1
952	1.7.4 Technical Requirements Other QC Measures	1.7.4.1 Transmission EM Water & WW			V1M3 1.7.4.1.a
953	1.7.4 Technical Requirements Other QC Measures	1.7.4.1 Transmission EM Water & WW	Filter Preparation	Requirement	V1M3 1.7.4.1.a.i
954	1.7.4 Technical Requirements Other QC Measures	1.7.4.1 Transmission EM Water & WW	SRM	Requirement	V1M3 1.7.4.1.a.ii
955	1.7.4 Technical Requirements Other QC Measures	1.7.4.1 Transmission EM Air			V1M3 1.7.4.1.b
956	1.7.4 Technical Requirements Other QC Measures	1.7.4.1 Transmission EM Air	Filter Preparation	Requirement	V1M3 1.7.4.1.b.i
957	1.7.4 Technical Requirements Other QC Measures	1.7.4.1 Transmission EM Air	SRM	Requirement	V1M3 1.7.4.1.b.ii
958	1.7.4 Technical Requirements Other QC Measures	1.7.4.1 Transmission EM Bulk Samples			V1M3 1.7.4.1.c

959	1.7.4 Technical Requirements Other QC Measures	1.7.4.1 Transmission EM Bulk Samples	Identification Criterion	Requirement	V1M3 1.7.4.1.c
960	1.7.4 Technical Requirements Other QC Measures	1.7.4.2 Phase Contrast			V1M3 1.7.4.2
961	1.7.4 Technical Requirements Other QC Measures	1.7.4.2 Phase Contrast	Fiber Distribution	Requirement	V1M3 1.7.4.2.a
962	1.7.4 Technical Requirements Other QC Measures	1.7.4.2 Phase Contrast	Blank Recounts	Requirement	V1M3 1.7.4.2.b
963	1.7.4 Technical Requirements Other QC Measures	1.7.4.2 Phase Contrast	National Program	Requirement	V1M3 1.7.4.2.c
964	1.7.4 Technical Requirements Other QC Measures	1.7.4.3 Polarized Light			V1M3 1.7.4.3
965	1.7.4 Technical Requirements Other QC Measures	1.7.4.3 Polarized Light	Friable Materials	Requirement	V1M3 1.7.4.3.a
966	1.7.4 Technical Requirements Other QC Measures	1.7.4.3 Polarized Light	Non-friable Materials	Requirement	V1M3 1.7.4.3.b
967	1.7.5 Analytical Sensitivity				V1M3 1.7.5
968	1.7.5 Analytical Sensitivity	1.7.5.1 Transmission EM			V1M3 1.7.5.1
969	1.7.5 Analytical Sensitivity	1.7.5.1 Transmission EM Water & WW			V1M3 1.7.5.1.1
970	1.7.5 Analytical Sensitivity	1.7.5.1 Transmission EM Water & WW	Threshold	Requirement	V1M3 1.7.5.1.1
971	1.7.5 Analytical Sensitivity	1.7.5.1 Transmission EM Air			V1M3 1.7.5.1.2

972	1.7.5 Analytical Sensitivity	1.7.5.1 Transmission EM Air	Threshold	Requirement	V1M3 1.7.5.1.2
973	1.7.5 Analytical Sensitivity	1.7.5.1 Transmission EM Bulk Samples			V1M3 1.7.5.1.3
974	1.7.5 Analytical Sensitivity	1.7.5.1 Transmission EM Bulk Samples	Range	Requirement	V1M3 1.7.5.1.3
975	1.7.5 Analytical Sensitivity	1.7.5.2 Phase Contrast			V1M3 1.7.5.2
976	1.7.5 Analytical Sensitivity	1.7.5.2 Phase Contrast	Quantitative Working Range	Requirement	V1M3 1.7.5.2
977	1.7.5 Analytical Sensitivity	1.7.5.3 Polarized Light			V1M3 1.7.5.3
978	1.7.5 Analytical Sensitivity	1.7.5.3 Polarized Light	Limit of Detection	Requirement	V1M3 1.7.5.3
979	1.7.6 Quality of Standards & Reagents				V1M3 1.7.6
980	1.7.6 Quality of Standards & Reagents	1.7.6.1 Transmission EM			V1M3 1.7.6.1
981	1.7.6 Quality of Standards & Reagents	1.7.6.1 Transmission EM	Need for Standards	Requirement	V1M3 1.7.6.1.a
982	1.7.6 Quality of Standards & Reagents	1.7.6.1 Transmission EM	Reference Standards	Requirement	V1M3 1.7.6.1.b
983	1.7.6 Quality of Standards & Reagents	1.7.6.1 Transmission EM	Reference Standards	Requirement	V1M3 1.7.6.1.c
984	1.7.6 Quality of Standards & Reagents	1.7.6.1 Transmission EM	Reagents	Requirement	V1M3 1.7.6.1.d
985	1.7.6 Quality of Standards & Reagents	1.7.6.1 Transmission EM	Mineral Fiber Collection	Requirement	V1M3 1.7.6.1.e
986	1.7.6 Quality of Standards & Reagents	1.7.6.2 Phase Contrast			V1M3 1.7.6.2

987	1.7.6 Quality of Standards & Reagents	1.7.6.2 Phase Contrast	Standard Source	Requirement	V1M3 1.7.6.2
988	1.7.6 Quality of Standards & Reagents	1.7.6.2 Phase Contrast	Reagents	Requirement	V1M3 1.7.6.2
989	1.7.6 Quality of Standards & Reagents	1.7.6.3 Polarized Light			V1M3 1.7.6.3
990	1.7.6 Quality of Standards & Reagents	1.7.6.3 Polarized Light	Reagents and Standards	Requirement	V1M3 1.7.6.3
991	1.7.7 Acceptance/Rejection Criteria				V1M3 1.7.7
992	1.7.7 Acceptance/Rejection Criteria	1.7.7.1 Transmission EM			V1M3 1.7.7.1
993	1.7.7 Acceptance/Rejection Criteria	1.7.7.1 Transmission EM Water & WW			V1M3 1.7.7.1.1
994	1.7.7 Acceptance/Rejection Criteria	1.7.7.1 Transmission EM Water & WW	Data Reduction	Requirement	V1M3 1.7.7.1.1.a
995	1.7.7 Acceptance/Rejection Criteria	1.7.7.1 Transmission EM Water & WW	Measurement Uncertainty	Requirement	V1M3 1.7.7.1.1.b
996	1.7.7 Acceptance/Rejection Criteria	1.7.7.1 Transmission EM Air			V1M3 1.7.7.1.2
997	1.7.7 Acceptance/Rejection Criteria	1.7.7.1 Transmission EM Air	Data Reduction	Requirement	V1M3 1.7.7.1.2.a
998	1.7.7 Acceptance/Rejection Criteria	1.7.7.1 Transmission EM Air	Measurement Uncertainty	Requirement	V1M3 1.7.7.1.2.b
999	1.7.7 Acceptance/Rejection Criteria	1.7.7.1 Transmission EM Bulk Samples			V1M3 1.7.7.1.3
1000	1.7.7 Acceptance/Rejection Criteria	1.7.7.1 Transmission EM Bulk Samples	Data Reduction	Requirement	V1M3 1.7.7.1.3.a
1001	1.7.7 Acceptance/Rejection Criteria	1.7.7.1 Transmission EM Bulk Samples	Measurement Uncertainty	Requirement	V1M3 1.7.7.1.3.b

1002	1.7.7 Acceptance/Rejection Criteria	1.7.7.2 Phase Contrast			V1M3 1.7.7.2
1003	1.7.7 Acceptance/Rejection Criteria	1.7.7.2 Phase Contrast	Data Reduction	Requirement	V1M3 1.7.7.2.1
1004	1.7.7 Acceptance/Rejection Criteria	1.7.7.2 Phase Contrast	Measurement Uncertainty	Requirement	V1M3 1.7.7.2.2
1005	1.7.7 Acceptance/Rejection Criteria	1.7.7.2 Phase Contrast	Reporting High Concentration	Requirement	V1M3 1.7.7.2.3
1006	1.7.7 Acceptance/Rejection Criteria	1.7.7.3 Polarized Light			V1M3 1.7.7.3
1007	1.7.7 Acceptance/Rejection Criteria	1.7.7.3 Polarized Light	Data Reduction	Requirement	V1M3 1.7.7.3.1
1008	1.7.7 Acceptance/Rejection Criteria	1.7.7.3 Polarized Light	Measurement Uncertainty	Requirement	V1M3 1.7.7.3.2
1009	1.7 Technical Requirements	1.7.8 Constant and Consistent Conditions			V1M3 1.7.8
1010	1.7 Technical Requirements	1.7.8 Constant and Consistent Conditions	Holding Time		V1M3 1.7.8.1
1011	1.7 Technical Requirements	1.7.8 Constant and Consistent Conditions	Sampling Time and Date	Record	V1M3 1.7.8.1
1012	1.7 Technical Requirements	1.7.8 Constant and Consistent Conditions	Collectors	Record	V1M3 1.7.8.1
1013	1.7 Technical Requirements	1.7.8 Constant and Consistent Conditions	Cross Contamination	Procedure	V1M3 1.7.8.2
1014	1.7 Technical Requirements	1.7.8 Constant and Consistent Conditions	Method Requirements	Requirement	V1M3 1.7.8.3

Does the laboratory comply with this section?	Yes	No
ASBESTOS TESTING		
Introduction		
This Standard applies to laboratories undertaking the examination of asbestos samples. This Standard is organized by analytical technique including transmission electron microscopy (TEM) for the analysis of water, wastewater, air, and bulk samples; phase contrast microscopy (PCM) for analysis of workplace air; and polarized light microscopy (PLM) for analysis of bulk samples. These procedures for asbestos analysis involve sample preparation followed by detection of asbestos.		
Scope		
The essential quality control procedures applicable to asbestos measurements are included in this document. Additional quality control requirements that are specified by method, regulation or project shall be met by laboratories.		
Terms and Definitions		
The relevant definitions from TNI, Volume 1, Module 2, Section 3.0 are the preferred references. Definitions related to this document, which are used differently or do not exist in the above references are defined below.		
Method Selection		
A reference method is a method issued by an organization generally recognized as competent to do so. (When ISO refers to a standard method, that term is equivalent to reference method).		
When a laboratory is required to analyze a parameter by a specified method due to a regulatory requirement, the parameter/method combination is recognized as a reference method.		
If there is not a regulatory requirement for the parameter/method combination, the parameter/method combination is recognized as a reference method if it can be analyzed by another similar reference method of the same matrix and technology. The inclusion of the parameter in the method shall meet all required calibration requirements of the method and the quality control requirements of the method to which the parameter is being added. If no QC exists in the method, the laboratory shall adhere to the requirements outlined in the similar method.		
A method that meets the above requirement shall be identified in such a way so that there is no confusion that the method has been modified.		
When it is necessary to use methods not covered by reference methods, these shall be subject to agreement with the client and shall include a clear specification of the client's requirements and the purpose of the environmental test.		
The method developed shall have been validated appropriately before use.		
Method Validation		
Validation is the confirmation, by examination and objective evidence, that the particular requirements for a specific intended use are fulfilled.		
The laboratory shall validate non-reference methods, laboratory-designed/developed methods, reference methods used outside their published scope, and amplifications and modifications of reference methods to confirm that the methods are fit for the intended use.		
The validation shall be as extensive as is necessary to meet the needs of the given application or field of application.		
The laboratory shall record the results obtained, the procedure used for the validation, and a statement as to whether the method is fit for the intended use.		

Laboratories shall participate in proficiency testing programs. The results of these analyses shall be used to evaluate the ability of the laboratory to produce acceptable data.		
Demonstration of Capability (DOC)		
General		
Prior to acceptance and institution of any method for data reporting, satisfactory initial DOC is required (see Section 1.6.2).		
Thereafter, ongoing DOC (Section 1.6.3), as per the quality control requirements in Section 1.7.3 (such as laboratory control samples) is required.		
In cases where a laboratory analyzes samples using a method that has been in use by the laboratory for at least one year prior to applying for accreditation, and there have been no significant changes in instrument type, personnel or method, the on-going DOC shall be acceptable as an initial DOC. The laboratory shall have records on file to demonstrate that an initial DOC is not required.		
For the initial DOC, appropriate records as discussed in Section 1.6.2 shall be completed. (***See 1.6.2.1)***		
An initial DOC shall be completed each time there is a change in instrument type, personnel, or method. ***(See 1.6.2)***		
All demonstrations shall be documented. All data applicable to the demonstration shall be retained and readily available at the laboratory.		
Initial DOC		
An initial DOC shall be conducted prior to using any method, and at any time there is a change in instrument type, personnel or method or any time that a method has not been performed by the laboratory or analyst in a twelve (12) month period.		
The laboratory shall document each initial DOC in a manner such that the following information is readily available for each affected employee:		
analyst(s) involved in preparation and/or analysis;		
matrix;		
analyte(s), class of analyte(s), or measured parameter(s);		
identification of method(s) performed;		
identification of laboratory-specific SOP used for analysis, including revision number;		
date(s) of analysis; and		
summary of analyses, including information outlined in Section 1.6.2.2.c.		
For asbestos, if the method or regulation does not specify a DOC, the following procedure is acceptable. It is the responsibility of the laboratory to document that other approaches to DOC are adequate.		
The analyte(s) shall be diluted in a volume of clean quality system matrix (a sample in which no target analytes or interferences are present at concentrations that will impact the results of a specific method) sufficient to prepare four aliquots.		
At least four (4) aliquots shall be prepared and analyzed according to the method either concurrently or over a period of days.		

Using all of the results, calculate the mean recovery in the appropriate reporting units and the standard deviations of the population sample (in the same units) for each parameter of interest. When it is not possible to determine mean and standard deviations, such as for presence/absence and logarithmic values, the laboratory shall assess performance against established and documented criteria.		
Compare the information from (c) above to the corresponding acceptance criteria for precision and accuracy in the method (if applicable) or in laboratory-generated acceptance criteria (if there are not established mandatory criteria). If all parameters meet the acceptance criteria, the analysis of actual samples may begin. If any one of the parameters does not meet the acceptance criteria, the performance is unacceptable for that parameter.		
When one or more of the tested parameters fail at least one of the acceptance criteria, the analyst shall proceed according to i) or ii) below.		
Locate and correct the source of the problem and repeat the test for all parameters of interest beginning with c) above.		
Beginning with c) above, repeat the test for all parameters that failed to meet criteria.		
Repeated failure, however, confirms a general problem with the measurement system. If this occurs, locate and correct the source of the problem and repeat the test for all compounds of interest beginning with b).		
On-Going DOC		
The laboratory shall have a documented procedure describing ongoing demonstration of capability. The analyst(s) shall demonstrate on-going capability by meeting the quality control requirements of the method, laboratory SOP, client specifications, and/or this Standard. It is the responsibility of the laboratory to document that other approaches to ongoing DOC are adequate.		
For asbestos, this ongoing DOC may be one of the following:		
acceptable performance of a blind sample (single blind to the analyst);		
NOTE: Successful analysis of a blind performance sample on a similar method using the same technology (e.g., GC/MS volatiles by purge and trap for Methods 524.2, 624 or 5030/8260) would only require documentation for one of the test.		
another initial DOC;		
at least four (4) consecutive laboratory control samples with acceptable levels of precision and accuracy. The laboratory shall determine the acceptable limits for precision and accuracy prior to analysis. The laboratory shall tabulate or be able to readily retrieve four (4) consecutive passing laboratory control samples (LCS) for each method for each analyst each year;		
a documented process of analyst review using quality control (QC) samples. QC samples can be reviewed to identify patterns for individuals or groups of analysts and determine if corrective action or retraining is necessary; or		
if a) through d) are not technically feasible, then analysis of real-world samples with results within predefined acceptance criteria (as defined by the laboratory or method) shall be performed.		
Technical Requirements		
Calibration		

Refer to methods referenced in the following Sections for specific equipment requirements. If NIST standard reference materials (SRM) specified below are unavailable, the laboratory may substitute an equivalent reference material with a certificate of analysis.		
Transmission Electron Microscopy		
Refer to methods referenced in the following Sections for specific equipment requirements.		
Water and Wastewater		
All calibrations listed below (unless otherwise noted) shall be performed under the same analytical conditions used for routine asbestos analysis and shall be recorded in a notebook and include date and analyst's signature. Frequencies stated below may be reduced to "before next use" if no samples are analyzed after the last calibration period has expired. Likewise, frequencies may have to be increased following non-routine maintenance or unacceptable calibration performance.		
Magnification Calibration. Magnification calibration shall be done at the fluorescent screen, with the calibration specimen at the eucentric position, at the magnification used for fiber counting, generally 10,000 and 20,000x. A logbook shall be maintained with the dates of the calibration recorded. Calibrations shall be performed monthly to establish the stability of magnification. Calibration data shall be displayed on control charts that show trends over time.		
Camera Constant. The camera length of the TEM in the Selected Area Electron Diffraction (SAED) mode shall be calibrated before SAED patterns of unknown samples are observed. The diffraction specimen shall be at the eucentric position for this calibration. This calibration shall allow accurate (<10% variation) measurement of layer-line spacings on the medium used for routine measurement, i.e., the phosphor screen or camera film. This shall also allow accurate (<5% variation) measurement of zone axis SAED patterns on permanent media (e.g., film).		
Calibrations shall be performed monthly to establish the stability of the camera constant. Where non-asbestiform minerals may be expected (e.g., winchite, richterite, industrial talc, vermiculite, etc.), an internal camera constant standard such as gold, shall be deposited and measured on each sample to facilitate accurate indexing of zone axis SAED patterns. In such cases, layer line analysis alone shall not be used. Calibration data shall be displayed on control charts that show trends over time.		
Spot Size. The diameter of the smallest beam spot at crossover shall be less than 250 nm as calibrated quarterly. Calibration data shall be displayed on control charts that show trends over time.		
Beam Dose. The beam dose shall be calibrated so that beam damage to chrysotile is minimized, specifically so that an electron diffraction pattern from a single fibril >1 ìm in length from a NIST SRM chrysotile sample is stable in the electron beam dose for at least 15 seconds.		
Energy Dispersive X-Ray Analysis (EDXA) System		

The x-ray energy vs. channel number for the EDXA system shall be calibrated to within 20 eV for at least two peaks between 0.7 keV and 10 keV. One peak shall be from the low end (0.7 keV to 2 keV) and the other peak from the high end (7 keV to 10 keV) of this range. The calibration of the x-ray energy shall be checked prior to each analysis of samples and recalibrated if out of the specified range.		
the ability of the system to resolve the Na Ká line from the Cu L line shall be confirmed quarterly by obtaining a spectrum from the NIST SRM 1866 crocidolite sample on a copper grid.		
The k-factors for elements found in asbestos (Na, Mg, Al, Si, Ca, and Fe) relative to Si shall be calibrated semiannually, or anytime the detector geometry may be altered. NIST SRM 2063a shall be used for Mg, Si, Ca, Fe, while k-factors for Na and Al may be obtained from suitable materials such as albite, kaersutite, or NIST SRM 99a. The k-factors shall be determined to a precision (2s) within 10% relative to the mean value obtained for Mg, Al, Si, Ca, and Fe, and within 20% relative to the mean value obtained for Na.		
The k-factor relative to Si for Na shall be between 1.0 and 4.0, for Mg and Fe shall be between 1.0 and 2.0, and for Al and Ca shall be between 1.0 and 1.75. The k-factor for Mg relative to Fe shall be 1.5 or less. Calibration data shall be displayed on control charts that show trends over time.		
The detector resolution shall be checked quarterly to ensure a full-width half maximum resolution of <175 eV at Mn Ká (5.90 keV). Calibration data shall be displayed on control charts that show trends over time.		
The portions of a grid in a specimen holder for which abnormal x-ray spectra are generated under routine asbestos analysis conditions shall be determined and these areas shall be avoided in asbestos analysis.		
The sensitivity of the detector for collecting x-rays from small volumes shall be documented quarterly by collecting resolvable Mg and Si peaks from a unit fibril of NIST SRM 1866 chrysotile.		
Low Temperature Asher. The low temperature asher shall be calibrated quarterly by determining a calibration curve for the weight vs. ashing time of collapsed mixed-celluloseester (MCE) filters. Calibration data shall be displayed on control charts that show trends over time.		
Grid Openings. The magnification of the grid opening measurement system shall be calibrated using an appropriate standard at a frequency of 20 openings/20 grids/lot of 1000 or 1 opening/sample. The variation in the calibration measurements (2s) is <5% of the mean calibration value.		
Air		
All calibrations shall be performed in accordance with Section 1.7.1.1.1, with the exception of magnification.		
Magnification calibration shall be done at the fluorescent screen, with the calibration specimen at the eucentric position, at the magnification used for fiber counting, generally 15,000 to 20,000x. A logbook shall be maintained with the dates of the calibration recorded. Calibrations shall be performed monthly to establish the stability of magnification.		

A logbook shall be maintained with the dates of the calibration recorded.		
Calibrations shall be performed monthly to establish the stability of magnification.		
Bulk Samples		
All calibrations shall be performed in accordance with Section 1.7.1.1.1.		
Phase Contrast Microscopy		
At least once daily, the analyst shall use the telescope ocular (or Bertrand lens, for some microscopes) supplied by the manufacturer to ensure that the phase rings (annular diaphragm and phase-shifting elements) are concentric.		
The phase-shift detection limit of the microscope shall be checked monthly or after modification or relocation using an HSE/NPL phase-contrast test slide for each analyst/microscope combination. This procedure assures that the minimum detectable fiber diameter (<ca. 0.25ìm) for this microscope is achieved.		
Prior to ordering the Walton-Beckett graticule, calibration, in accordance with NIOSH 7400, Issue 2, 15 August 1994, Appendix A, shall be performed to obtain a counting area 100 ìm in diameter at the image plane. The diameter, dc (mm), of the circular counting area and the disc diameter shall be specified when ordering the graticule.		
The field diameter (D) shall be verified (or checked), to a tolerance of 100 ìm ± 2 ìm, with a stage micrometer upon receipt of the graticule from the manufacturer. When changes (zoom adjustment, disassembly, replacement, etc.) occur in the eyepiece-objective-reticle combination, field diameter shall be re-measured (or recalibrated) to determine field area (mm2). Recalibration of field diameter shall also be required when there is a change in interpupillary distance (i.e., change in analyst). Acceptable range for field area shall be 0.00754 mm2 to 0.00817 mm2. The actual field area shall be documented and used.		
Polarized Light Microscopy		
Microscope Alignment. To accurately measure the required optical properties, a properly aligned polarized light microscope (PLM) shall be utilized. The PLM shall be aligned before each use.		
Refractive Index Liquids. Series of nD = 1.49 through 1.72 in intervals less than or equal to 0.005. Refractive index liquids for dispersion staining, high-dispersion series 1.550, 1.605, 1.680. The accurate measurement of the refractive index (RI) of a substance requires the use of calibrated refractive index liquids. These liquids shall be calibrated at first use and semiannually, or next use, whichever is less frequent, to an accuracy of 0.004, with a temperature accuracy of 2°C using a refractometer or RI glass beads.		
Quality Control		
Negative Controls		

Transmission Electron Microscopy		
Water and Wastewater		
Blank determinations shall be made prior to sample collection. When using polyethylene bottles, one (1) bottle from each batch, or a minimum of one (1) from each twenty-four (24) shall be tested for background level. When using glass bottles, four (4) bottles from each twenty-four (24) shall be tested. An acceptable bottle blank level is defined as < 0.01 Million Fibers per Liter (MFL) > 10 ìm.		
A process blank sample consisting of fiber-free water shall be run before the first field sample. The quantity of water shall be > 10 mL for a 25-mm diameter filter and > 50 mL for a 47-mm diameter filter.		
Air		
A blank filter shall be prepared with each set of samples. A blank filter shall be left uncovered during preparation of the sample set and a wedge from that blank filter shall be prepared alongside wedges from the sample filters. At minimum, the blank filter shall be analyzed for each twenty (20) samples analyzed.		
Maximum contamination on a single blank filter shall be no more than 53 structures/mm2. Maximum average contamination for all blank filters shall be no more than 18 structures/mm2.		
Bulk Samples		
Contamination checks using asbestos-free material, such as the glass fiber blank in SRM 1866, shall be performed at a frequency of one for every twenty samples analyzed. The detection of asbestos at a concentration exceeding 0.1% will require an investigation to detect and remove the source of the asbestos contamination.		
The laboratory shall maintain a list of non-asbestos fibers that can be confused with asbestos. The list shall include crystallographic and/or chemical properties that disqualify each fiber being identified as asbestos.		
The laboratory shall have a set of reference asbestos materials, from which a set of reference diffraction and x-ray spectra may be developed.		
Phase Contrast Microscopy		
At least two field blanks (or 10% of the total samples, whichever is greater) shall be submitted for analysis with each set of samples. Field blanks shall be handled in a manner representative of actual handling of associated samples in the set with a single exception that air shall not be drawn through the blank sample.		

A blank cassette shall be opened for approximately thirty (30) seconds at the same time other cassettes are opened just prior to analysis.		
Results from field blank samples shall be used in the calculation to determine final airborne fiber concentration.		
The identity of blank filters shall be unknown to the counter until all counts have been completed.		
If a field blank yields greater than seven (7) fibers per one hundred (100) graticule fields, report possible contamination of the samples.		
Polarized Light Microscopy		
Friable Materials. At least one (1) blank slide shall be prepared daily or with every fifty (50) samples analyzed, whichever is less. This is prepared by mounting a sub-sample of an isotropic verified non-asbestos-containing material (non-ACM) (e.g., fiberglass in SRM 1866) in a drop of immersion oils normally used on a clean slide, rubbing preparation tools (forceps, dissecting needles, etc.) in the mount and placing a clean coverslip on the drop.		
The entire area under the coverslip shall be scanned to detect any asbestos contamination.		
A similar check shall be made after every twenty (20) uses of each piece of homogenization equipment.		
An isotropic verified non-ACM shall be homogenized in the clean equipment, a slide prepared with the material and the slide scanned for asbestos contamination. (This can be substituted for the blank slide mentioned in this Section.)		
Non-Friable Materials. At least one (1) non-ACM non-friable material shall be prepared and analyzed with every twenty (20) samples analyzed. This non-ACM shall go through the full preparation and analysis regimen for the type of analysis being performed.		
Test Variability/Reproducibility		
Transmission Electron Microscopy		
Quality assurance analyses shall be performed regularly covering all time periods, instruments, tasks, and personnel. The selection of samples shall be random and samples of special interest may be included in the selection of samples for quality assurance analyses. When possible, the checks on personnel performance shall be executed without their prior knowledge. A disproportionate number of analyses shall not be performed prior to internal or external audits. It is recommended that a laboratory initially be at 100% quality control (all samples re-analyzed). The proportion of quality control samples can later be lowered gradually, as control indicates, to a minimum of 10%.		

Water and Wastewater		
All analyses shall be performed on relocator grids so that other laboratories can easily repeat analyses on the same grid openings. Quality assurance analyses shall not be postponed during periods of heavy workloads.		
The total number of QA samples and blanks shall be greater than or equal to 10% of the total sample workload. Precision of analyses is related to concentration, as gleaned from inter-laboratory proficiency testing. Relative standard deviations (RSD) for amphibole asbestos decreased from 50% at 0.8 MFL to 25% at 7 MFL in inter-laboratory proficiency testing, while RSD for chrysotile was higher, 50% at 6 MFL.		
Replicate. A second, independent analysis shall be performed on the same grids but on different grid openings than used in the original analysis of a sample. Results shall be within 1.5x of Poisson standard deviation. This shall be performed at a frequency of one (1) per one hundred (100) samples.		
Duplicate. A second aliquot of sample shall be filtered through a second filter, prepared and analyzed in the same manner as the original preparation of that sample. Results shall be within 2.0x of Poisson standard deviation. This shall be performed at a frequency of one (1) per one hundred (100) samples.		
Verified Analyses. A second, independent analysis shall be performed on the same grids and grid openings used in the original analysis of a sample. The two sets of results shall be compared according to Turner and Steel (NISTIR 5351). This shall be performed at a frequency of one (1) per twenty (20) samples. Qualified analysts shall maintain an average of ≥ 80% true positives, ≤ 20% false negatives, and ≤ 10% false positives.		
Air		
All analyses shall be performed on relocator grids so that other laboratories can easily repeat analyses on the same grid openings.		
The laboratory and TEM analysts shall obtain mean analytical results on NIST SRM 1876b so that trimmed mean values fall within 80% of the lower limit and 110% of the upper limit of the 95% confidence limits as published on the certificate. These limits are derived from the allowable false positives and false negatives given in Section 1.7.3.1.1.c, Verified Analysis, below. SRM 1876b shall be analyzed a minimum of once per year by each TEM analyst.		
The laboratory shall have documentation demonstrating that TEM analysts correctly classify at least 90% of both bundles and single fibrils of asbestos structures greater than or equal to 1 µm in length in known standard materials traceable to NIST, such as NIST bulk asbestos SRM 1866.		
Inter-laboratory analyses shall be performed to detect laboratory bias. The frequency of inter-laboratory verified analysis shall correspond to a minimum of one (1) per two hundred (200) grid square analyses for clients.		
If more than one TEM is used for asbestos analysis, intermicroscope analyses shall be performed to detect instrument bias.		
Replicate. A second, independent analysis shall be performed in accordance with Section 1.7.3.1.1.a.		

Duplicate. A second wedge from a sample filter shall be prepared and analyzed in the same manner as the original preparation of that sample. Results shall be within 2.0x of Poisson standard deviation. This shall be performed at a frequency of one (1) per one hundred (100) samples.		
Verified Analyses. A second, independent analysis shall be performed on the same grids and grid openings in accordance with Section 1.7.3.1.1.c.		
Bulk Samples		
Bulk samples with low (< 10%) asbestos content are the most problematic. At least 30% of a laboratory's QC analyses shall be performed on samples containing from 1% to 10% asbestos.		
Intra-Analyst Precision. At least one (1) out of fifty (50) samples shall be re-analyzed by the same analyst. For single analyst laboratories, at least one (1) out of every ten (10) samples shall be re-analyzed by the same analyst.		
Inter-Analyst Precision. At least one (1) out of fifteen (15) samples shall be re-analyzed by another analyst. Inter-analyst results will require additional re-analysis, possibly including another analyst, to resolve discrepancies when classification (ACM vs. non-ACM) errors occur, when asbestos identification errors occur, or when inter-analyst precision is found to be unacceptable.		
Inter-Laboratory Precision. The laboratory shall participate in round robin testing with at least one (1) other laboratory. Samples shall be sent to this other laboratory at least four (4) times per year.		
These samples shall be samples previously analyzed as QC samples.		
Results of these analyses shall be assessed in accordance with QC requirements.		
The QC requirements shall address misclassifications (false positives, false negatives) and misidentification of asbestos types.		
Phase Contrast Microscopy		
Inter-Laboratory Precision. Each laboratory analyzing air samples for compliance determination shall implement an inter-laboratory quality assurance program that includes participation of at least two (2) other independent laboratories. Each laboratory shall participate in round robin testing at least once every six months with at least all the other laboratories in its inter-laboratory quality assurance group.		
Each laboratory shall submit slides typical of its own workload for use in this program.		
The round robin shall be designed and results analyzed using appropriate statistical methodology.		
Results of this QA program shall be posted in each laboratory to keep the microscopists informed.		

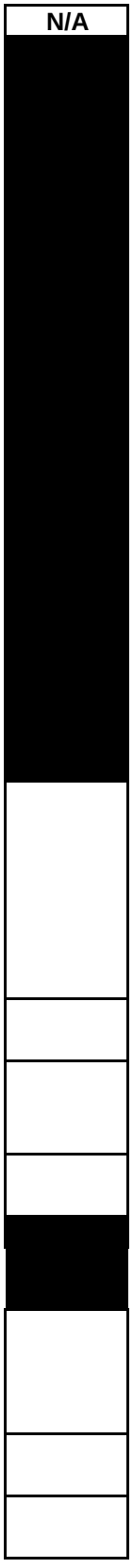
Intra- and Inter-Analyst Precision. Each analyst shall select and count a prepared slide from a “reference slide library” on each day on which air counts are performed. Reference slides shall be prepared using well-behaved samples taken from the laboratory workload. Fiber densities shall cover the entire range routinely analyzed by the laboratory. These slides shall be counted by all analysts to establish an original standard deviation and corresponding limits of acceptability. Results from the daily reference sample analysis shall be compared to the statistically derived acceptance limits using a control chart or a database. It is recommended that the labels on the reference slides be periodically changed so that the analysts do not become familiar with the samples. Intra- and inter-analyst precision may be estimated from blind recounts on reference samples. Inter-analyst precision shall be posted in each laboratory to keep the microscopists informed.		
Polarized Light Microscopy		
Refer to Section 1.7.3.1.3		
Other Quality Control Measures		
Transmission Electron Microscopy		
Water and Wastewater		
Filter preparations shall be made from all six (6) asbestos types from NIST SRMs 1866 and 1867. These preparations shall have concentrations between one (1) and twenty (20) structures (>10µm) per 0.01 mm2. One of these preparations shall be analyzed independently at a frequency of one (1) per one hundred (100) samples analyzed. Results shall be evaluated as verified asbestos analysis in accordance with S. Turner and E.B. Steel, NISTIR 5351, Airborne Asbestos Method: Standard Test Method for Verified Analysis of Asbestos by Transmission Electron Microscopy – Version 2.0, 1994.		
NIST SRM 1876b shall be analyzed annually by each analyst. Results shall be evaluated in accordance with limits published for that SRM.		
Air		
Filter preparations shall be made from all six (6) asbestos types in accordance with Section 1.7.4.1.a)i.		
NIST SRM 1876b shall be analyzed annually.		
Bulk Samples		

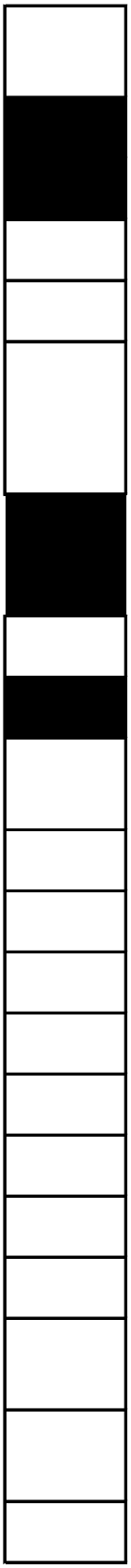
All analysts shall be able to correctly identify the six (6) regulated asbestos types (chrysotile, amosite, crocidolite, anthophyllite, actinolite, and tremolite). Standards for the six (6) asbestos types listed are available from NIST (SRMs 1866 and 1867).		
Phase Contrast Microscopy		
Test for Non-Random Fiber Distribution. Blind recounts by the same analyst shall be performed on 10% of the filters counted. A person other than the counter shall re-label slides before the second count. A test for type II error shall be performed to determine whether a pair of counts by the same analyst on the same slide shall be rejected due to non-random fiber distribution. If a pair of counts is rejected by this test, the remaining samples in the set shall be recounted and the new counts shall be tested against first counts. All rejected paired counts shall be discarded.		
It shall not be necessary to use this statistic on blank recounts.		
All laboratories shall participate in a national sample testing scheme such as the Proficiency Analytical Testing (PAT) program or the Asbestos Analysts Registry (AAR) program, both sponsored by the American Industrial Hygiene Association (AIHA).		
Polarized Light Microscopy		
Friable Materials. Because accuracy cannot be determined by re-analysis of routine field samples, at least one (1) out of one hundred (100) samples shall be a standard or reference sample that has been routinely resubmitted to determine analyst's precision and accuracy. A set of these samples may be accumulated from proficiency testing samples with predetermined weight compositions or from standards generated with weighed quantities of asbestos and other bulk materials. At least half of the reference samples submitted for this QC shall contain between 1 and 10% asbestos.		
Non-Friable Materials. At least one (1) out of one hundred (100) samples shall be a verified quantitative standard that has routinely been resubmitted to determine analyst precision and accuracy.		
Analytical Sensitivity		
Transmission Electron Microscopy		
Water and Wastewater		
An analytical sensitivity of 200,000 fibers per liter (0.2 MFL) is required for each sample analyzed. Analytical sensitivity is defined as the waterborne concentration represented by the finding of one asbestos structure in the total area of filter examined. This value will depend on the fraction of the filter sampled and the dilution factor (if applicable).		
Air		

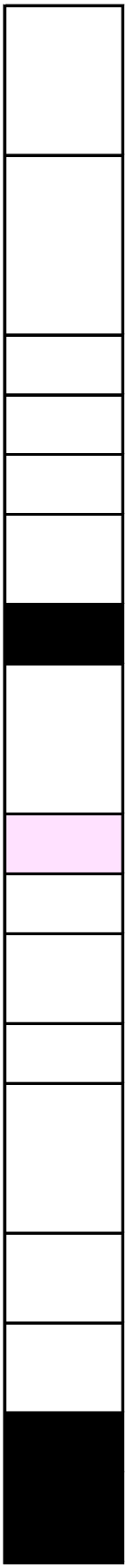
An analytical sensitivity of 0.005 structures/cm2 is required for each sample analyzed. Analytical sensitivity is defined as the airborne concentration represented by the finding of one asbestos structure in the total area of filter examined. This value will depend on the effective surface area of the filter, the filter area analyzed, and the volume of air sampled.		
Bulk Samples		
The range is dependent on the type of bulk material being analyzed. The sensitivity may be as low as 0.0001%.		
Phase Contrast Microscopy		
The normal quantitative working range of the method is 0.04 to 0.5 fiber/ cm2 for a 1000 L air sample. An ideal counting range on the filter shall be 100 to 1300 fibers/mm2. The limit of detection (LOD) is estimated to be 5.5 fibers per 100 fields or 7 fibers/mm2. The LOD in fiber/cc will depend on sample volume and quantity of interfering dust but shall be <0.01 fiber/cm2 for atmospheres free of interferences.		
Polarized Light Microscopy		
The laboratory shall utilize a method that provides a limit of detection that is appropriate and relevant for the intended use of the data. Limit of detection shall be determined by the protocol in the method or applicable regulation.		
Quality of Standards and Reagents		
Transmission Electron Microscopy		
The quality control program shall establish and maintain provisions for asbestos standards.		
Reference standards that are used in an asbestos laboratory shall be obtained from NIST, EPA, or suppliers who participate in supplying NIST standards or NIST traceable asbestos. Any reference standards purchased outside the United States shall be traceable back to each country's national standards laboratory. Commercial suppliers of reference standards shall conform to ANSI N42.22 to assure the quality of their products.		
Reference standards shall be accompanied with a certificate of calibration whose content is as described in ANSI N42.22-1995, Section 8, Certificates.		
All reagents used shall be analytical reagent grade or better.		
The laboratory shall have mineral fibers or data from mineral fibers that will allow differentiating asbestos from at least the following "look-alikes": fibrous talc, sepiolite, wollastonite, attapulgite (palygorskite), halloysite, vermiculite scrolls, antigorite, lizardite, pyroxenes, hornblende, richterite, winchite, or any other asbestiform minerals that are suspected as being present in the sample.		
Phase Contrast Microscopy		

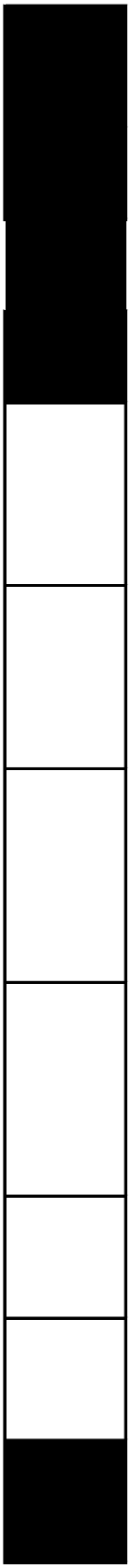
Standards of known concentration have not been developed for this testing method. Routine workload samples that have been statistically validated and national proficiency testing samples such as Proficiency Analytical Testing (PAT) and Asbestos Analysts Registry (AAR) samples available from the American Industrial Hygiene Association (AIHA) may be utilized as reference samples (refer to Section D.6.2.2 b) to standardize the optical system and analyst.		
All other testing reagents and devices (HSE/NPL test slide and Walton-Beckett Graticule) shall conform to the specifications of the method (refer to National Institute for Occupational Safety and Health (NIOSH) 7400, Issue 2, 15 August 1994).		
Polarized Light Microscopy		
Refer to Section 1.7.6.1.		
Data Acceptance/Rejection Criteria		
Transmission Electron Microscopy		
Water and Wastewater		
The concentration of asbestos in a given sample shall be calculated in accordance with EPA/600/R-94/134, Method 100.2, Section 12.1.		
Measurement Uncertainties. The laboratory shall calculate and report the upper and lower 95% confidence limits on the mean concentration of asbestos fibers found in the sample.		
Air		
The concentration of asbestos in a given sample shall be calculated in accordance with the method utilized.		
Measurement Uncertainties. The laboratory shall calculate and report the upper and lower 95% confidence limits on the mean concentration of asbestos fibers found in the sample.		
Bulk Samples		
The concentration of asbestos in a given sample shall be calculated in accordance with the method utilized (e.g., EPA/600/R-93/116, July 1993).		
Measurement Uncertainties. Proficiency testing for floor tiles analyzed by TEM following careful gravimetric reduction has revealed an inter-laboratory standard deviation of approximately 20% for residues containing 70% or more asbestos. Standard deviations range from 20% to 60% for residues with lower asbestos content.		

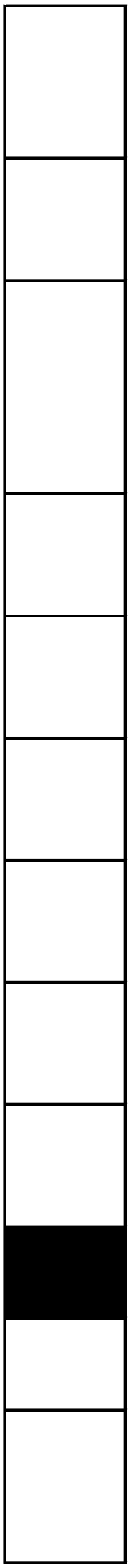
Phase Contrast Microscopy		
Airborne fiber concentration in a given sample shall be calculated in accordance with NIOSH 7400, Issue 2, 15 August 1994, Sections 20 and 21.		
Measurement Uncertainties. The laboratory shall calculate and report the intra-laboratory and inter-laboratory relative standard deviation with each set of results (NIOSH 7400, Issue 2, 15 August 1994).		
Fiber counts above 1300 fibers/mm2 and fiber counts from samples with >50% of the filter area covered with particulate shall be reported as “uncountable” or “probably biased”. Other fiber counts outside the 100-1300 fibers/mm2 range shall be reported as having “greater than optimal variability” and as being “probably biased”.		
Polarized Light Microscopy		
The concentration of asbestos in a given sample shall be calculated in accordance with the method utilized (e.g., EPA/600/R-93/116, July 1993).		
Method Uncertainties. Precision and accuracy shall be determined by the individual laboratory for the percent range involved. If point counting and/or visual estimates are used, a table of reasonable expanded errors shall be generated for different concentrations of asbestos.		
Constant and Consistent Test Conditions Sample and Sampling Requirements		
Samples shall be transported to the laboratory as soon as possible after collection.		
Date and time of sampling shall be noted on submittal forms.		
The names of the collectors with their signatures and the site shall be included on the chain-of-custody forms. No preservatives are required during sampling.		
The laboratory shall establish and adhere to written procedures to minimize the possibility of cross contamination between samples.		
Refer to the specific method of analysis for additional requirements.		

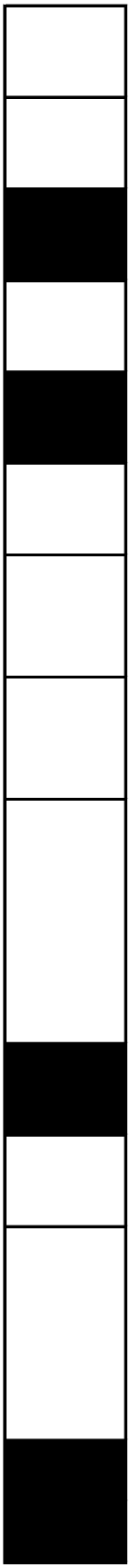

N/A

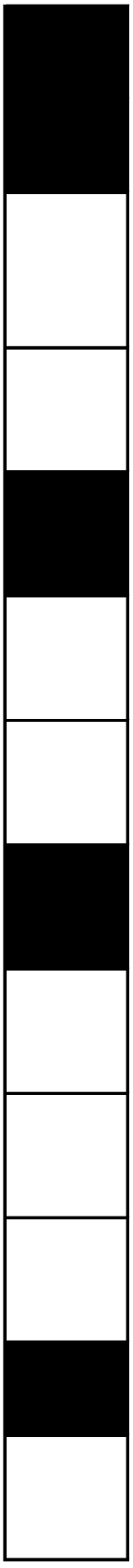


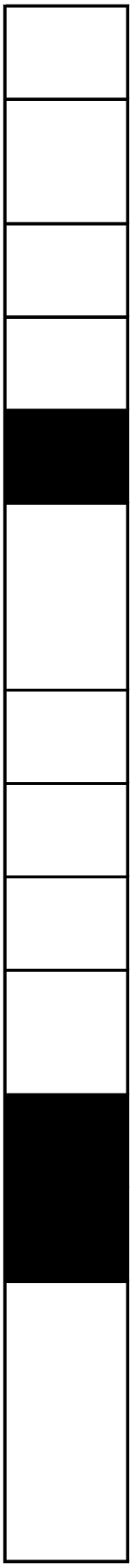


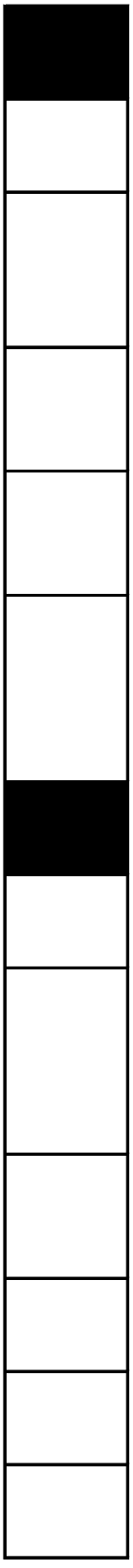


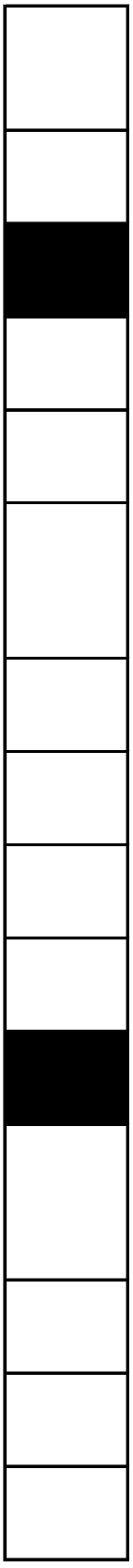


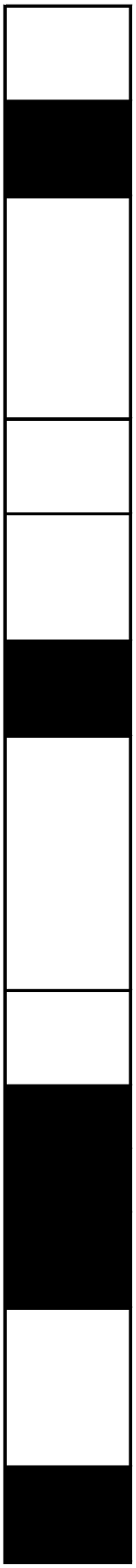


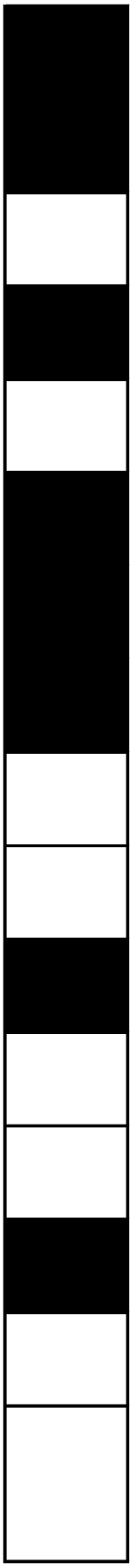


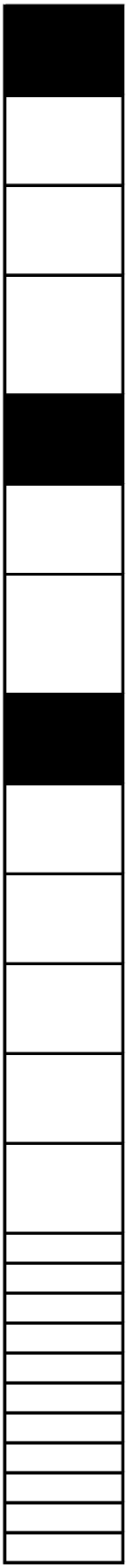












ID	Major Topic	Topic	Subject	Category	Citation
1015					V1M4 1
1016	1.1 Introduction				V1M4 1.1
1017	1.1 Introduction				V1M4 1.1
1018	1.2 Scope				V1M4 1.2
1019	1.2 Scope				V1M4 1.2
1020	1.3 Terms and Definitions				V1M4 1.3
1021	1.3 Terms and Definitions				V1M4 1.3
1022	1.3 Terms and Definitions				V1M4 1.3.1
1023	1.3 Terms and Definitions				V1M4 1.3.1
1024	1.3 Terms and Definitions				V1M4 1.3.2
1025	1.3 Terms and Definitions				V1M4 1.3.2
1026	1.4 Method Selection				V1M4 1.4
1027	1.4 Method Selection	Reference Method	Regulatory	Definition	V1M4 1.4
1028	1.4 Method Selection	Reference Method	Regulatory	Requirement	V1M4 1.4
1029	1.4 Method Selection	Reference Method	QC	Requirement	V1M4 1.4
1030	1.4 Method Selection	Added Analytes	Identification	Requirement	
1031	1.4 Method Selection	Non Reference Methods	Customer Communication	Requirement	V1M4 1.4
1032	1.4 Method Selection	Non Reference Methods	Validation	Requirement	V1M4 1.4
1033	1.5 Method Validation				V1M4 1.5

1034	1.5 Method Validation	1.5.1 General			V1M4 1.5.1
1035	1.5 Method Validation	1.5.1 General	Reference Methods	Requirement	V1M4 1.5.1 a)
1036	1.5 Method Validation	1.5.1 General	Non Reference Methods	Requirement	V1M4 1.5.1 b)
1037	1.5 Method Validation	1.5.2 LOD/LOQ			V1M4 1.5.2
1038	1.5 Method Validation	1.5.2 LOD/LOQ	Documentation	Procedure	V1M4 1.5.2
1039	1.5 Method Validation	1.5.2.1 LOD			V1M4 1.5.2.1
1040	1.5 Method Validation	1.5.2.1 LOD	LOD Study	Exception	V1M4 1.5.2.1
1041	1.5 Method Validation	1.5.2.1 LOD	Appropriateness	Requirement	V1M4 1.5.2.1
1042	1.5 Method Validation	1.5.2.1 LOD	Mandated Procedure	Requirement	V1M4 1.5.2.1
1043	1.5 Method Validation	1.5.2.1 LOD	Selected Procedure	Record	V1M4 1.5.2.1
1044	1.5 Method Validation	1.5.2.1 LOD	Processing	Requirement	V1M4 1.5.2.1
1045	1.5 Method Validation	1.5.2.1 LOD	Verification	Requirement	V1M4 1.5.2.1 a)
1046	1.5 Method Validation	1.5.2.1 LOD	Verification Procedure	Requirement	V1M4 1.5.2.1 b)
1047	1.5 Method Validation	1.5.2.1 LOD	Extent of Verification	Requirement	V1M4 1.5.2.1 b)
1048	1.5 Method Validation	1.5.2.1 LOD	LOD Study	Exception	V1M4 1.5.2.1 c)
1049	1.5 Method Validation	1.5.2.1 LOD	Initial Determination	Requirement	V1M4 1.5.2.1 d)
1050	1.5 Method Validation	1.5.2.1 LOD	Frequency	Requirement	V1M4 1.5.2.1 e)
1051	1.5 Method Validation	1.5.2.1 LOD	Frequency	Requirement	V1M4 1.5.2.1 f)

1052	1.5 Method Validation	1.5.2.2 LOQ			V1M4 1.5.2.2
1053	1.5 Method Validation	1.5.2.2 LOQ	Processing	Requirement	V1M4 1.5.2.2 a)
1054	1.5 Method Validation	1.5.2.2 LOQ	LOQ Study	Exception	V1M4 1.5.2.2 b)
1055	1.5 Method Validation	1.5.2.2 LOQ	Verification	Requirement	V1M4 1.5.2.2 c)
1056	1.5 Method Validation	1.5.2.2 LOQ	Verification	Exception	V1M4 1.5.2.2 d)
1057	1.5 Method Validation	1.5.2.2 LOQ	Frequency	Requirement	V1M4 1.5.2.2 e)
1058	1.5 Method Validation	1.5.3 Precision & Bias			V1M4 1.5.3
1059	1.5 Method Validation	1.5.3 Precision & Bias	Reference Methods	Requirement	V1M4 1.5.3 a)
1060	1.5 Method Validation	1.5.3 Precision & Bias	Non Reference Methods	Requirement	V1M4 1.5.3 b)
1061	1.5 Method Validation	1.5.3 Precision & Bias	Non Reference Methods	Requirement	V1M4 1.5.3 b)
1062	1.5 Method Validation	1.5.3 Precision & Bias	Non Reference Methods		V1M4 1.5.3 b)
1063	1.5 Method Validation	1.5.3 Precision & Bias	Non Reference Methods	Option	V1M4 1.5.3 b) i.
1064	1.5 Method Validation	1.5.3 Precision & Bias	Non Reference Methods	Option	V1M4 1.5.3 b) ii.

1065	1.5 Method Validation	1.5.4 Selectivity			V1M4 1.5.4
1066	1.5 Method Validation	1.5.4 Selectivity	Method Specified	Requirement	V1M4 1.5.4
1067	1.6 DOC				V1M4 1.6
1068	1.6 DOC	1.6.1 General			V1M4 1.6.1
1069	1.6 DOC	1.6.1 General	Initial DOC	Requirement	V1M4 1.6.1
1070	1.6 DOC	1.6.1 General	Ongoing DOC	Requirement	V1M4 1.6.1
1071	1.6 DOC	1.6.1 General	DOC	Exception	V1M4 1.6.1
1072	1.6 DOC	1.6.1 General	DOC	Record	V1M4 1.6.1
1073	1.6 DOC	1.6.1 General	Documentation	Record	V1M4 1.6.1
1074	1.6 DOC	1.6.1 General	Frequency	Requirement	V1M4 1.6.1
1075	1.6 DOC	1.6.1 General	Documentation	Requirement	V1M4 1.6.1
1076	1.6 DOC	1.6.1 General	Data	Record	V1M4 1.6.1
1077	1.6 DOC	1.6.2 Initial DOC			V1M4 1.6.2
1078	1.6 DOC	1.6.2 Initial DOC	DOC Frequency	Requirement	V1M4 1.6.2
1079	1.6 DOC	1.6.2 Initial DOC	Documentation	Record	V1M4 1.6.2.1
1080	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents	V1M4 1.6.2.1 a)
1081	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents	V1M4 1.6.2.1 b)
1082	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents	V1M4 1.6.2.1 c)
1083	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents	V1M4 1.6.2.1 d)
1084	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents	V1M4 1.6.2.1 e)
1085	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents	V1M4 1.6.2.1 f)
1086	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents	V1M4 1.6.2.1 g)
1087	1.6 DOC	1.6.2 Initial DOC	Procedure	Option	V1M4 1.6.2.2
1088	1.6 DOC	1.6.2 Initial DOC	Procedure	Option	V1M4 1.6.2.2 a)
1089	1.6 DOC	1.6.2 Initial DOC	Procedure	Option	V1M4 1.6.2.2 b)

1090	1.6 DOC	1.6.2 Initial DOC	Procedure	Option	V1M4 1.6.2.2 c)
1091	1.6 DOC	1.6.2 Initial DOC	Procedure	Option	V1M4 1.6.2.2 d)
1092	1.6 DOC	1.6.2 Initial DOC	Procedure	Option	V1M4 1.6.2.2 e)
1093	1.6 DOC	1.6.2 Initial DOC	Procedure	Option	V1M4 1.6.2.2 e) i.
1094	1.6 DOC	1.6.2 Initial DOC	Procedure	Option	V1M4 1.6.2.2 e) ii.
1095	1.6 DOC	1.6.2 Initial DOC	Procedure	Option	V1M4 1.6.2.2 f)
1096	1.6 DOC	1.6.2 Initial DOC	Added Analyte	Requirement	V1M4 1.6.2.2 g)
1097	1.6 DOC	1.6.3 Ongoing DOC			V1M4 1.6.3
1098	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Requirement	V1M4 1.6.3.1
1099	1.6 DOC	1.6.3 Ongoing DOC			V1M4 1.6.3.2
1100	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option	V1M4 1.6.3.2 a)
1101	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option	V1M4 1.6.3.2 a)
1102	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option	V1M4 1.6.3.2 b)
1103	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option	V1M4 1.6.3.2 c)
1104	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option	V1M4 1.6.3.2 d)
1105	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option	V1M4 1.6.3.2 e)
1106	1.7 Technical Requirement				V1M4 1.7

1107	1.7 Technical Requirement	1.7.1.Initial Calibration			V1M4 1.7.1
1108	1.7 Technical Requirement	1.7.1.Initial Calibration			V1M4 1.7.1.1
1109	1.7 Technical Requirement	1.7.1.Initial Calibration			V1M4 1.7.1.1
1110	1.7 Technical Requirement	1.7.1.Initial Calibration	Multiple/Conflicting Requirements	Requirement	V1M4 1.7.1.1
1111	1.7 Technical Requirement	1.7.1.Initial Calibration	Essential Elements		V1M4 1.7.1.1
1112	1.7 Technical Requirement	1.7.1.Initial Calibration	Process	Procedure	V1M4 1.7.1.1 a)
1113	1.7 Technical Requirement	1.7.1.Initial Calibration	Data	Record	V1M4 1.7.1.1 b)
1114	1.7 Technical Requirement	1.7.1.Initial Calibration	Quantitation	Requirement	V1M4 1.7.1.1 c)
1115	1.7 Technical Requirement	1.7.1.Initial Calibration	Second Source Standard	Requirement	V1M4 1.7.1.1 d)
1116	1.7 Technical Requirement	1.7.1.Initial Calibration	Acceptance Criteria	Requirement	V1M4 1.7.1.1 e)
1117	1.7 Technical Requirement	1.7.1.Initial Calibration	Lowest Calibration Concentration	Requirement	V1M4 1.7.1.1 f)
1118	1.7 Technical Requirement	1.7.1.Initial Calibration	Highest Calibration Concentration	Requirement	V1M4 1.7.1.1 g)
1119	1.7 Technical Requirement	1.7.1.Initial Calibration	One-Point Calibration	Requirement	V1M4 1.7.1.1 h)
1120	1.7 Technical Requirement	1.7.1.Initial Calibration	One-Point Calibration	Requirement	V1M4 1.7.1.1 h) i.

1121	1.7 Technical Requirement	1.7.1.Initial Calibration	One-Point Calibration	Requirement	V1M4 1.7.1.1 h) ii.
1122	1.7 Technical Requirement	1.7.1.Initial Calibration	One-Point Calibration	Requirement	V1M4 1.7.1.1 h) iii.
1123	1.7 Technical Requirement	1.7.1.Initial Calibration	One-Point Calibration	Requirement	V1M4 1.7.1.1 h) iv.
1124	1.7 Technical Requirement	1.7.1.Initial Calibration	Corrective Actions	Requirement	V1M4 1.7.1.1 i)
1125	1.7 Technical Requirement	1.7.1.Initial Calibration	Minimum Calibration Points	Requirement	V1M4 1.7.1.1 j)
1126	1.7 Technical Requirement	1.7.2 Continuing Calibration			V1M4 1.7.2
1127	1.7 Technical Requirement	1.7.2 Continuing Calibration	Frequency	Requirement	V1M4 1.7.2
1128	1.7 Technical Requirement	1.7.2 Continuing Calibration	Documentation	Procedure	V1M4 1.7.2 a)
1129	1.7 Technical Requirement	1.7.2 Continuing Calibration	Extent of Verification	Requirement	V1M4 1.7.2 b)
1130	1.7 Technical Requirement	1.7.2 Continuing Calibration	CC Performance		V1M4 1.7.2 c)
1131	1.7 Technical Requirement	1.7.2 Continuing Calibration	Batch Frequency	Requirement	V1M4 1.7.2 c) i.
1132	1.7 Technical Requirement	1.7.2 Continuing Calibration	Time Frequency	Requirement	V1M4 1.7.2 c) ii.
1133	1.7 Technical Requirement	1.7.2 Continuing Calibration	Method Frequency	Requirement	V1M4 1.7.2 c) iii.
1134	1.7 Technical Requirement	1.7.2 Continuing Calibration	Calibration Reconstruction	Record	V1M4 1.7.2 d)
1135	1.7 Technical Requirement	1.7.2 Continuing Calibration	Acceptance Criteria	Requirement	V1M4 1.7.2 e)
1136	1.7 Technical Requirement	1.7.2 Continuing Calibration	Corrective Actions	Requirement	V1M4 1.7.2 e)
1137	1.7 Technical Requirement	1.7.2 Continuing Calibration	Verification of Correction Action	Requirement	V1M4 1.7.2 e)
1138	1.7 Technical Requirement	1.7.2 Continuing Calibration	Process without verified calibration	Requirement	V1M4 1.7.2 e)

1139	1.7 Technical Requirement	1.7.2 Continuing Calibration	Process without verified calibration	Requirement	V1M4 1.7.2 e)
1140	1.7 Technical Requirement	1.7.2 Continuing Calibration	Process without verified calibration	Requirement	V1M4 1.7.2 e)
1141	1.7 Technical Requirement	1.7.2 Continuing Calibration	Data Usability	Option	V1M4 1.7.2 e) i.
1142	1.7 Technical Requirement	1.7.2 Continuing Calibration	Data Usability	Option	V1M4 1.7.2 e) ii.
1143	1.7 Technical Requirement	1.7.3 QC			V1M4 1.7.3
1144	1.7 Technical Requirement				V1M4 1.7.3
1145	1.7 Technical Requirement	1.7.3.1 Negative Control			V1M4 1.7.3.1
1146	1.7 Technical Requirement	1.7.3.1 Negative Control	Method Blank Processing	Requirement	V1M4 1.7.3.1 a)
1147	1.7 Technical Requirement	1.7.3.1 Negative Control	Method Blank Processing	Requirement	V1M4 1.7.3.1 a)
1148	1.7 Technical Requirement	1.7.3.1 Negative Control	Blank Assessment	Procedure	V1M4 1.7.3.1 a)
1149	1.7 Technical Requirement	1.7.3.1 Negative Control	Reporting	Requirement	V1M4 1.7.3.1 a)
1150	1.7 Technical Requirement	1.7.3.1 Negative Control	Frequency	Requirement	V1M4 1.7.3.1 b)
1151	1.7 Technical Requirement	1.7.3.1 Negative Control	Frequency	Requirement	V1M4 1.7.3.1 b)
1152	1.7 Technical Requirement	1.7.3.1 Negative Control	Matrix Attributes	Requirement	V1M4 1.7.3.1 c)
1153	1.7 Technical Requirement	1.7.3.1 Negative Control	Performing	Exception	V1M4 1.7.3.1 d)
1154	1.7 Technical Requirement	1.7.3.2 Positive Controls			V1M4 1.7.3.2
1155	1.7 Technical Requirement	1.7.3.2 Positive Controls	Purpose and Use	Requirement	V1M4 1.7.3.2.1
1156	1.7 Technical Requirement	1.7.3.2 Positive Controls	Frequency	Requirement	V1M4 1.7.3.2.2

1157	1.7 Technical Requirement	1.7.3.2 Positive Controls	Performance	Exception	V1M4 1.7.3.2.2
1158	1.7 Technical Requirement	1.7.3.2 Positive Controls	Frequency	Requirement	V1M4 1.7.3.2.2
1159	1.7 Technical Requirement	1.7.3.2 Positive Controls	Matrix Attributes	Requirement	V1M4 1.7.3.2.3
1160	1.7 Technical Requirement	1.7.3.2 Positive Controls	Substitution	Option	V1M4 1.7.3.2.3
1161	1.7 Technical Requirement	1.7.3.2 Positive Controls	CRM	Option	V1M4 1.7.3.2.3
1162	1.7 Technical Requirement	1.7.3.2 Positive Controls	Spike Components	Requirement	V1M4 1.7.3.2.3
1163	1.7 Technical Requirement	1.7.3.2 Positive Controls	Spike Components	Option	V1M4 1.7.3.2.3 a)
1164	1.7 Technical Requirement	1.7.3.2 Positive Controls	Spike Components	Option	V1M4 1.7.3.2.3 b)
1165	1.7 Technical Requirement	1.7.3.2 Positive Controls	Multi Analytes Methods	Requirement	V1M4 1.7.3.2.3 b)
1166	1.7 Technical Requirement	1.7.3.2 Positive Controls	Multi Analytes Methods	Option	V1M4 1.7.3.2.3 b) i.
1167	1.7 Technical Requirement	1.7.3.2 Positive Controls	Multi Analytes Methods	Option	V1M4 1.7.3.2.3 b) ii.
1168	1.7 Technical Requirement	1.7.3.2 Positive Controls	Multi Analytes Methods	Option	V1M4 1.7.3.2.3 b) iii.
1169	1.7 Technical Requirement	1.7.3.3 Sample Specific Controls			V1M4 1.7.3.3
1170	1.7 Technical Requirement	1.7.3.3 Sample Specific Controls	Documentation	Procedure	V1M4 1.7.3.3
1171	1.7 Technical Requirement	1.7.3.3 Sample Specific Controls	Documentation	Procedure	V1M4 1.7.3.3
1172	1.7 Technical Requirement	1.7.3.3.1 MS/MSD	MS/MSD		V1M4 1.7.3.3.1

1173	1.7 Technical Requirement	1.7.3.3.1 MS/MSD	Use	Requirement	V1M4 1.7.3.3.1 a)
1174	1.7 Technical Requirement	1.7.3.3.1 MS/MSD	Frequency	Requirement	V1M4 1.7.3.3.1 b)
1175	1.7 Technical Requirement	1.7.3.3.1 MS/MSD	Spike Components	Requirement	V1M4 1.7.3.3.1 c)
1176	1.7 Technical Requirement	1.7.3.3.1 MS/MSD	Multi-peak Components	Requirement	V1M4 1.7.3.3.1 c)
1177	1.7 Technical Requirement	1.7.3.3.1 MS/MSD	Spike Components	Requirement	V1M4 1.7.3.3.1 c)
1178	1.7 Technical Requirement	1.7.3.3.1 MS/MSD	Spike Components	Option	V1M4 1.7.3.3.1 c) i.
1179	1.7 Technical Requirement	1.7.3.3.1 MS/MSD	Spike Components	Option	V1M4 1.7.3.3.1 c) ii.
1180	1.7 Technical Requirement	1.7.3.3.1 MS/MSD	Spike Components	Option	V1M4 1.7.3.3.1 c) iii.
1181	1.7 Technical Requirement	1.7.3.3.2 Matrix Duplicates			V1M4 1.7.3.3.2
1182	1.7 Technical Requirement	1.7.3.3.2 Matrix Duplicates	Use		V1M4 1.7.3.3.2 a)
1183	1.7 Technical Requirement	1.7.3.3.2 Matrix Duplicates	Frequency	Requirement	V1M4 1.7.3.3.2 b)
1184	1.7 Technical Requirement	1.7.3.3.2 Matrix Duplicates	Origin	Requirement	V1M4 1.7.3.3.2 c)
1185	1.7 Technical Requirement	1.7.3.3.3 Surrogate Spikes			V1M4 1.7.3.3.3
1186	1.7 Technical Requirement	1.7.3.3.3 Surrogate Spikes	Preparation	Requirement	V1M4 1.7.3.3.3 a)
1187	1.7 Technical Requirement	1.7.3.3.3 Surrogate Spikes	Extent	Requirement	V1M4 1.7.3.3.3 b)
1188	1.7 Technical Requirement	1.7.3.3.3 Surrogate Spikes	Source	Requirement	V1M4 1.7.3.3.3 c)
1189	1.7 Technical Requirement	1.7.3.4 Data Reduction			V1M4 1.7.3.4
1190	1.7 Technical Requirement	1.7.3.4 Data Reduction	Documentation	Procedure	V1M4 1.7.3.4
1191	1.7 Technical Requirement	1.7.3.5 Reagent & Water Quality			V1M4 1.7.3.5

1192	1.7 Technical Requirement	1.7.3.5 Reagent & Water Quality	Grade	Requirement	V1M4 1.7.3.5 a)
1193	1.7 Technical Requirement	1.7.3.5 Reagent & Water Quality	Water Monitoring	Requirement	V1M4 1.7.3.5 b)
1194	1.7 Technical Requirement	1.7.3.5 Reagent & Water Quality	Titrant Verification	Requirement	V1M4 1.7.3.5 c)
1195	1.7 Technical Requirement	1.7.3.6 Selectivity			V1M4 1.7.3.6
1196	1.7 Technical Requirement	1.7.3.6 Selectivity	Documentation	Procedure	V1M4 1.7.3.6
1197	1.7 Technical Requirement	1.7.4 Acceptance/Rejection Criteria			V1M4 1.7.4
1198	1.7 Technical Requirement	1.7.4.1 Negative Control			V1M4 1.7.4.1
1199	1.7 Technical Requirement	1.7.4.1 Negative Control	Evaluation	Requirement	V1M4 1.7.4.1
1200	1.7 Technical Requirement	1.7.4.1 Negative Control	Investigation	Requirement	V1M4 1.7.4.1
1201	1.7 Technical Requirement	1.7.4.1 Negative Control	Data Qualifiers	Requirement	V1M4 1.7.4.1 a)
1202	1.7 Technical Requirement	1.7.4.1 Negative Control	Data Qualifiers	Requirement	V1M4 1.7.4.1 b)
1203	1.7 Technical Requirement	1.7.4.1 Negative Control	Investigation	Requirement	V1M4 1.7.4.1 c)
1204	1.7 Technical Requirement	1.7.4.2 Positive Control			V1M4 1.7.4.2
1205	1.7 Technical Requirement	1.7.4.2 Positive Control	Calculation	Requirement	V1M4 1.7.4.2 a)
1206	1.7 Technical Requirement	1.7.4.2 Positive Control	Evaluation	Requirement	V1M4 1.7.4.2 a)
1207	1.7 Technical Requirement	1.7.4.2 Positive Control	Unacceptable Results	Requirement	V1M4 1.7.4.2 a)
1208	1.7 Technical Requirement	1.7.4.2 Positive Control	Unacceptable Results	Option	V1M4 1.7.4.2 a) i.

1209	1.7 Technical Requirement	1.7.4.2 Positive Control	Unacceptable Results	Option	V1M4 1.7.4.2 a) ii.
1210	1.7 Technical Requirement	1.7.4.2 Positive Control	Allowable Marginal Exceedances	Requirement	V1M4 1.7.4.2 b)
1211	1.7 Technical Requirement	1.7.4.2 Positive Control	Allowable Marginal Exceedances		V1M4 1.7.4.2 b)
1212	1.7 Technical Requirement	1.7.4.2 Positive Control	Allowable Marginal Exceedances	Option	V1M4 1.7.4.2 b)
1213	1.7 Technical Requirement	1.7.4.2 Positive Control	Allowable Marginal Exceedances	Option	V1M4 1.7.4.2 b)
1214	1.7 Technical Requirement	1.7.4.2 Positive Control	Allowable Marginal Exceedances	Option	V1M4 1.7.4.2 b)
1215	1.7 Technical Requirement	1.7.4.2 Positive Control	Allowable Marginal Exceedances	Option	V1M4 1.7.4.2 b)
1216	1.7 Technical Requirement	1.7.4.2 Positive Control	Allowable Marginal Exceedances	Option	V1M4 1.7.4.2 b)
1217	1.7 Technical Requirement	1.7.4.2 Positive Control	Allowable Marginal Exceedances	Option	V1M4 1.7.4.2 b)
1218	1.7 Technical Requirement	1.7.4.2 Positive Control	Corrective Actions	Requirement	V1M4 1.7.4.2 b)
1219	1.7 Technical Requirement	1.7.4.3 Sample Specific Controls			V1M4 1.7.4.3
1220	1.7 Technical Requirement	1.7.4.3a MS/MSD			V1M4 1.7.4.3 a)
1221	1.7 Technical Requirement	1.7.4.3a MS/MSD	Documentation	Procedure	V1M4 1.7.4.3 a)
1222	1.7 Technical Requirement	1.7.4.3a MS/MSD	Evaluation	Requirement	V1M4 1.7.4.3 a)
1223	1.7 Technical Requirement	1.7.4.3.b Matrix Duplicates			V1M4 1.7.4.3 b)

1224	1.7 Technical Requirement	1.7.4.3.b Matrix Duplicates			V1M4 1.7.4.3 b)
1225	1.7 Technical Requirement	1.7.4.3.b Matrix Duplicates	Documentation	Procedure	V1M4 1.7.4.3 b)
1226	1.7 Technical Requirement	1.7.4.3.b Matrix Duplicates	Evaluation	Requirement	V1M4 1.7.4.3 b)
1227	1.7 Technical Requirement	1.7.4.3.c Surrogates			V1M4 1.7.4.3 c)
1228	1.7 Technical Requirement	1.7.4.3.c Surrogates	Acceptance Criteria	Requirement	V1M4 1.7.4.3 c)
1229	1.7 Technical Requirement	1.7.4.3.c Surrogates	Evaluation	Requirement	V1M4 1.7.4.3 c)
1230	1.7 Technical Requirement	1.7.4.3.c Surrogates	Reporting	Requirement	V1M4 1.7.4.3 c)
1231	1.7 Technical Requirement	1.7.5 Sample handing			V1M4 1.7.5
1232	1.7 Technical Requirement	1.7.5 Sample handing	Temperature	Requirement	V1M4 1.7.5 a)
1233	1.7 Technical Requirement	1.7.5 Sample handing	Temperature	Exception	V1M4 1.7.5 a) i.
1234	1.7 Technical Requirement	1.7.5 Sample handing	Temperature	Exception	V1M4 1.7.5 a) ii.
1235	1.7 Technical Requirement	1.7.5 Sample handing	Temperature	Exception	V1M4 1.7.5 a) iii.
1236	1.7 Technical Requirement	1.7.5 Sample handing	Preservation Checks	Requirement	V1M4 1.7.5 b)
1237	1.7 Technical Requirement	1.7.5 Sample handing	Preservation Checks	Exception	V1M4 1.7.5 b)

Does the laboratory comply with this section?	Yes
CHEMICAL TESTING	
Introduction	
This document contains detailed quality control requirements for environmental testing activities involving chemical measurements. The evaluation of laboratories for this discipline is in conjunction with a quality system as specified in the general requirements module. Adherence to quality systems requirements will ensure that all quality control procedures specified in this module are being followed.	
Scope	
The essential quality control procedures applicable to chemistry measurements are included in this module. Additional quality control requirements that are either specified by method, regulation or project shall be met by laboratories.	
Terms and Definitions	
The relevant definitions from TNI, Volume 1, Module 2, Section 3.0 are the preferred references. Definitions related to this document, which are used differently or do not exist in the above references are defined below.	
Additional Terms and Definitions	
Reserved	
Exclusions and Exceptions	
Reserved	
Method Selection	
A reference method is a method issued by an organization generally recognized as competent to do so. (When ISO refers to a standard method, that term is equivalent to reference method).	
When a laboratory is required to analyze a parameter by a specified method due to a regulatory requirement, the parameter/method combination is recognized as a reference method.	
If there is not a regulatory requirement for the parameter/method combination, the parameter/ method combination need not be validated under 1.5.1b) as a non-reference method if it can be analyzed by another similar reference method of the same matrix and technology. The inclusion of the parameter in the method shall meet all required calibration requirements and the quality control requirements of the method to which the parameter is being added. If no QC exists in the method, the laboratory shall adhere to the requirements outlined in the similar method. For example, when adding acetone to Method 624, the calibration and QC requirements shall follow Method 624.	
A method that meets the above requirement shall be identified in such a way so that there is no confusion that the method has been modified.	
When it is necessary to use methods not covered by reference methods, these shall be subject to agreement with the client and shall include a clear specification of the client's requirements and the purpose of the environmental test.	
The method developed shall have been validated appropriately before use.	
Method Validation	

Validation of Methods	
The laboratory shall validate reference methods via the procedures specified in Sections 1.5.2 and 1.5.3.	
The laboratory shall validate non-reference methods, laboratory-designed/developed methods, reference methods used outside their published scope, and amplifications and modifications of reference methods to confirm that the methods are fit for the intended use. The validation shall be as extensive as is necessary to meet the needs of the given application or field of application. The laboratory shall record the results obtained, the procedure used for the validation, and a statement as to whether the method is fit for the intended use. In the absence of other specifications, the minimum requirements for method validation are given in Sections 1.5.2, 1.5.3 and 1.5.4.	
Limit of Detection and Limit of Quantitation (However Named)	
Procedures used for determining limits of detection and quantitation shall be documented. Documentation shall include the quality system matrix type. All supporting data shall be retained.	
Limit of Detection (LOD)	
If the laboratory is not reporting a value below the Limit of Quantitation, a Limit of Detection study is not required.	
The laboratory shall utilize a method that provides an LOD that is appropriate and relevant for the intended use of the data.	
If a mandated method or regulation includes protocols for determining detection limits, these shall be followed.	
The laboratory shall document how LODs were derived from the determinations. If the protocol for determining the LOD is not specified, the selection of the procedure shall reflect instrument limitations and the intended application of the method.	
All sample-processing and analysis steps of the analytical method shall be included in the determination or validation of the LOD.	
When required, the laboratory shall determine or verify the LOD for the method for each target analyte of concern in the quality system matrices.	
The validity of the LOD shall be verified by detection (a value above zero) of the analyte(s) in a QC sample in each quality system matrix. This QC sample shall contain the analyte at no more than 3X the LOD for single analyte tests and 4X the LOD for multiple analyte tests.	
This verification shall be performed on every instrument that is to be used for analysis of samples and reporting of data. The validity of the LOD shall be verified as part of the LOD determination process. This verification shall be done prior to the use of the LOD for the sample analysis.	
An LOD study is not required for any component for which spiking solutions or quality control samples are not available such as temperature.	
The LOD shall be initially determined for the compounds of interest in each method in a quality system matrix in which there are neither target analytes nor interferences at a concentration that would impact the results or the LOD shall be performed in the quality system matrix of interest.	
An LOD shall be performed each time there is a change in the method that affects how the test is performed, or when a change in instrumentation occurs that affects the sensitivity of the analysis.	
The LOD, if required, shall be verified annually for each quality system matrix, technology, and analyte.	

Limit of Quantitation (LOQ)	
All sample-processing and analysis steps of the analytical method shall be included in the determination of the LOQ.	
The LOQ study is not required for any component or property for which spiking solutions or quality control samples are not available or otherwise inappropriate (e.g., pH).	
The validity of the LOQ shall be verified by successful analysis of a QC sample containing the analytes of concern in each quality system matrix at 1 to 2 times the claimed LOQ. A successful analysis is one where the recovery of each analyte is within the laboratory established method acceptance criteria or client data quality objectives for accuracy.	
When an LOD is determined or verified by the laboratory, the LOQ shall be above the LOD.	
The LOQ shall be verified annually for each quality system matrix, technology, and analyte. However, the annual LOQ verification is not required if the LOD was determined or verified annually on that instrument.	
Evaluation of Precision and Bias	
Reference Methods. The laboratory shall evaluate the precision and bias of a reference method for each analyte of concern for each quality system matrix according to Section 1.6 or alternate documented procedure when the analyte cannot be spiked into the sample matrix and QC samples are not commercially available.	
Non-Reference Methods. For laboratory-developed methods or non-reference methods that were not in use by the laboratory before July 2003, the laboratory shall have a documented procedure to evaluate precision and bias. The laboratory shall also compare results of the precision and bias measurements with criteria established by the client, by criteria given in the reference method or criteria established by the laboratory.	
Precision and bias measurements shall evaluate the method across the analytical calibration range of the method. The laboratory shall also evaluate precision and bias in the relevant quality system matrices and shall process the samples through the entire measurement system for each analyte of interest.	
Examples of a systematic approach to evaluate precision and bias could be the following:	
Analyze QC samples in triplicate containing the analytes of concern at or near the limit of quantitation, at the upper-range of the calibration (upper 20%) and at a mid-range concentration. Process these samples on different days as three (3) sets of samples through the entire measurement system for each analyte of interest. Each day, one (1) QC sample at each concentration is analyzed. A separate method blank shall be subjected to the analytical method along with the QC samples on each of the three (3) days. (Note that the three (3) samples at the LOQ concentration can demonstrate sensitivity as well.) For each analyte, calculate the mean recovery for each day, for each level over each day, and for all nine (9) samples. Calculate the relative standard deviation for each of the separate means obtained. Compare the standard deviations for the different days and the standard deviations for the different concentrations. If the different standard deviations are all statistically insignificant (e.g., F-test), then compare the overall mean and standard deviation with the established criteria from above.	
A validation protocol, such as the Tier I, Tier II, and Tier III requirements in US EPA Office of Water's Alternate Test Procedure (ATP) approval process.	

Evaluation of Selectivity	
The laboratory shall evaluate selectivity by following the checks established within the method, which may include mass spectral tuning, second column confirmation, ICP inter-element interference checks, chromatography retention time windows, sample blanks, spectrochemical absorption or fluorescence profiles, co-precipitation evaluations, and electrode response factors.	
Demonstration of Capability (DOC)	
General	
Prior to acceptance and institution of any method for which data will be reported, a satisfactory initial DOC is required ***(see Section 1.6.2).***	
Thereafter, ongoing DOC (Section 1.6.3), as per the quality control requirements in Section 1.7.3 (such as laboratory control samples) is required.	
In cases where a laboratory analyzes samples using a method that has been in use by the laboratory for at least one year prior to applying for accreditation, and there have been no significant changes in instrument type, personnel or method, the ongoing DOC shall be acceptable as an initial DOC.	
The laboratory shall have records on file to demonstrate that an initial DOC is not required.	
For the initial DOC, appropriate records as discussed in ***Section 1.6.2*** shall be completed.	
An initial DOC shall be completed each time there is a change in instrument type, personnel, or method. ***(see 1.6.2)***	
All demonstrations shall be documented. .	
All data applicable to the demonstration shall be retained and readily available at the laboratory.	
Initial DOC	
An initial DOC shall be conducted prior to using any method, and at any time there is a change in instrument type, personnel or method or any time that a method has not been performed by the laboratory or analyst in a twelve (12) month period.	
The laboratory shall document each initial DOC in a manner such that the following information is readily available for each affected employee:	
analyst(s) involved in preparation and/or analysis;	
matrix;	
analyte(s), class of analyte(s), or measured parameter(s);	
identification of method(s) performed;	
identification of laboratory-specific SOP used for analysis, including revision number;	
date(s) of analysis; and	
summary of analyses, including information outlined in Section 1.6.2.2.c.	
If the method or regulation does not specify an initial DOC, the following procedure is acceptable. It is the responsibility of the laboratory to document that other approaches to initial DOC are adequate.	
The analyte(s) shall be diluted in a volume of clean quality system matrix (a sample in which no target analytes or interferences are present at concentrations that will impact the results of a specific method) sufficient to prepare four (4) aliquots at the concentration specified, or if unspecified, to a concentration of one (1) to four (4) times the limit of quantitation.	
At least four (4) aliquots shall be prepared and analyzed according to the method(s) either concurrently or over a period of days.	

Using all of the results, calculate the mean recovery in the appropriate reporting units and the standard deviations of the sample (in the same units) for each parameter of interest. When it is not possible to determine mean and standard deviations, such as for presence/absence and logarithmic values, the laboratory shall assess performance against established and documented criteria.	
Compare the information from (c) above to the corresponding acceptance criteria for precision and accuracy in the method (if applicable) or in laboratory-generated acceptance criteria (if there are not established mandatory criteria). If all parameters meet the acceptance criteria, the analysis of actual samples may begin. If any one of the parameters does not meet the acceptance criteria, the performance is unacceptable for that parameter.	
When one or more of the tested parameters fail at least one of the acceptance criteria, the analyst shall proceed according to i) or ii) below.	
Locate and correct the source of the problem and repeat the test for all parameters of interest beginning with b) above.	
Beginning with b) above, repeat the test for all parameters that failed to meet criteria.	
Repeated failure, however, confirms a general problem with the measurement system. If this occurs, locate and correct the source of the problem and repeat the test for all compounds of interest beginning with b).	
When an analyte not currently found on the laboratory's list of accredited analytes is added to an existing accredited method, an initial demonstration shall be performed for that analyte.	
Ongoing DOC	
The laboratory shall have a documented procedure describing ongoing DOC. The analyst(s) shall demonstrate on-going capability by meeting the quality control requirements of the method, laboratory SOP, client specifications, and/or this Standard. It is the responsibility of the laboratory to document that other approaches to ongoing DOC are adequate.	
This on-going demonstration may be one of the following:	
acceptable performance of a blind sample (single blind to the analyst);	
Note: Successful analysis of a blind performance sample on a similar method using the same technology (e.g., GC/MS volatiles by purge and trap for Methods 524.2, 624 or 5030/8260) would only require documentation for one of the tests.	
another initial DOC;	
at least four (4) consecutive laboratory control samples with acceptable levels of precision and accuracy. The laboratory shall determine the acceptable limits for precision and accuracy prior to analysis. The laboratory shall tabulate or be able to readily retrieve four (4) consecutive passing LCSs for each method for each analyst each year;	
a documented process of analyst review using QC samples. QC samples can be reviewed to identify patterns for individuals or groups of analysts and determine if corrective action or retraining is necessary;	
if a) through d) are not technically feasible, then analysis of real-world samples with results within a predefined acceptance criteria (as defined by the laboratory or method) shall be performed.	
Technical Requirements	

Initial Calibration	
Instrument Calibration	
This module specifies the essential elements that shall define the procedures and documentation for initial instrument calibration and continuing instrument calibration verification to ensure that the data shall be of known quality for the intended use. This Standard does not specify detailed procedural steps (“how to”) for calibration, but establishes the essential elements for selection of the appropriate technique(s). This approach allows flexibility and permits the employment of a wide variety of analytical procedures and statistical approaches currently applicable for calibration.	
If more stringent standards or requirements are included in a mandated method or by regulation, the laboratory shall demonstrate that such requirements are met. If it is not apparent which Standard is more stringent, then the requirements of the regulation or mandated method are to be followed.	
The following items are essential elements of initial instrument calibration:	
the details of the initial instrument calibration procedures including calculations, integrations, acceptance criteria and associated statistics shall be included or referenced in the method SOP. When initial instrument calibration procedures are referenced in the method, then the referenced material shall be retained by the laboratory and be available for review;	
sufficient raw data records shall be retained to permit reconstruction of the initial instrument calibration (e.g., calibration date, method, instrument, analysis date, each analyte name, analyst’s initials or signature; concentration and response, calibration curve or response factor; or unique equation or coefficient used to reduce instrument responses to concentration);	
sample results shall be quantitated from the initial instrument calibration and may not be quantitated from any continuing instrument calibration verification unless otherwise required by regulation, method, or program;	
all initial instrument calibrations shall be verified with a standard obtained from a second manufacturer or from a different lot. Traceability shall be to a national standard, when commercially available;	
criteria for the acceptance of an initial instrument calibration shall be established (e.g., correlation coefficient or relative percent difference). The criteria used shall be appropriate to the calibration technique employed;	
the lowest calibration standard shall be at or below the LOQ. Any data reported below the LOQ shall be considered to have an increased quantitative uncertainty and shall be reported using defined qualifiers or explained in the narrative;	
the highest calibration standard shall be at or above the highest concentration for which quantitative data are to be reported. Any data reported above the calibration range shall be considered to have an increased quantitative uncertainty and shall be reported using defined qualifiers or explained in the narrative;	
the following shall occur for instrument technology (such as ICP or ICP/MS) with validated techniques from manufacturers or methods employing standardization with a zero point and a single point calibration standard:	
Prior to the analysis of samples, the zero point and single point calibration standard shall be analyzed and the linear range of the instrument shall be established by analyzing a series of standards, one of which shall be at or below the LOQ. Sample results within the established linear range will not require data qualifiers.	

A zero point and single point calibration standard shall be analyzed with each analytical batch.	
A standard corresponding to the limit of quantitation shall be analyzed with each analytical batch and shall meet established acceptance criteria.	
The linearity is verified at a frequency established by the method and/or the manufacturer.	
if the initial instrument calibration results are outside established acceptance criteria, corrective actions shall be performed and all associated samples re-analyzed. If re-analysis of the samples is not possible, data associated with an unacceptable initial instrument calibration shall be reported with appropriate data qualifiers; and	
if a reference or mandated method does not specify the number of calibration standards, the minimum number of points for establishing the initial instrument calibration shall be three.	
Continuing Calibration	
When an initial instrument calibration is not performed on the day of analysis, the validity of the initial calibration shall be verified prior to sample analyses by a continuing instrument calibration verification with each analytical batch. The following items are essential elements of continuing instrument calibration verification.	
The details of the continuing instrument calibration procedure, calculations and associated statistics shall be included or referenced in the method SOP.	
Calibration shall be verified for each compound, element, or other discrete chemical species, except for multi-component analytes such as aroclors, chlordane, total petroleum hydrocarbons, or toxaphene, where a representative chemical, related substance or mixture can be used.	
Instrument calibration verification shall be performed:	
at the beginning and end of each analytical batch. If an internal standard is used, only one verification needs to be performed at the beginning of the analytical batch;	
if the time period for calibration or the most recent calibration verification has expired; or	
for analytical systems that contain a calibration verification requirement.	
Sufficient raw data records shall be retained to permit reconstruction of the continuing instrument calibration verification (e.g., method, instrument, analysis date, each analyte name, concentration and response, calibration curve or response factor, or unique equations or coefficients used to convert instrument responses into concentrations). Continuing calibration verification records shall explicitly connect the continuing verification data to the initial instrument calibration.	
Criteria for the acceptance of a continuing instrument calibration verification shall be established.	
If the continuing instrument calibration verification results obtained are outside the established acceptance criteria and analysis of a second consecutive (immediate) calibration verification fails to produce results within acceptance criteria, corrective actions shall be performed.	
The laboratory shall demonstrate acceptable performance after corrective action with two consecutive calibration verifications, or a new initial instrument calibration shall be performed.	
If the laboratory has not verified calibration, sample analyses may not occur until the analytical system is calibrated or calibration verified.	

If samples are analyzed using a system on which the calibration has not yet been verified the results shall be flagged.	
Data associated with an unacceptable calibration verification may be fully useable under the following special conditions:	
when the acceptance criteria for the continuing calibration verification are exceeded high (i.e., high bias) and there are associated samples that are non-detects, then those non-detects may be reported. Otherwise the samples affected by the unacceptable calibration verification shall be re-analyzed after a new calibration curve has been established, evaluated and accepted; or	
when the acceptance criteria for the continuing calibration verification are exceeded low (i.e., low bias), those sample results may be reported if they exceed a maximum regulatory limit/decision level. Otherwise the samples affected by the unacceptable verification shall be re-analyzed after a new calibration curve has been established, evaluated and accepted.	
Quality Control	
The laboratory shall have quality control procedures for monitoring the validity of environmental tests undertaken as specified in this Section.(see requirements below)	
Negative Control – Method Performance: Method Blank	
The method blank is used to assess the samples in the preparation batch for possible contamination during the preparation and processing steps.	
The method blank shall be processed along with and under the same conditions as the associated samples to include all steps of the analytical procedure.	
Procedures shall be in place to determine if a method blank is contaminated.	
Any affected samples associated with a contaminated method blank shall be reprocessed for analysis or the results reported with appropriate data qualifying codes.	
The method blank shall be analyzed at a minimum of one (1) per preparation batch.	
In those instances for which no separate preparation method is used (for example, volatiles in water), the batch shall be defined as environmental samples that are analyzed together with the same method and personnel, using the same lots of reagents, not to exceed the analysis of twenty (20) environmental samples, not including method blanks, LCS, matrix spikes and matrix duplicates.	
The method blank shall consist of a quality system matrix that is similar to the associated samples and is known to be free of the analytes of interest.	
Method blanks are not applicable for certain analyses, such as pH, Conductivity, Flash Point and Temperature.	
Positive Control – Method Performance: Laboratory Control Sample (LCS)	
The LCS is used to evaluate the performance of the total analytical system, including all preparation and analysis steps. Results of the LCS are compared to established criteria and, if found to be outside of these criteria, indicates that the analytical system is “out of control.” Any affected samples associated with an out of control LCS shall be reprocessed for re-analysis or the results reported with appropriate data qualifying codes.	
The LCS shall be analyzed at a minimum of one (1) per preparation batch.	

Exceptions would be for those analytes for which no spiking solutions are available, such as total suspended solids, total dissolved solids, total volatile solids, total solids, pH, color, odor, temperature, dissolved oxygen or turbidity.	
In those instances for which no separate preparation method is used (example: volatiles in water) the batch shall be defined as environmental samples that are analyzed together with the same method and personnel, using the same lots of reagents, not to exceed the analysis of twenty (20) environmental samples, not including method blanks, LCS, matrix spikes and matrix duplicates.	
The LCS is a quality system matrix, known to be free of analytes of interest, spiked with known concentrations of analytes.	
Note: The matrix spike may be used in place of this control as long as the acceptance criteria are as stringent as for the LCS.	
Alternatively, the LCS may consist of a media containing known and verified concentrations of analytes or as Certified Reference Material (CRM). All analyte concentrations shall be within the calibration range of the methods. The following shall be used in choosing components for the spike mixtures:	
The components to be spiked shall be as specified by the mandated method or regulation or as requested by the client. In the absence of specified spiking components, the laboratory shall spike per the following:	
for those components that interfere with an accurate assessment, such as spiking simultaneously with technical chlordane, toxaphene and PCBs, the spike shall be chosen that represents the chemistries and elution patterns of the components to be reported; and	
for those methods that have extremely long lists of analytes, a representative number may be chosen. The analytes selected shall be representative of all analytes reported.	
The following criteria shall be used for determining the minimum number of analytes to be spiked. However, the laboratory shall insure that all targeted components are included in the spike mixture over a two (2) year period:	
For methods that include one (1) to ten (10) targets, spike all components.	
For methods that include eleven (11) to twenty (20) targets, spike at least ten (10) or 80%, whichever is greater.	
For methods with more than twenty (20) targets, spike at least sixteen (16) components.	
Sample Specific Controls	
The laboratory shall document procedures for determining the effect of the sample matrix on method performance. These procedures relate to the analyses of quality system matrix specific Quality Control (QC) samples and are designed as data quality indicators for a specific sample using the designated method. These controls alone are not used to judge laboratory performance.	
Examples of matrix-specific QC include: Matrix Spike (MS), Matrix Spike Duplicate (MSD), sample duplicates, and surrogate spikes. The laboratory shall have procedures in place for tracking, managing, and handling matrix-specific QC criteria, including spiking appropriate components at appropriate concentrations, calculating recoveries and relative percent difference, and evaluating and reporting results based on performance of the QC samples.	
Matrix Spike; Matrix Spike Duplicates	

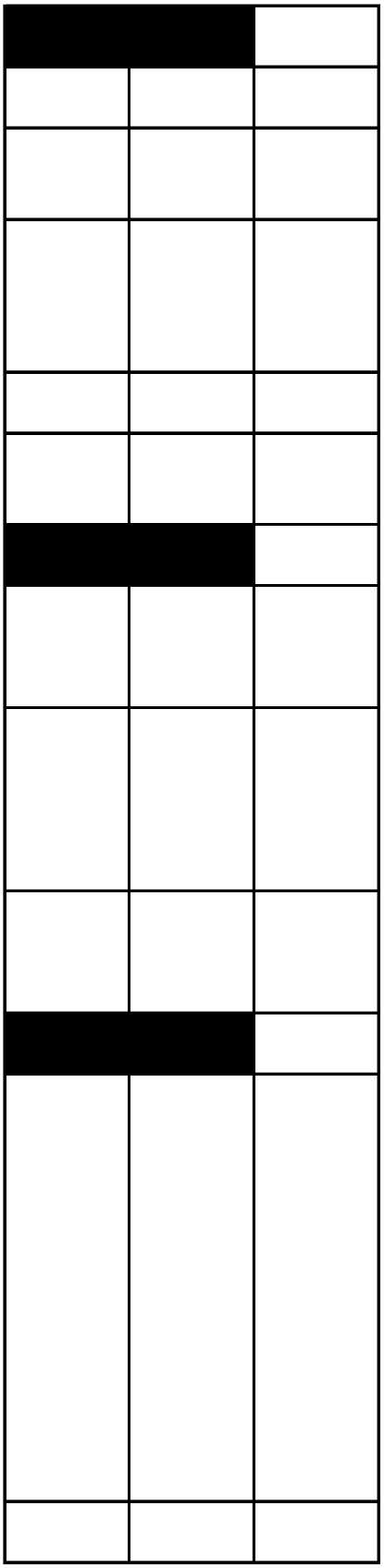
Matrix-specific QC samples indicate the effect of the sample matrix on the precision and accuracy of the results generated using the selected method. The information from these controls is sample/matrix specific and would not normally be used to determine the validity of the entire batch.	
The frequency of the analysis of matrix spikes are as specified by the method or may be determined as part of the contract review process.	
The components to be spiked shall be as specified by the mandated method. Any permit specified analytes, as specified by regulation or client requested analytes, shall also be included. If there are no specified components, the laboratory shall spike per the following:	
For those components that interfere with an accurate assessment such as spiking simultaneously with technical chlordane, toxaphene and PCBs, the spike shall be chosen that represents the chemistries and elution patterns of the components to be reported.	
For those methods that have extremely long lists of analytes, a representative number may be chosen using the following criteria for choosing the number of analytes to be spiked. However, the laboratory shall insure that all targeted components are included in the spike mixture over a two (2) year period.	
For methods that include one (1) to ten (10) targets, spike all components.	
For methods that include eleven (11) to twenty (20) targets, spike at least ten (10) or 80%, whichever is greater.	
For methods with more than twenty (20) targets, spike at least sixteen (16) components.	
Matrix Duplicates	
Matrix duplicates are defined as replicate aliquots of the same sample taken through the entire analytical procedure. The results from this analysis indicate the precision of the results for the specific sample using the selected method. The matrix duplicate may provide a usable measure of sample homogeneity. It may also provide a measure of precision when target analytes are present.	
The frequency of the analysis of matrix duplicates are as specified by the method or may be determined as part of the contract review process.	
Matrix duplicates are performed on replicate aliquots of actual samples. The composition is usually not known.	
Surrogate Spikes	
Surrogates, when required, are chosen to reflect the chemistries of the targeted components of the method and are added prior to sample preparation/extraction.	
Except where the matrix precludes its use or when not commercially available, surrogate compounds shall be added to all samples, standards, and blanks for all appropriate methods.	
Surrogate compounds are chosen to represent the various chemistries of the target analytes in the method. They are often specified by the mandated method and are deliberately chosen for their being unlikely to occur as an environmental contaminant. Often this is accomplished by using deuterated analogs of select compounds.	
Data Reduction	
The procedures for data reduction, such as use of linear regression, shall be documented.	
Reagent Quality, Water Quality and Checks	

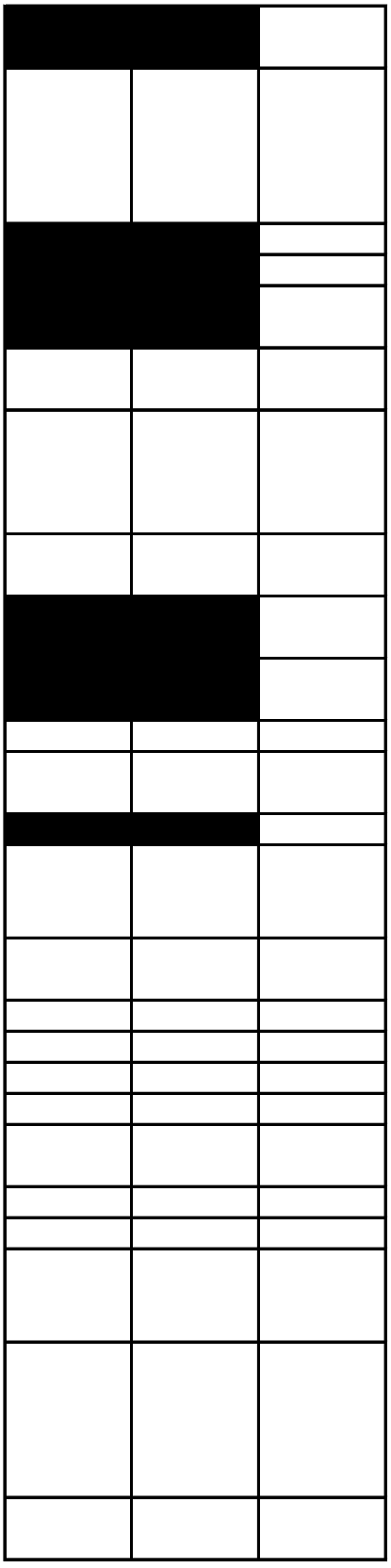
In methods where the purity of reagents is not specified, analytical reagent grade shall be used. Reagents of lesser purity than those specified by the method shall not be used. Documentation of purity shall be available.	
The quality of water sources shall be monitored and documented and shall meet method specified requirements.	
The laboratory shall verify the concentration of titrants in accordance with written laboratory procedures.	
Selectivity	
The laboratory shall document selectivity by following the checks established within the method.	
Data Acceptance/Rejection Criteria	
Negative Control – Method Performance: Method Blank	
While the goal is to have no detectable contaminants, each method blank shall be critically evaluated as to the nature of the interference and the effect on the analysis of each sample within the batch.	
The source of contamination shall be investigated and measures taken to minimize or eliminate the problem and affected samples reprocessed or data shall be appropriately qualified if: ***(1.7.4.1.c)***	
the concentration of a targeted analyte in the blank is at or above the reporting limit as established by the method or by regulation, AND is greater than 1/10 of the amount measured in the sample;	
the blank contamination otherwise affects the sample results as per the method requirements or the individual project data quality objectives; and a blank is determined to be contaminated.	
The cause shall be investigated and measures taken to minimize or eliminate the problem. Samples associated with a contaminated blank shall be evaluated as to the best corrective action for the samples (e.g., reprocessing or data qualifying codes). In all cases the corrective action shall be documented.	
Positive Control – Method Performance: Laboratory Control Sample (LCS)	
The results of the individual batch LCS are calculated in percent recovery or other appropriate statistical technique that allows comparison to established acceptance criteria. The laboratory shall document the calculation.	
The individual LCS is compared to the acceptance criteria as published in the mandated method. Where there are no established criteria, the laboratory shall determine internal criteria and document the method used to establish the limits or utilize client specified assessment criteria.	
An LCS that is determined to be within the criteria effectively establishes that the analytical system is in control and validates system performance for the samples in the associated batch. Samples analyzed along with an LCS determined to be “out of control” shall be considered suspect and the samples reprocessed and re-analyzed or the data reported with appropriate data qualifying codes. This includes any allowable marginal exceedance as described in b) below.	
when the acceptance criteria for the positive control are exceeded high (i.e., high bias) and there are associated samples that are non-detects, then those non-detects may be reported with data qualifying codes; or	

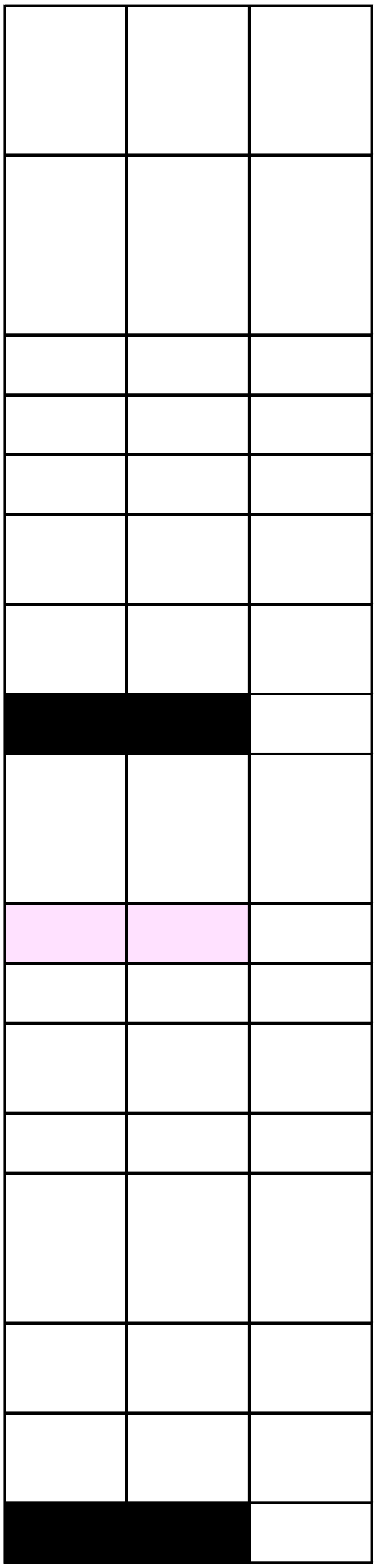
when the acceptance criteria for the positive control are exceeded low (i.e., low bias), those sample results may be reported if they exceed a maximum regulatory limit/decision level with data qualifying codes.	
Allowable Marginal Exceedances. If a large number of analytes are in the LCS, it becomes statistically likely that a few will be outside control limits. This may not indicate that the system is out of control, therefore corrective action may not be necessary. Upper and lower marginal exceedance (ME) limits can be established to determine when corrective action is necessary. A ME is defined as being beyond the LCS control limit (three standard deviations), but within the ME limits. ME limits are between three (3) and four (4) standard deviations around the mean. The number of allowable marginal exceedances is based on the number of analytes in the LCS. If more analytes exceed the LCS control limits than is allowed, or if any one analyte exceeds the ME limits, the LCS fails and corrective action is necessary. This marginal exceedance approach is relevant for methods with long lists of analytes. It will not apply to target analyte lists with fewer than eleven analytes.	
The number of allowable marginal exceedances is as follows:	
Number of Analytes in LCS >90 Number Allowed as Marginal Exceedances 5	
Number of Analytes in LCS 71-90 Number Allowed as Marginal Exceedances 4	
Number of Analytes in LCS 51-70 Number Allowed as Marginal Exceedances 3	
Number of Analytes in LCS 31-50 Number Allowed as Marginal Exceedances 2	
Number of Analytes in LCS 11-30 Number Allowed as Marginal Exceedances 1	
Number of Analytes in LCS <11 Number Allowed as Marginal Exceedances 0	
If the same analyte exceeds the LCS control limit consecutively, it is an indication of a systemic problem. The source of the error shall be located and corrective action taken. Laboratories shall have a written procedure to monitor the application of marginal exceedance allowance to the LCS.	
Sample Specific Controls	
Matrix Spike; Matrix Spike Duplicates	
The results from matrix spike/matrix spike duplicate are primarily designed to assess the precision and accuracy of analytical results in a given matrix and are expressed as percent recovery (%R), relative percent difference (RPD), or other appropriate statistical technique that allows comparison to established acceptance criteria. The laboratory shall document the calculation for %R, RPD or other statistical treatment used.	
The results are compared to the acceptance criteria as published in the mandated method. Where there are no established criteria, the laboratory shall determine internal criteria and document the method used to establish the limits. For matrix spike results outside established criteria, corrective action shall be documented or the data for that sample reported with appropriate data qualifying codes.	
Matrix Duplicates	

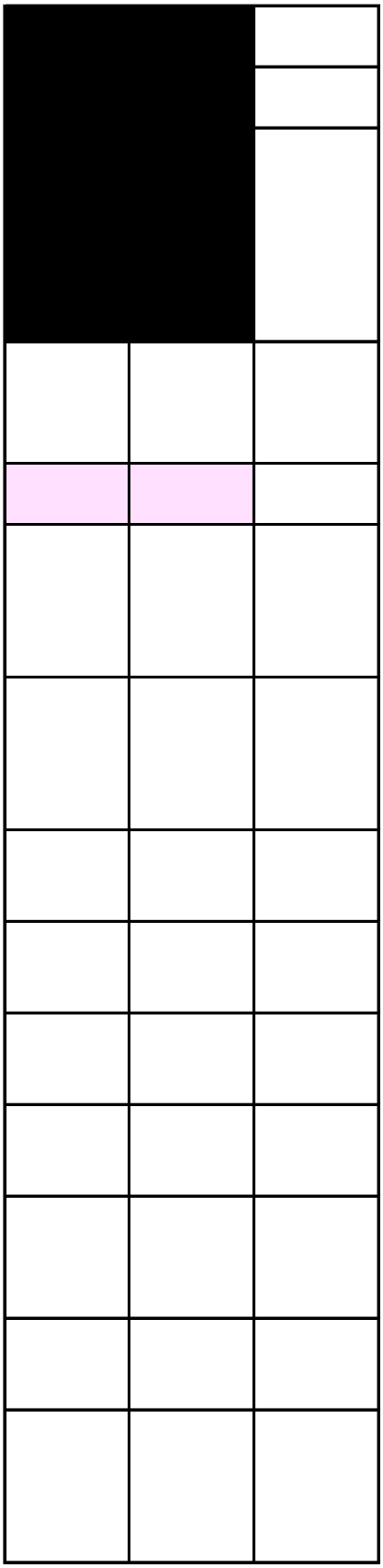
The results from matrix duplicates are primarily designed to assess the homogeneity of the particular sample chosen. If that sample is homogenous it may also describe the precision of analytical results in a given matrix.	
These may be expressed as relative percent difference (RPD) or another statistical treatment (e.g., absolute differences). The laboratory shall document the calculation for relative percent difference or other statistical treatments.	
Results are compared to the acceptance criteria as published in the mandated method. Where there are no established criteria, the laboratory shall determine internal criteria and document the method used to establish the limits. For matrix duplicates results outside established criteria, corrective action shall be documented or the data for that sample reported with appropriate data qualifying codes.	
Surrogate Spikes	
The results are compared to the acceptance criteria as published in the mandated method. Where there are no established criteria, the laboratory shall determine internal criteria and document the method used to establish the limits.	
Surrogates outside the acceptance criteria shall be evaluated for the effect indicated for the individual sample results. The appropriate corrective action may be guided by the data quality objectives or other site-specific requirements.	
Results reported from analyses with surrogate recoveries outside the acceptance criteria shall include appropriate data qualifiers.	
Sample Handling	
All samples that require thermal preservation shall be considered acceptable if the arrival temperature of a representative sample container is either within 2°C of the required temperature or the method specified range. For samples with a specified temperature of 4°C, samples with a temperature ranging from just above the freezing temperature of water to 6°C shall be acceptable.	
Samples that are delivered to the laboratory on the same day they are collected may not meet the requirements of Section 1.7.5.a. In these cases, the samples shall be considered acceptable if the samples were received on ice.	
If sample analysis is begun within fifteen (15) minutes of collection, thermal preservation is not required.	
Thermal preservation is not required in the field if the laboratory receives and refrigerates the sample within fifteen (15) minutes of collection.	
The laboratory shall implement procedures for checking sample preservation using readily available techniques, such as pH or chlorine, prior to or during sample preparation or analysis.	
An exception is allowed for volatile organic compound analyses; chemical preservation may be checked after analysis.	

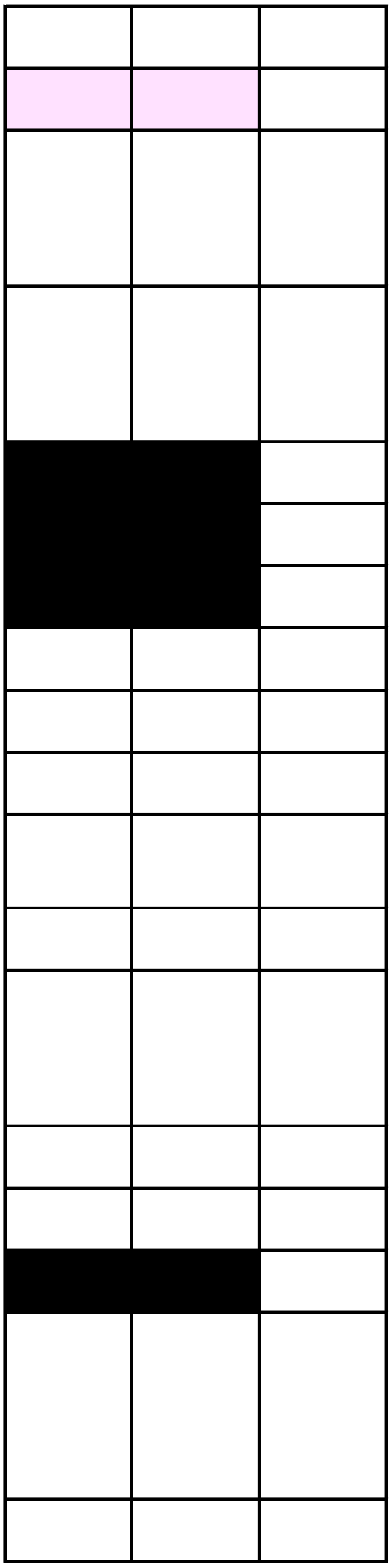
No	N/A	

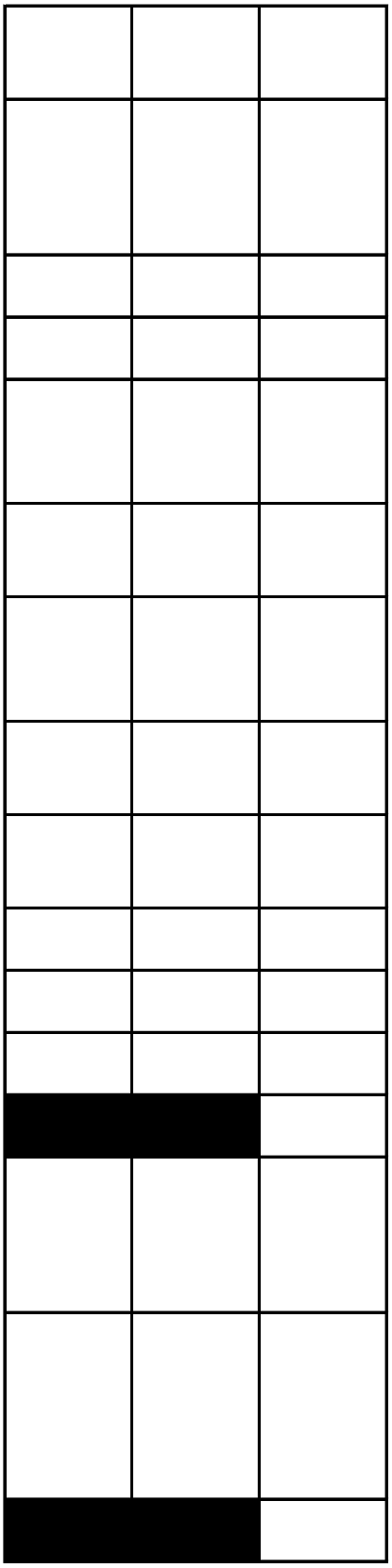


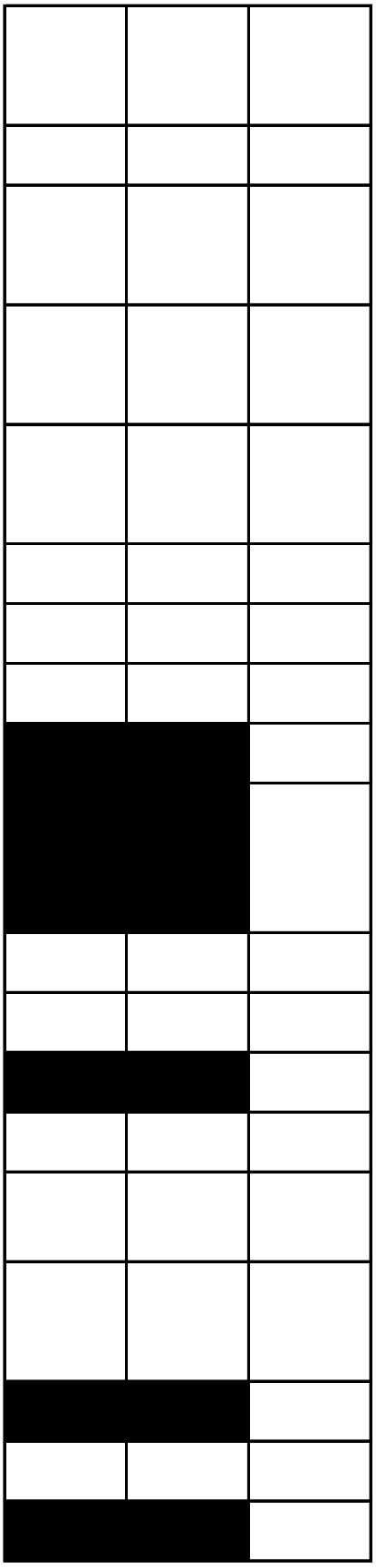


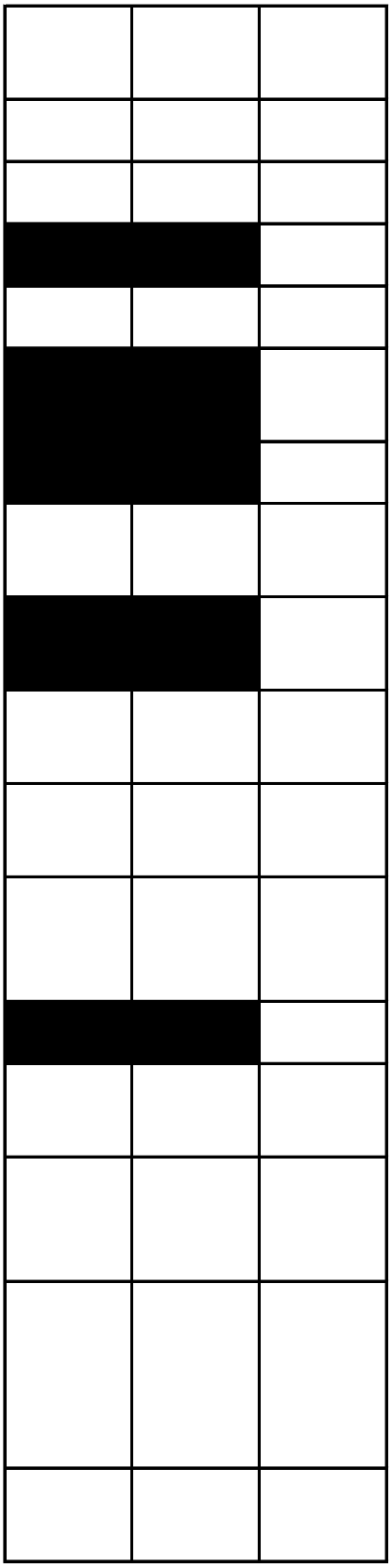


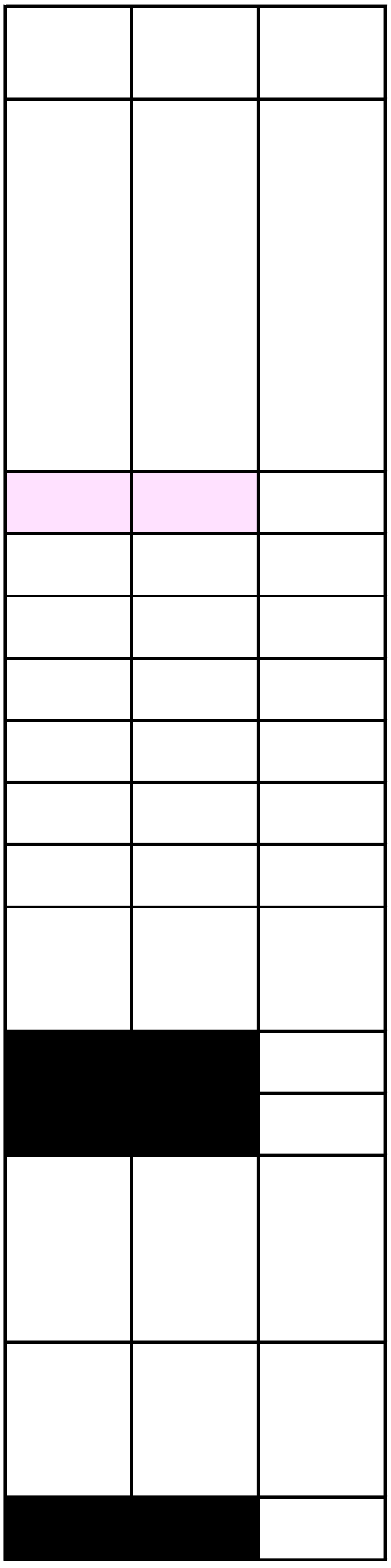


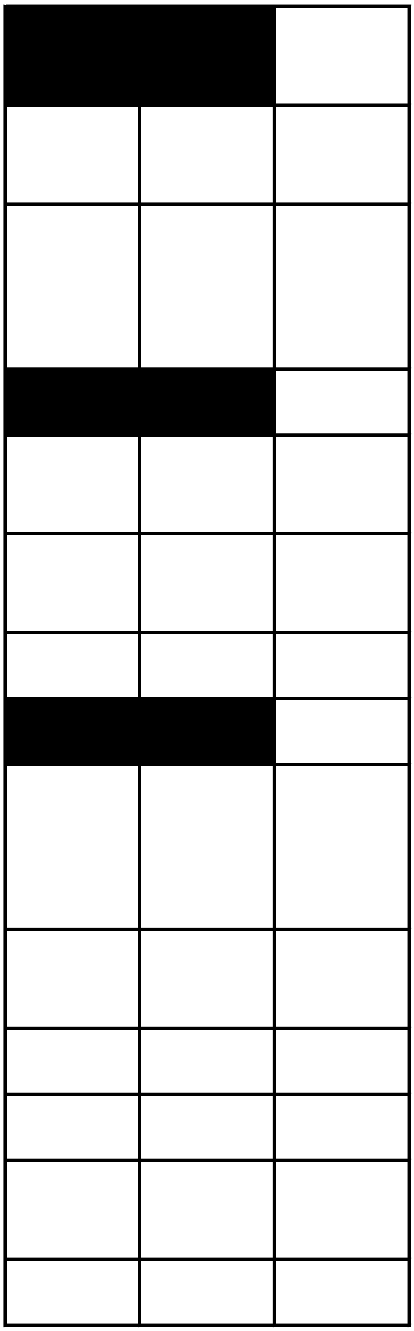












ID	Major Topic	Topic	Subject	Category
1238				
1239	1.1 Introduction			
1240	1.1 Introduction			
1241	1.2 Scope			
1242	1.2 Scope			
1243	1.3 Definitions			
1244	1.3 Definitions			
1245	1.3 Definitions			
1246	1.3 Definitions			
1247	1.3 Definitions			
1248	1.3 Definitions			
1249	1.4 Method Selection			
1250	1.4 Method Selection	Reference Method	Regulatory	Definition
1251	1.4 Method Selection	Reference Method	Regulatory	Definition
1252	1.4 Method Selection	Reference Method	Regulatory	Definition
1253	1.4 Method Selection	Non Reference Method	Customer Communication	Requirement
1254	1.4 Method Selection	Non Reference Method	Validation	Requirement
1255	1.5 Method Validation			
1256	1.5 Method Validation	General		Definition
1257	1.5 Method Validation	General	Scope	Requirement
1258	1.5 Method Validation	General	Extent	Requirement
1259	1.5 Method Validation	General	Documentation	Requirement

1260	1.5 Method Validation	General	Record Retention	Requirement
1261	1.5 Method Validation	General	PT Program	Requirement
1262	1.5 Method Validation	General	Assessment	Requirement
1263	1.5 Method Validation	1.5.1 Accuracy	Procedure	Option
1264	1.5 Method Validation	1.5.2 Precision	Procedure	Option
1265	1.5 Method Validation	1.5.3 Selectivity	Procedure	Option
1266	1.6 Demonstration of Capability			
1267	1.6 Demonstration of Capability	1.6.1 General		
1268	1.6 Demonstration of Capability	1.6.1 General	Initial DOC	Requirement
1269	1.6 Demonstration of Capability	1.6.1 General	Ongoing DOC	Requirement
1270	1.6 Demonstration of Capability	1.6.1 General	DOC	Exception
1271	1.6 Demonstration of Capability	1.6.1 General	Initial DOC Exception	Requirement
1272	1.6 Demonstration of Capability	1.6.1 General	Documentation	Record
1273	1.6 Demonstration of Capability	1.6.1 General	Initial DOC Frequency	Requirement
1274	1.6 Demonstration of Capability	1.6.1 General	Documentation	Requirement
1275	1.6 Demonstration of Capability	1.6.1 General	Data	Record
1276	1.6 Demonstration of Capability	1.6.2 Initial DOC		
1277	1.6 Demonstration of Capability	1.6.2 Initial DOC	IDOC	Requirement
1278	1.6 Demonstration of Capability	1.6.2 Initial DOC	IDOC Frequency	Requirement
1279	1.6 Demonstration of Capability	1.6.2 Initial DOC	IDOC Frequency	Requirement
1280	1.6 Demonstration of Capability	1.6.2 Initial DOC	Documentation	Record
1281	1.6 Demonstration of Capability	1.6.2 Initial DOC	DOC Record	Contents

1282	1.6 Demonstration of Capability	1.6.2 Initial DOC	DOC Record	Contents
1283	1.6 Demonstration of Capability	1.6.2 Initial DOC	DOC Record	Contents
1284	1.6 Demonstration of Capability	1.6.2 Initial DOC	DOC Record	Contents
1285	1.6 Demonstration of Capability	1.6.2 Initial DOC	DOC Record	Contents
1286	1.6 Demonstration of Capability	1.6.2 Initial DOC	DOC Record	Contents
1287	1.6 Demonstration of Capability	1.6.2 Initial DOC	DOC Record	Contents
1288	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure	Requirement
1289	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure	Option
1290	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure	Option
1291	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure	Option
1292	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure	Option
1293	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure	Option
1294	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure	Option
1295	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure	Option
1296	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure	Option
1297	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure	Option
1298	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure	Option
1299	1.6 Demonstration of Capability	1.6.2 Initial DOC	Procedure	Option
1300	1.6 Demonstration of Capability	1.6.3 Ongoing DOC		

1301	1.6 Demonstration of Capability	1.6.3 Ongoing DOC	Documentation	Procedure
1302	1.6 Demonstration of Capability	1.6.3 Ongoing DOC	Analyst	Requirement
1303	1.6 Demonstration of Capability	1.6.3 Ongoing DOC	Alternate Procedures	Requirement
1304	1.6 Demonstration of Capability	1.6.3 Ongoing DOC	Procedure	
1305	1.6 Demonstration of Capability	1.6.3 Ongoing DOC	Procedure	Option
1306	1.6 Demonstration of Capability	1.6.3 Ongoing DOC	Procedure	Option
1307	1.6 Demonstration of Capability	1.6.3 Ongoing DOC	Procedure	Option
1308	1.6 Demonstration of Capability	1.6.3 Ongoing DOC	Procedure	Option
1309	1.6 Demonstration of Capability	1.6.3 Ongoing DOC	Procedure	Option
1310	1.6 Demonstration of Capability	1.6.3 Ongoing DOC	Procedure	Option
1311	1.7 Technical Requirements			
1312	1.7 Technical Requirements	1.7.1 Calibration		
1313	1.7 Technical Requirements	1.7.1 Calibration	Calibration	Procedure
1314	1.7 Technical Requirements	1.7.1 Calibration	Procedure Origin	Requirement
1315	1.7 Technical Requirements	1.7.1 Calibration	Continuous Monitors	
1316	1.7 Technical Requirements	1.7.1 Calibration	Continuous Monitors	Requirement
1317	1.7 Technical Requirements	1.7.1 Calibration	Continuous Monitors	Requirement
1318	1.7 Technical Requirements	1.7.1 Calibration	Continuous Monitors	Requirement
1319	1.7 Technical Requirements	1.7.2 Continuing Calibration		
1320	1.7 Technical Requirements	1.7.2 Continuing Calibration		
1321	1.7 Technical Requirements	1.7.3 Quality Control		

1322	1.7 Technical Requirements	1.7.3.1 Sterility Checks and Method Blanks		
1323	1.7 Technical Requirements	1.7.3.1 Method Blanks		
1324	1.7 Technical Requirements	1.7.3.1 Method Blanks	Performance Criteria	Requirement
1325	1.7 Technical Requirements	1.7.3.1 Method Blanks	Filtration	Requirement
1326	1.7 Technical Requirements	1.7.3.1 Method Blanks	Filtration	Requirement
1327	1.7 Technical Requirements	1.7.3.1 Method Blanks	Filtration	Requirement
1328	1.7 Technical Requirements	1.7.3.1 Method Blanks	Filtration Series	Requirement
1329	1.7 Technical Requirements	1.7.3.1 Method Blanks	Filtration Procedure	Requirement
1330	1.7 Technical Requirements	1.7.3.1 Method Blanks	Filtration Procedure	Requirement
1331	1.7 Technical Requirements	1.7.3.1 Method Blanks	Pour Place	Requirement
1332	1.7 Technical Requirements	1.7.3.1 Sterility Checks		
1333	1.7 Technical Requirements	1.7.3.1 Sterility Checks	Prepared Media	Requirement
1334	1.7 Technical Requirements	1.7.3.1 Sterility Checks	Laboratory Prepared Media	Requirement
1335	1.7 Technical Requirements	1.7.3.1 Sterility Checks	Frequency	Requirement
1336	1.7 Technical Requirements	1.7.3.1 Sterility Checks	Presterilized Funnels	Requirement
1337	1.7 Technical Requirements	1.7.3.1 Sterility Checks	Laboratory Sterilized Funnels	Requirement
1338	1.7 Technical Requirements	1.7.3.1 Sterility Checks	Sample Containers	Requirement
1339	1.7 Technical Requirements	1.7.3.1 Sterility Checks	Laboratory Sterilized Containers	Requirement
1340	1.7 Technical Requirements	1.7.3.1 Sterility Checks	Contract Laboratory	Option
1341	1.7 Technical Requirements	1.7.3.1 Sterility Checks	Record Retention	Requirement
1342	1.7 Technical Requirements	1.7.3.1 Sterility Checks	Dilution Water	Requirement
1343	1.7 Technical Requirements	1.7.3.1 Sterility Checks	Purchased Dilution Water	Requirement
1344	1.7 Technical Requirements	1.7.3.1 Sterility Checks	Membrane Filter	Requirement
1345	1.7 Technical Requirements	1.7.3.2 Test Variability		

1346	1.7 Technical Requirements	1.7.3.2 Test Variability	Duplicate Counts	Requirement
1347	1.7 Technical Requirements	1.7.3.3 Sample Specific Controls		
1348	1.7 Technical Requirements	1.7.3.3 Sample Specific Controls	Matrix Spike	Requirement
1349	1.7 Technical Requirements	1.7.3.3 Sample Specific Controls	Sample Matrix Duplicates	Requirement
1350	1.7 Technical Requirements	1.7.3.4 Data Reduction		
1351	1.7 Technical Requirements	1.7.3.4 Data Reduction	Calculations and Statistics	Requirement
1352	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality		
1353	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Appropriateness	Requirement
1354	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Media Preparation	Option
1355	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Laboratory Prepared Media	
1356	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Laboratory Prepared Media	Requirement
1357	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Laboratory Prepared Media	Requirement
1358	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Laboratory Prepared Media	Requirement
1359	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Ready to Use Media	
1360	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Ready to Use Media	Requirement
1361	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Ready to Use Media	Requirement
1362	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Ready to Use Media	Requirement

1363	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Reagent Water	
1364	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Reagent Water	Requirement
1365	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Reagent Water	Requirement
1366	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Reagent Water	Requirement
1367	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Reagent Water	Record
1368	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Reagent Water	Requirement
1369	1.7 Technical Requirements	1.7.3.5 Standard, Reagent & Media Quality	Reagent Water	Requirement
1370	1.7 Technical Requirements	1.7.3.6 Selectivity		
1371	1.7 Technical Requirements	1.7.3.6 Selectivity	Media checks	Requirement
1372	1.7 Technical Requirements	1.7.3.6 Selectivity	Organism Verification	Requirement
1373	1.7 Technical Requirements	1.7.3.6 Selectivity	Reference Cultures	Requirement
1374	1.7 Technical Requirements	1.7.3.6 Selectivity	Reference Cultures	Option
1375	1.7 Technical Requirements	1.7.3.6 Selectivity	Reference Cultures	Requirement
1376	1.7 Technical Requirements	1.7.3.6 Selectivity	Working Stocks	Requirement
1377	1.7 Technical Requirements	1.7.3.6 Selectivity	Culture Controls	

1378	1.7 Technical Requirements	1.7.3.6 Selectivity	Negative Culture Control	
1379	1.7 Technical Requirements	1.7.3.6 Selectivity	Negative Culture Control	
1380	1.7 Technical Requirements	1.7.3.6 Selectivity	Negative Culture Control	Requirement
1381	1.7 Technical Requirements	1.7.3.6 Selectivity	Positive Culture Control	
1382	1.7 Technical Requirements	1.7.3.6 Selectivity	Positive Culture Control	
1383	1.7 Technical Requirements	1.7.3.6 Selectivity	Positive Culture Control	Requirement
1384	1.7 Technical Requirements	1.7.3.7 Test Conditions		
1385	1.7 Technical Requirements	1.7.3.7 Test Conditions	Laboratory Facilities	
1386	1.7 Technical Requirements	1.7.3.7 Test Conditions	Laboratory Facilities	Requirement
1387	1.7 Technical Requirements	1.7.3.7 Test Conditions	Laboratory Facilities	Requirement
1388	1.7 Technical Requirements	1.7.3.7 Test Conditions	Laboratory Facilities	Requirement
1389	1.7 Technical Requirements	1.7.3.7 Test Conditions	Laboratory Equipment	
1390	1.7 Technical Requirements	1.7.3.7 Test Conditions	Temperature Measuring Devices	
1391	1.7 Technical Requirements	1.7.3.7 Test Conditions	Temperature Measuring Devices	Requirement
1392	1.7 Technical Requirements	1.7.3.7 Test Conditions	Temperature Measuring Devices	Requirement
1393	1.7 Technical Requirements	1.7.3.7 Test Conditions	Temperature Measuring Devices	Requirement
1394	1.7 Technical Requirements	1.7.3.7 Test Conditions	Autoclaves	
1395	1.7 Technical Requirements	1.7.3.7 Test Conditions	Autoclaves	Requirement
1396	1.7 Technical Requirements	1.7.3.7 Test Conditions	Autoclaves	Requirement

1397	1.7 Technical Requirements	1.7.3.7 Test Conditions	Autoclaves	Requirement
1398	1.7 Technical Requirements	1.7.3.7 Test Conditions	Sterilization Temperature	Requirement
1399	1.7 Technical Requirements	1.7.3.7 Test Conditions	Sterilization Temperature	Requirement
1400	1.7 Technical Requirements	1.7.3.7 Test Conditions	Sterilization Temperature	Requirement
1401	1.7 Technical Requirements	1.7.3.7 Test Conditions	Autoclaves	Record
1402	1.7 Technical Requirements	1.7.3.7 Test Conditions	Autoclave Maintenance	Requirement
1403	1.7 Technical Requirements	1.7.3.7 Test Conditions	Autoclave Maintenance	Option
1404	1.7 Technical Requirements	1.7.3.7 Test Conditions	Autoclave Mechanical Timing Device	Requirement
1405	1.7 Technical Requirements	1.7.3.7 Test Conditions	Volumetric Equipment	
1406	1.7 Technical Requirements	1.7.3.7 Test Conditions	Volumetric Equipment	
1407	1.7 Technical Requirements	1.7.3.7 Test Conditions	Volumetric Equipment Verification	Requirement
1408	1.7 Technical Requirements	1.7.3.7 Test Conditions	Volumetric Equipment Verification	Requirement
1409	1.7 Technical Requirements	1.7.3.7 Test Conditions	Volumetric Equipment Verification	Requirement
1410	1.7 Technical Requirements	1.7.3.7 Test Conditions	UV Instruments	
1411	1.7 Technical Requirements	1.7.3.7 Test Conditions	UV Instruments	Requirement
1412	1.7 Technical Requirements	1.7.3.7 Test Conditions	UV Instruments	Requirement
1413	1.7 Technical Requirements	1.7.3.7 Test Conditions	Incubators, Water Baths, Ovens	
1414	1.7 Technical Requirements	1.7.3.7 Test Conditions	Incubators, Water Baths, Ovens	Requirement
1415	1.7 Technical Requirements	1.7.3.7 Test Conditions	Incubators, Water Baths, Ovens	Record
1416	1.7 Technical Requirements	1.7.3.7 Test Conditions	Labware	

1417	1.7 Technical Requirements	1.7.3.7 Test Conditions	Labware	Procedure
1418	1.7 Technical Requirements	1.7.3.7 Test Conditions	Labware	Requirement
1419	1.7 Technical Requirements	1.7.3.7 Test Conditions	Labware Inhibitory Residue	Requirement
1420	1.7 Technical Requirements	1.7.3.7 Test Conditions	Labware Residue	Requirement
1421	1.7 Technical Requirements	1.7.4 Data Acceptance / Rejection		
1422	1.7 Technical Requirements	1.7.4 Data Acceptance / Rejection	Method Procedures	Requirement
1423	1.7 Technical Requirements	1.7.5 Sample Handling		
1424	1.7 Technical Requirements	1.7.5 Sample Handling	Thermal Preservation	Requirement
1425	1.7 Technical Requirements	1.7.5 Sample Handling	Thermal Preservation	Option
1426	1.7 Technical Requirements	1.7.5 Sample Handling	Thermal Preservation	Option
1427	1.7 Technical Requirements	1.7.5 Sample Handling	Thermal Preservation	Option
1428	1.7 Technical Requirements	1.7.5 Sample Handling	Chlorine Checks	
1429	1.7 Technical Requirements	1.7.5 Sample Handling	Chlorine Checks	
1430	1.7 Technical Requirements	1.7.5 Sample Handling	Chlorine Checks	Option
1431	1.7 Technical Requirements	1.7.5 Sample Handling	Chlorine Checks	Option
1432	1.7 Technical Requirements	1.7.5 Sample Handling	Chlorine Checks	Option
1433	1.7 Technical Requirements	1.7.5 Sample Handling	Chlorine Checks	Option

Citation
V1M5 1
V1M5 1.1
V1M5 1.2
V1M5 1.2
V1M5 1.3
V1M5 1.3
V1M5 1.3.1
V1M5 1.3.1
V1M5 1.3.2
V1M5 1.3.2
V1M5 1.4
V1M5 1.4
V1M5 1.4
V1M5 1.4
V1M5 1.4
V1M5 1.4
V1M5 1.5
V1M5 1.5
V1M5 1.5
V1M5 1.5
V1M5 1.5

V1M5 1.5
V1M5 1.5
V1M5 1.5
V1M5 1.5.1
V1M5 1.5.2
V1M5 1.5.3
V1M5 1.6
V1M5 1.6.1
V1M5 1.6.1
V1M5 1.6.1
V1M5 1.6.1
V1M5 1.6.1
V1M5 1.6.1
V1M5 1.6.1
V1M5 1.6.1
V1M5 1.6.1
V1M5 1.6.1
V1M5 1.6.2
V1M5 1.6.2
V1M5 1.6.2
V1M5 1.6.2
V1M5 1.6.2.1
V1M5 1.6.2.1 a)

V1M5 1.6.2.1 b)
V1M5 1.6.2.1 c)
V1M5 1.6.2.1 d)
V1M5 1.6.2.1 e)
V1M5 1.6.2.1 f)
V1M5 1.6.2.1 g)
V1M5 1.6.2.2
V1M5 1.6.2.2 a)
V1M5 1.6.2.2 a)
V1M5 1.6.2.2 a)
V1M5 1.6.2.2 b)
V1M5 1.6.2.2 c)
V1M5 1.6.2.2 d)
V1M5 1.6.2.2 e)
V1M5 1.6.2.2 f)
V1M5 1.6.2.2 f) i.
V1M5 1.6.2.2 f) ii.
V1M5 1.6.2.2 g)
V1M5 1.6.3

V1M5 1.6.3.1
V1M5 1.6.3.1
V1M5 1.6.3.1
V1M5 1.6.3.2
V1M5 1.6.3.2 a)
V1M5 1.6.3.2 b)
V1M5 1.6.3.2 c)
V1M5 1.6.3.2 d)
V1M5 1.6.3.2 e)
V1M5 1.6.3.2 f)
V1M5 1.7
V1M5 1.7.1
V1M5 1.7.1 a)
V1M5 1.7.1 a)
V1M5 1.7.1 b)
V1M5 1.7.1 b) i.
V1M5 1.7.1 b) ii.
V1M5 1.7.1 b) ii.
V1M5 1.7.2
V1M5 1.7.2
V1M5 1.7.3

V1M5 1.7.3.1
V1M5 1.7.3.1 a)
V1M5 1.7.3.1 a)
V1M5 1.7.3.1 a) i.
V1M5 1.7.3.1 a) i.
V1M5 1.7.3.1 a) i.
V1M5 1.7.3.1 a) ii.
V1M5 1.7.3.1 a) ii.
V1M5 1.7.3.1 a) ii.
V1M5 1.7.3.1 a) iii.
V1M5 1.7.3.1 b)
V1M5 1.7.3.1 b) i.
V1M5 1.7.3.1 b) i.
V1M5 1.7.3.1 b) i.
V1M5 1.7.3.1 b) ii.
V1M5 1.7.3.1 b) ii.
V1M5 1.7.3.1 b) iii.
V1M5 1.7.3.1 b) iii.
V1M5 1.7.3.1 b) iii.
V1M5 1.7.3.1 b) iii.
V1M5 1.7.3.1 b) iv.
V1M5 1.7.3.1 b) iv.
V1M5 1.7.3.1 b) v.
V1M5 1.7.3.2

V1M5 1.7.3.2
V1M5 1.7.3.3
V1M5 1.7.3.3 a)
V1M5 1.7.3.3 b)
V1M5 1.7.3.4
V1M5 1.7.3.4
V1M5 1.7.3.5
V1M5 1.7.3.5
V1M5 1.7.3.5 a)
V1M5 1.7.3.5 a) i.
V1M5 1.7.3.5 a) i. 1
V1M5 1.7.3.5 a) i. 2
V1M5 1.7.3.5 a) i. 3
V1M5 1.7.3.5 a) ii.
V1M5 1.7.3.5 a) ii. 1
V1M5 1.7.3.5 a) ii. 2
V1M5 1.7.3.5 b)

V1M5 1.7.3.5 c)
V1M5 1.7.3.5 c) i.
V1M5 1.7.3.5 c) ii.
V1M5 1.7.3.5 c) iii.
V1M5 1.7.3.5 c) iv.
V1M5 1.7.3.5 c) v.
V1M5 1.7.3.5 d)
V1M5 1.7.3.6
V1M5 1.7.3.6 a)
V1M5 1.7.3.6 b)
V1M5 1.7.3.6 c)
V1M5 1.7.3.6 c)
V1M5 1.7.3.6 c) i.
V1M5 1.7.3.6 c) ii.
V1M5 1.7.3.6 d)

V1M5 1.7.3.6 d) i.
V1M5 1.7.3.6 d) i. 1
V1M5 1.7.3.6 d) i. 2
V1M5 1.7.3.6 d) ii.
V1M5 1.7.3.6 d) ii. 1
V1M5 1.7.3.6 d) ii. 2
V1M5 1.7.3.7
V1M5 1.7.3.7 a)
V1M5 1.7.3.7 a)
V1M5 1.7.3.7 a)
V1M5 1.7.3.7 a)
V1M5 1.7.3.7 b)
V1M5 1.7.3.7 b) i.
V1M5 1.7.3.7 b) i.
V1M5 1.7.3.7 b) i.
V1M5 1.7.3.7 b) i.
V1M5 1.7.3.7 b) ii.
V1M5 1.7.3.7 b) ii.
V1M5 1.7.3.7 b) ii.

V1M5 1.7.3.7 b) ii.
V1M5 1.7.3.7 b) ii.
V1M5 1.7.3.7 b) ii.
V1M5 1.7.3.7 b) ii.
V1M5 1.7.3.7 b) ii.
V1M5 1.7.3.7 b) ii.
V1M5 1.7.3.7 b) ii.
V1M5 1.7.3.7 b) ii.
V1M5 1.7.3.7 b) iii.
V1M5 1.7.3.7 b) iii.
V1M5 1.7.3.7 b) iii. 1
V1M5 1.7.3.7 b) iii. 2
V1M5 1.7.3.7 b) iii. 3
V1M5 1.7.3.7 b) iv.
V1M5 1.7.3.7 b) iv.
V1M5 1.7.3.7 b) iv.
V1M5 1.7.3.7 b) v.
V1M5 1.7.3.7 b) v. 1
V1M5 1.7.3.7 b) v. 2
V1M5 1.7.3.7 b) vi.

V1M5 1.7.3.7 b) vi. 1
V1M5 1.7.3.7 b) vi. 2
V1M5 1.7.3.7 b) vi. 3
V1M5 1.7.3.7 b) vi. 4
V1M5 1.7.4
V1M5 1.7.4
V1M5 1.7.5
V1M5 1.7.5 a)
V1M5 1.7.5 a) i.
V1M5 1.7.5 a) ii.
V1M5 1.7.5 a) iii.
V1M5 1.7.5 b)
V1M5 1.7.5 b)
V1M5 1.7.5 b) i.
V1M5 1.7.5 b) ii.
V1M5 1.7.5 b) iii.
1.7.5 b) iv.

Does the laboratory comply with this section?	Yes
MICROBIOLOGICAL TESTING	
Introduction	
This Standard applies to laboratories undertaking microbiological analysis of environmental samples. Microbiological testing refers to and includes the detection, isolation, enumeration, or identification of microorganisms and/or their metabolites, or determination of the presence or absence of growth in materials and media. The evaluation of laboratories for this discipline is in conjunction with a quality system as specified in general requirements module. Adherence to quality systems requirements will ensure that all quality control procedures specified in this module are being followed.	
Scope	
The essential quality control procedures applicable to microbiological analysis are included in this module. Additional quality control requirements that are either specified by method, regulation or project shall be met by laboratories.	
Terms and Definitions	
The relevant definitions from TNI, Volume 1, Module 2, Section 3.0 apply. Definitions related to this document, which are used differently or do not exist in the above references are defined below.	
Additional Terms and Definitions	
Reserved	
Exclusions and Exceptions	
Reserved	
Method Selection	
A reference method is a method issued by an organization generally recognized as competent to do so. (When ISO refers to a standard method, that term is equivalent to reference method).	
When a laboratory is required to analyze a parameter by a specified method due to a regulatory requirement, the parameter/method combination is recognized as a reference method.	
If there is not a regulatory requirement for the parameter/method combination, the parameter/method combination is recognized as a reference method if it can be analyzed by another similar reference method of the same matrix and technology.	
When it is necessary to use methods not covered by reference methods, these shall be subject to agreement with the client and shall include a clear specification of the client's requirements and the purpose of the environmental test.	
The method developed shall have been validated appropriately before use.	
Method Validation	
Validation is the confirmation by examination and the objective evidence that the particular requirements for a specific intended use are fulfilled.	
The laboratory shall validate non-reference methods, laboratory-designed/developed methods, reference methods used outside their published scope, and amplifications and modifications of reference methods to confirm that the methods are fit for the intended use.	
The validation shall be as extensive as is necessary to meet the needs of the given application or field of application.	
The laboratory shall record the results obtained, the procedure used for the validation, and a statement as to whether the method is fit for the intended use. The minimum requirements for method validation are given in Sections 1.5.1, 1.5.2 and 1.5.3.	

The laboratory shall maintain documentation of the validation procedure for as long as the method is in use and for at least five (5) years past the date of last use.	
Laboratories shall participate in a proficiency test program when available. The results of these analyses shall be used to evaluate the ability of the laboratory to produce acceptable data.	
The following assessment shall be performed. If no reference method exists, or if the data quality objectives are different from the reference method, then the laboratory shall demonstrate that the method meets the quality objectives for the intended use.	
Accuracy – Use at least one (1) known pure reference culture at the anticipated environmental conditions, and compare the method results to that of a reference method.	
Precision – Perform at least ten (10) replicate analyses with both the proposed and reference method, using the target microorganisms of choice. The results shall show that the methods are not statistically different.	
Selectivity (sensitivity) – Verify all responses in at least ten (10) samples using mixed cultures that include the target organism(s), and at varying concentrations (microbial identification testing or equivalent processes may be used). Calculate the number of false positive and false negative results.	
Demonstration of Capability (DOC)	
General	
Prior to acceptance and institution of any method for data reporting, satisfactory initial DOC is required ***(see Section 1.6.2)*** .	
Thereafter, ongoing DOC (Section 1.6.3), as per the quality control requirements in Section 1.7.3, is required.	
In cases where a laboratory analyzes samples using a method that has been in use by the laboratory for at least one year prior to applying for accreditation, and there have been no significant changes in instrument type, personnel or method, the ongoing DOC shall be acceptable as an initial DOC.	
The laboratory shall have records on file to demonstrate that an initial DOC is not required.	
For the initial DOC, appropriate records as discussed in Section 1.6.2 shall be completed ***(1.6.2).***	
An initial DOC shall be completed each time there is a change in instrument type, personnel, or method.***(1.6.2)***	
All demonstrations shall be documented.	
All data applicable to the demonstration shall be retained and readily available at the laboratory.	
Initial DOC	
An initial DOC shall be made prior to using any method,	
An initial DOC shall be at any time there is a change in instrument type, personnel or method	
An initial DOC shall be made any time that a method has not been performed by the laboratory or analyst in a twelve (12) month period.	
The laboratory shall document each initial DOC in a manner such that the following information is readily available for each affected employee:	
analyst(s) involved in preparation and/or analysis;	

matrix;	
organism(s);	
identification of method(s) performed;	
identification of laboratory-specific SOP used for analysis, including revision number;	
date(s) of analysis;	
summary of analyses, including information outlined in Section 1.6.2.2.c.	
If the method or regulation does not specify an initial DOC, the following procedure is acceptable. It is the responsibility of the laboratory to document that other approaches to initial DOC are adequate.	
The target organism(s) shall be diluted in a volume of clean quality system matrix (a sample in which no target organisms or interferences are present at concentrations that will impact the results of a specific method).	
This matrix shall be sterile phosphate or sterile peptone solution unless specified by the manufacturer.	
Prepare at least four (4) aliquots at the concentration specified, or if unspecified, to the countable range for plate methods or working range for most probable number (MPN) type methods.	
At least four (4) aliquots shall be prepared and analyzed according to the method either concurrently or over a period of days.	
Using all of the results, convert these results to logarithmic values, then calculate the mean recovery and standard deviation of the log converted results in the appropriate reporting units for each organism of interest. When it is not possible to determine mean and standard deviations, such as for presence/absence, the laboratory shall assess performance against established and documented criteria.	
For qualitative tests, acceptable performance in a blind study, either internally or externally generated, may be used to meet this Standard, provided that the study consists of a minimum of a blank, a negative culture, and a positive culture for each target organism or metabolite (e.g. b-glucuronidase in E. coli.).	
Compare the information from c) above to the corresponding acceptance criteria for precision and accuracy in the method (if applicable or in laboratory-generated acceptance criteria (if there are not established mandatory criteria). If all parameters meet the acceptance criteria, the analysis of actual samples may begin. If any one of the parameters does not meet the acceptance criteria, the performance is unacceptable for that parameter.	
When one or more of the tested parameters fail at least one of the acceptance criteria, the analyst shall proceed according to i) or ii) below.	
Locate and correct the source of the problem and repeat the initial DOC for all parameters of interest beginning with b) above.	
Repeat the initial DOC for all parameters that failed to meet criteria.	
Repeated failure, however, confirms a general problem with the measurement system. If this occurs, locate and correct the source of the problem and repeat the test for all compounds of interest beginning with b).	
Ongoing DOC	

The laboratory shall have a documented procedure describing ongoing DOC.	
The analyst(s) shall demonstrate ongoing capability by meeting the quality control requirements of the method, laboratory SOP, client specifications, and/or this Standard.	
It is the responsibility of the laboratory to document that other approaches to ongoing DOC are adequate.	
This ongoing demonstration may include one of the following or by performing another initial DOC.	
Analysis of one sample or clean matrix that is fortified with a known quantity of the target organism, with results meeting the laboratory acceptance criteria for accuracy and, where applicable to the testing technique, also meeting the observational details expected for the presumptive, confirmed and completed phases defined in the method.	
Analysis of one sample in duplicate for each target organism and test, with results meeting the laboratory acceptance criterion for precision.	
Acceptable results for one-single-blind proficiency test sample for target organisms in each field of accreditation.	
Performance of an alternate adequate procedure for the field of accreditation, the procedure and acceptance criteria being documented in the laboratory's quality system.	
A documented process of analyst review using QC samples. QC samples can be reviewed to identify patterns for individuals or groups of analysts and determine if corrective action or retraining is necessary; or	
f a) through e) are not technically feasible, then analysis of real-world samples with results within a predefined acceptance criteria (as defined by the laboratory or method) shall be performed.	
Technical Requirements	
Calibration	
The laboratory shall have documented procedures for calibration, verification, and quality control of support equipment including conductivity meters, oxygen meters, pH meters, hygrometers, and other similar measurement instruments.	
These procedures shall refer to applicable reference methods.	
For instruments that are continuous monitors, such as in-line specific conductance meters:	
The laboratory shall document acceptable calibration verification at least once a month.	
An initial calibration shall be performed if a continuing calibration is unacceptable,	
An initial calibration shall be performed when the instrument is being returned to service after having been taken off line.	
Continuing Calibration	
Reserved for specific procedures.	
Quality Control	

Sterility Checks and Method Blanks	
Method Blanks	
The laboratory shall demonstrate that the filtration equipment and filters, sample containers, media and reagents have not been contaminated through improper handling or preparation, inadequate sterilization, or environmental exposure.	
For filtration technique, the laboratory shall conduct method blanks per the analytical method.	
At a minimum, the filtration series shall include a beginning and ending blank.	
The filtration series may include single or multiple filtration units, which have been sterilized prior to beginning the series.	
The filtration series is considered ended when more than thirty (30) minutes elapses between successive filtrations.	
During a filtration series, filter funnels shall be rinsed with three (3) 20-30 ml portions of sterile rinse water after each sample filtration.	
In addition, laboratories shall insert a method blank after every ten (10) samples or sanitize filtration units by UV light after each sample filtration.	
For pour plate technique, method blanks of the medium shall be made by pouring, at a minimum, one uninoculated plate for each lot of pre-prepared, ready-to-use media	
Sterility Checks	
A sterility check shall be analyzed for each lot of pre-prepared, ready-to-use medium (including chromofluorogenic reagent)	
A sterility check shall be analyzed for each batch of medium prepared in the laboratory.	
A sterility check shall be done prior to first use of the medium.	
For pre-sterilized single use funnels, a sterility check shall be performed on one funnel per lot	
For laboratory-sterilized funnels, a sterility check shall be performed on one funnel per sterilization batch.	
Sterility checks on sample containers shall be performed on at least one (1) container for each lot of purchased, pre-sterilized containers.	
For containers prepared and sterilized in the laboratory, a sterility check shall be performed on one (1) container per sterilized batch with nonselective growth media.	
These sterility checks may be performed by a contracted laboratory if the laboratory does not have the requisite equipment to perform them.	
All correspondence and results from a contracted laboratory shall be retained for a period of five (5) years after the completion of the test(s).	
A sterility check shall be performed on each batch of dilution water prepared in the laboratory with non-selective growth media.	
A sterility check shall be performed on each lot of pre-prepared, ready-to-use dilution water with non-selective growth media.	
At least one (1) filter from each new lot of membrane filters shall be checked for sterility with nonselective growth media.	
Test Variability/Reproducibility	

For methods that specify colony counts such as membrane filter or plated media, duplicate counts shall be performed monthly on one positive sample, for each month that the test is performed. If the laboratory has two or more analysts, each analyst shall count typical colonies on the same plate. Counts shall be within 10% difference to be acceptable. In a laboratory with only one microbiology analyst, the same plate shall be counted twice by the analyst, with no more than 5% difference between the counts.	
Sample Specific Controls (where applicable)	
Matrix spikes shall be performed per method requirements.	
Sample matrix duplicates shall be performed per method requirements.	
Data Reduction	
The calculations, data reduction and statistical interpretations specified by each method shall be identified and followed.	
Quality of Standards, Reagents and Media	
The laboratory shall ensure that the quality of the reagents and media used is appropriate for the test concerned.	
Media – Culture media may be prepared from commercial dehydrated powders or may be purchased ready-to-use.	
Laboratory-prepared media	
Media prepared by the laboratory from basic ingredients shall be tested for performance (e.g., for selectivity, sensitivity, sterility, growth promotion, and growth inhibition) prior to first use.	
Media shall be used within the holding time limits specified in the accredited method.	
Detailed testing criteria information shall be defined in the laboratory's methods, SOPs, or similar documentation.	
Ready-to-use media	
Ready-to-use media shall be used within the manufacturer's expiration date. If the manufacturer's expiration date is greater than those noted in Section 1.7.3.5 a) i) 2. above, the laboratory shall request, and have available documentation from the manufacturer demonstrating media quality for the extended time period.	
Any ready-to-use media used past the expiration date shall be verified for usability by running quality control checks comparing the media with freshly prepared media or by testing recovery with known densities of culture controls.	
Reagents and commercial dehydrated powders shall be used within the shelf life of the product, and shall be documented as per TNI Volume 1, Module 2 Quality Systems General Requirements.	

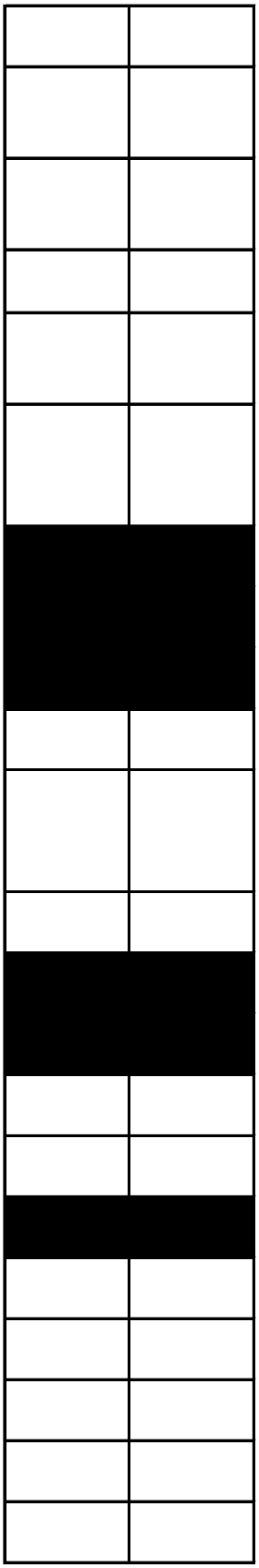
Reagent Water	
The quality of the reagent water used in the laboratory, such as distilled water, de-ionized water or reverse-osmosis produced water shall be monitored for bactericidal and inhibitory substances and shall be used in the preparation of media, solutions and buffers.	
The quality of the water shall be monitored for chlorine residual, specific conductance, total organic carbon, ammonia/organic nitrogen and heterotrophic bacteria plate count monthly (when in use), when maintenance is performed on the water treatment system, or at startup after a period of disuse longer than one month.	
Analysis for metals and the Bacteriological Water Quality Test (to determine presence of toxic agents or growth promoting substances) shall be performed annually. (An exception to performing the Bacteriological Water Quality Test shall be given to laboratories that can supply documentation to show that their water source meets the criteria, as specified by the method, for Type I or Type II reagent water.)	
Results of the above analyses (metals and bacteriological water quality) shall meet the specifications of the required method and records of analyses shall be maintained for five (5) years.	
Reagent water purchased from an outside source and used for the preparations of media, solutions and buffers shall meet the criteria specified in items ii) and iii) above. The laboratory shall have documented records of this information. Purchased reagent water that has been in use for longer than the testing intervals specified in items i) through i or in the accredited method shall either be re-tested or discarded.	
Documentation for media prepared in the laboratory shall include date of preparation, preparer's initials, type , manufacturer, lot number, final pH, expiration date, and the amount of reagents used. Documentation for media purchased pre-prepared, ready-to-use (including reagent water purchased from outside sources) shall include manufacturer, lot number, type of media received, date of receipt, expiration date of the media, and pH of the media.	
Selectivity	
All growth and recovery media shall be checked to assure that the target organism(s) respond in an acceptable and predictable manner.	
To ensure that analysis results are accurate, target organism identity shall be verified as specified in the method (e.g., by use of the completed test, or by use of secondary verification tests such as a catalase test or by the use of a completed test such as brilliant green (BG) or E. coli (EC) broth.	
In order to ensure identity and traceability, reference cultures used for positive and negative controls shall be obtained from a recognized national collection, organization, or manufacturer recognized by the accreditation body.	
Microorganisms may be single use preparations or cultures maintained for their intended use by documented procedures that demonstrate the continued purity and viability of the organism.	
Reference cultures may be revived (if freeze-dried) or transferred from slants and sub-cultured once to provide reference stocks. The reference stocks shall be preserved by a technique that maintains the characteristics of the strains. Reference stocks shall be used to prepare working stocks for routine work. If reference stocks have been thawed, they shall not be refrozen and re-used.	
Working stocks shall not be sequentially cultured more than five (5) times and shall not be sub-cultured to replace reference stocks.	
Culture Controls	

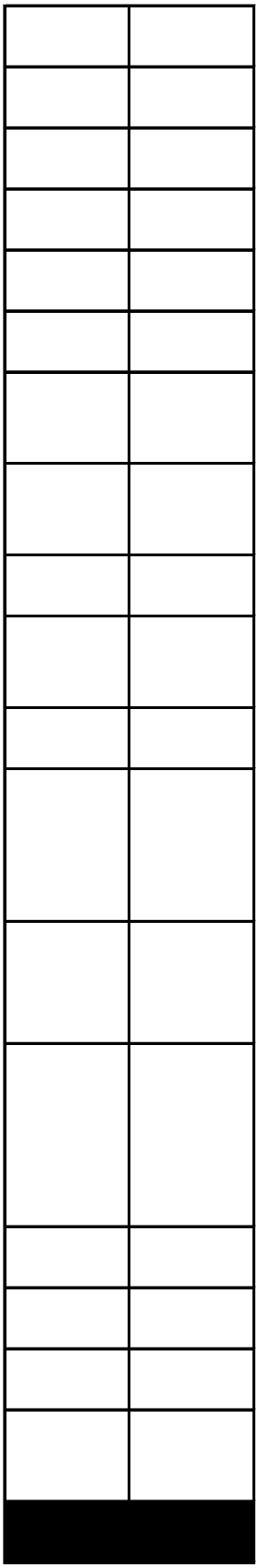
Negative Culture Controls	
Negative culture controls demonstrate that the medium does not support the growth of non-target organisms or does not exhibit the typical positive reaction of the target organism(s).	
Each pre-prepared, ready-to-use lot of selective medium (including chromofluorogenic reagent) and each batch of selective medium prepared in the laboratory shall be analyzed with one or more known negative culture controls (i.e. non-target organisms), as appropriate to the method. This shall be done prior to first use of the medium.	
Positive Culture Controls	
Positive culture controls demonstrate that the medium can support the growth of the target organism(s), and that the medium produces the specified or expected reaction to the target organism(s).	
Each pre-prepared, ready-to-use lot of medium (including chromofluorogenic reagent) and each batch of medium prepared in the laboratory shall be tested with at least one pure culture of a known positive reaction. This shall be done prior to first use of the medium.	
Constant and Consistent Test Conditions	
Laboratory Facilities	
Floors and work surfaces shall be non-absorbent and easy to clean and disinfect. Work surfaces shall be adequately sealed.	
Laboratories shall provide sufficient storage space, and shall be clean and free from dust accumulation.	
Plants, food, and drink shall be prohibited from the laboratory work area.	
Laboratory Equipment	
Temperature Measuring Devices	
Temperature measuring devices such as liquid-in-glass thermometers, thermocouples, and platinum resistance thermometers used in incubators, autoclaves and other equipment shall be the appropriate quality to meet specification(s) in the method.	
The graduation of the temperature measuring devices shall be appropriate for the required accuracy of measurement and they shall be verified to national or international standards for temperature.	
Verification shall be done at least annually (see TNI Volume 1, Module 2, Section 5.5.13.1).	
Autoclaves	
The performance of each autoclave shall be initially evaluated by establishing its functional properties and performance, for example heat distribution characteristics with respect to typical uses.	
Autoclaves shall meet specified temperature tolerances. Pressure cookers shall not be used for sterilization of growth media.	

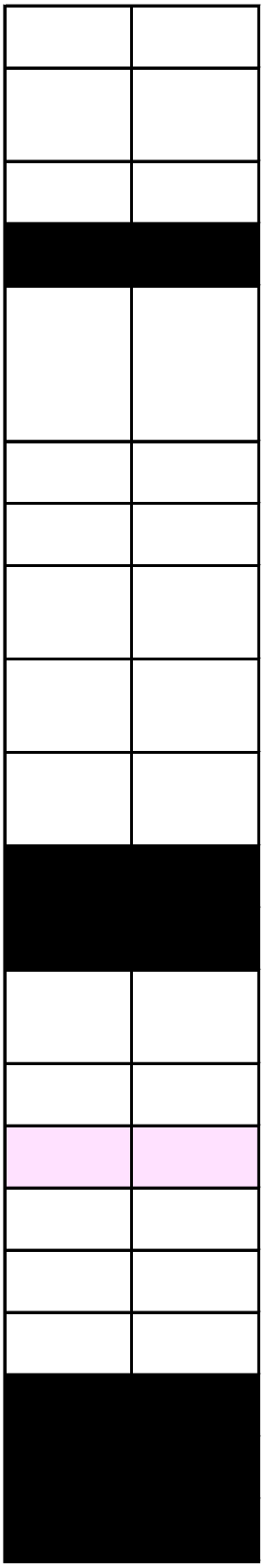
Pressure cookers shall not be used for sterilization of growth media.	
Demonstration of sterilization temperature shall be provided by use of a continuous temperature recording device or by use of a maximum registering thermometer with every cycle.	
At least once during each month that the autoclave is used, appropriate biological indicators shall be used to determine effective sterilization. The selected biological indicator shall be effective at the sterilization temperature and time needed to sterilize lactose-based media.	
Temperature sensitive tape shall be used with the contents of each autoclave run to indicate that the autoclave contents have been processed.	
Records of autoclave operations shall be maintained for every cycle. Records shall include: date, contents, maximum temperature reached, pressure, time in sterilization mode, total run time (may be recorded as time in and time out) and analyst's initials.	
Autoclave maintenance, either internally or by service contract, shall be performed annually, and shall include a pressure check and verification of temperature device. Records of the maintenance shall be maintained in equipment logs.	
NOTE: When it has been determined that the autoclave has no leaks, pressure checks can be documented using the formula PV = nRT.	
The autoclave mechanical timing device shall be checked quarterly against a stopwatch and the actual time elapsed documented.	
Volumetric Equipment	
Volumetric equipment shall be verified as follows:	
equipment with movable parts such as automatic dispensers, dispensers/diluters, and mechanical hand pipettes shall be verified for accuracy quarterly.	
equipment such as filter funnels, bottles, non-Class A glassware, and other containers with volumetric markings (including sample analysis vessels) shall be verified once per lot prior to first use. This verification may be volumetric or gravimetric.	
the volume of the disposable volumetric equipment such as sample bottles, and disposable pipettes shall be checked once per lot.	
UV Instruments	
UV instruments, used for sanitization, shall be tested quarterly for effectiveness with an appropriate UV light meter, by plate count agar spread plates or other methods providing equivalent results such as uvcide strips.	
Replace bulbs if output is less than 70% of original for light tests or if count reduction is less than 99% for a plate containing 200 to 300 organisms.	
Incubators, Water Baths, Ovens	
The uniformity of temperature distribution in incubators and water baths shall be established.	
Records shall be maintained for each cycle that include date, cycle time, temperature, contents and analyst's initials.	
Labware (Glassware and Plasticware)	

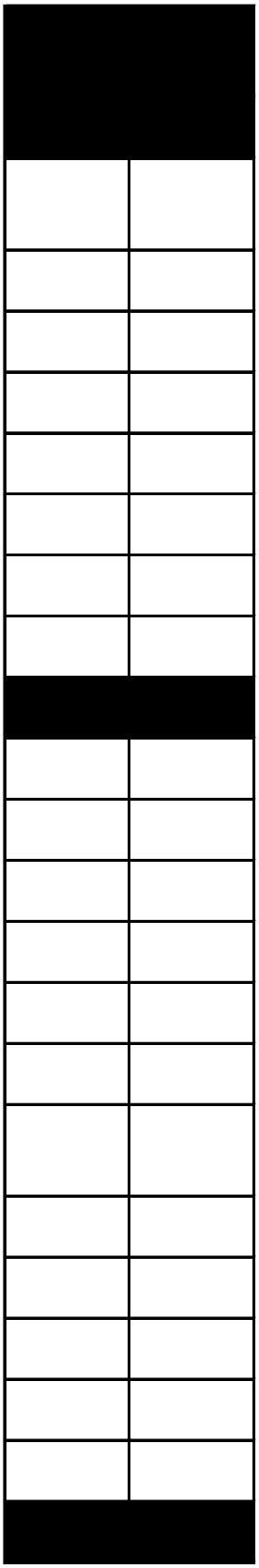
The laboratory shall have a documented procedure for washing labware, if applicable. Detergents designed for laboratory use shall be used.	
Glassware shall be made of borosilicate or other non-corrosive material, free of chips and cracks, and shall have readable measurement marks.	
Labware that is washed and reused shall be tested for possible presence of residues that may inhibit or promote growth of microorganisms by performing the Inhibitory Residue Test annually, and each time the lab changes the lot of detergent or washing procedures.	
Washed labware shall be tested at least once daily, each day of washing, for possible acid or alkaline residue by testing at least one piece of labware with a suitable pH indicator such as bromothymol blue. Records of tests shall be maintained.	
Data Acceptance/Rejection Criteria	
Method criteria and evaluation methods shall be used.	
Sample Handling	
Samples that require thermal preservation shall be considered acceptable if the arrival temperature of a representative sample container meets the method or mandated temperature requirement.	
Samples that are delivered to the laboratory on the same day they are collected may not meet the requirements of Section 1.7.5.a). In these cases, the samples shall be considered acceptable if the samples were received on ice.	
If sample analysis is begun within fifteen (15) minutes of collection, thermal preservation is not required.	
Thermal preservation is not required in the field if the laboratory receives the sample and either begins the analysis or refrigerates the sample within fifteen (15) minutes of collection.	
Microbiological samples from known chlorinated sources (such as wastewater effluent), unknown sources where chlorine usage is suspected (such a new client or a new source) and all potable water sources (including source water) shall be checked for absence of chlorine residual.	
Laboratories that receive samples from potable water sources (including source water) that have a demonstrated history of acceptable preservation may check a sample from each source at a frequency of once per month if:	
the laboratory can show that the received sample containers are from their laboratory;	
sufficient sodium thiosulfate was in each container before sample collection to neutralize at minimum 5 mg/l of chlorine for drinking water and 15 mg/l of chlorine for wastewater samples;	
one container from each batch of laboratory prepared containers or lot of purchased ready-to-use containers is checked to ensure efficacy of the sodium thiosulfate to 5 mg/l chlorine or 15 mg/l chlorine as appropriate and the check is documented;	
chlorine residual is checked in the field and actual concentration is documented with sample submission.	

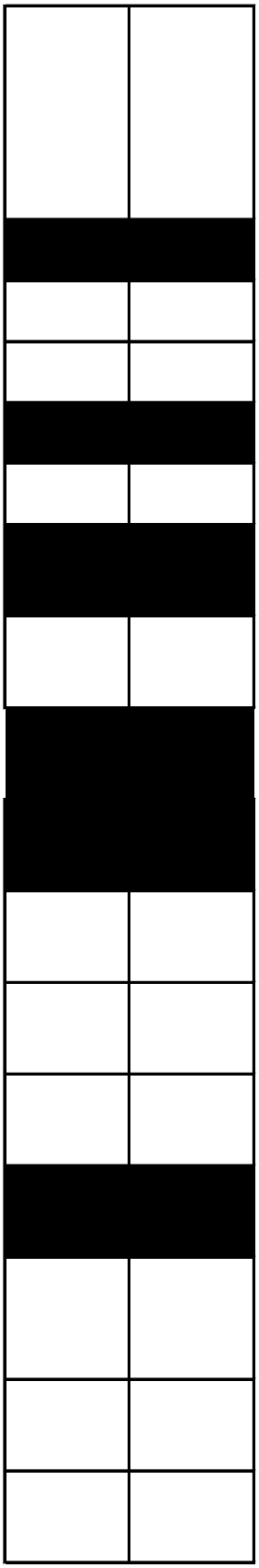
No	N/A
[redacted]	
[redacted]	

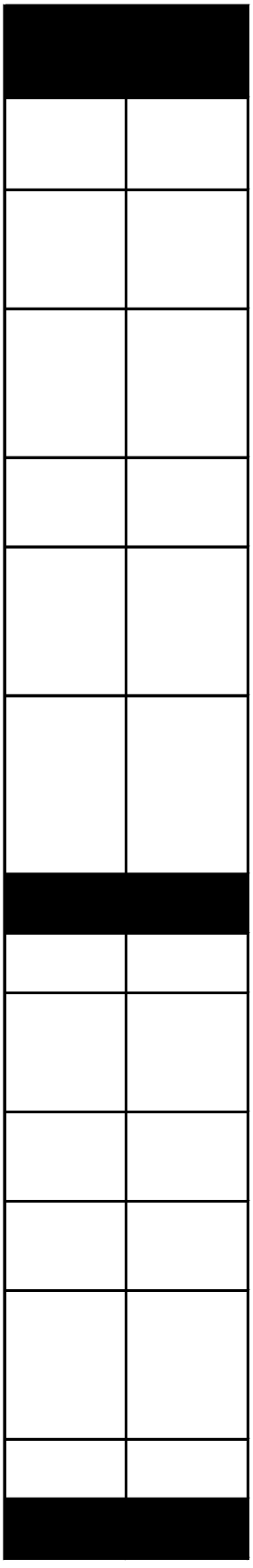


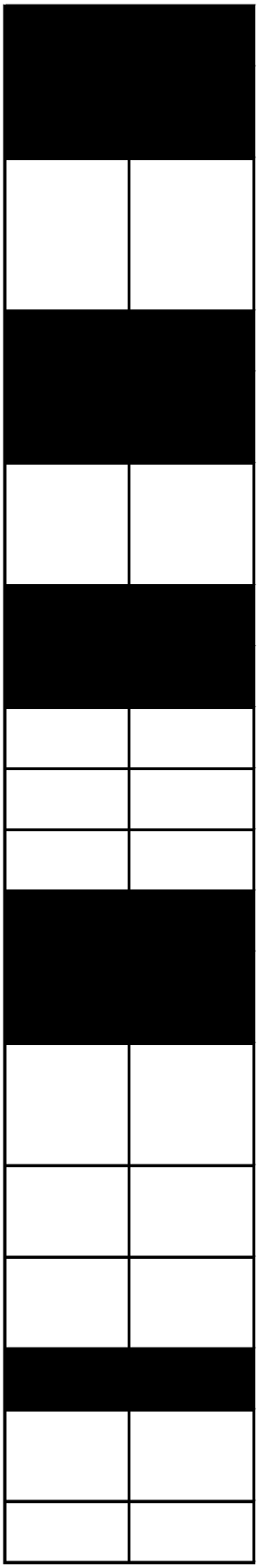


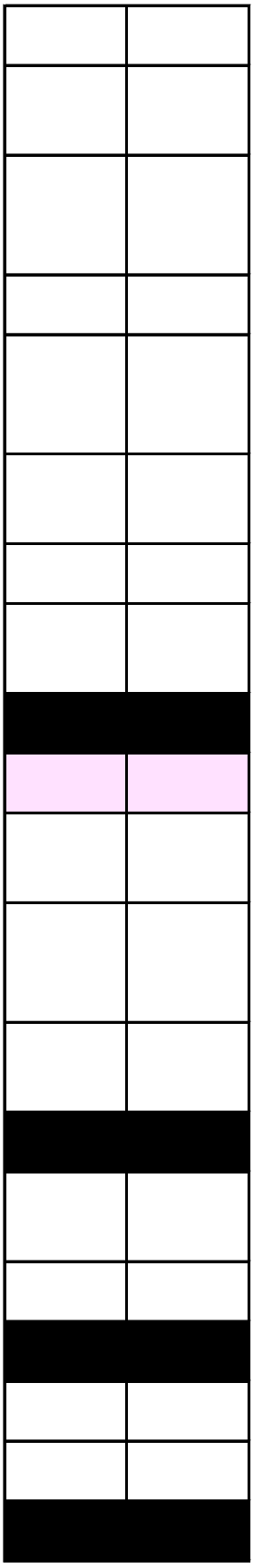


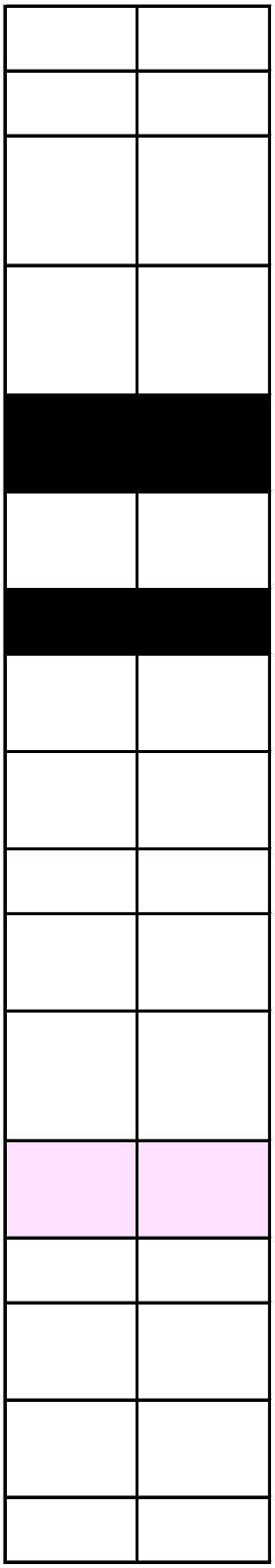












ID	Major Topic	Topic	Subject	Category
1434	1.0 Radiochemical testing			
1435	1.1 Introduction			
1436	1.1 Introduction			
1437	1.2 Scope			
1438	1.2 Scope			
1439	1.2 Scope			
1440	1.3 Definitions			
1441	1.3 Definitions			
1442	1.3 Definitions			
1443	1.3 Definitions			
1444	1.3 Definitions			
1445	1.3 Definitions			
1446	1.4 Method Selection			
1447	1.4 Method Selection	Reference Method	Regulatory	Definition
1448	1.4 Method Selection	Reference Method	Regulatory	Definition
1449	1.4 Method Selection	Reference Method	QC	Requirement
1450	1.4 Method Selection	Non Reference Method	Customer Communication	Requirement
1451	1.4 Method Selection	Non Reference Method	Validation	Requirement
1452	1.5 Method Validation			
1453	1.5 Method Validation	1.5.1 Validation		
1454	1.5 Method Validation	1.5.1 Validation	General	Definition

1455	1.5 Method Validation	1.5.1 Validation	Reference Method	Requirement
1456	1.5 Method Validation	1.5.1 Validation	Non Reference Method Validation	Requirement
1457	1.5 Method Validation	1.5.1 Validation	Non Reference Method Validation	Requirement
1458	1.5 Method Validation	1.5.1 Validation	Documentation	Requirement
1459	1.5 Method Validation	1.5.2 Detectable Activity		
1460	1.5 Method Validation	1.5.2 Detectable Activity	General	Procedure
1461	1.5 Method Validation	1.5.2 Detectable Activity	Documentation	Requirement
1462	1.5 Method Validation	1.5.2 Detectable Activity	Data	Record
1463	1.5 Method Validation	1.5.2.1 Minimum Detectable Activity		
1464	1.5 Method Validation	1.5.2.1 Minimum Detectable Activity	Relevancy	Procedure
1465	1.5 Method Validation	1.5.2.1 Minimum Detectable Activity	Mandated Method	Requirement
1466	1.5 Method Validation	1.5.2.1 Minimum Detectable Activity	Selection Criteria	Procedure
1467	1.5 Method Validation	1.5.2.1 Minimum Detectable Activity	Target Analytes	Requirement
1468	1.5 Method Validation	1.5.2.1 Minimum Detectable Activity	Processing	Requirement
1469	1.5 Method Validation	1.5.2.1 Minimum Detectable Activity	Quality System Matrix	Requirement
1470	1.5 Method Validation	1.5.2.1 Minimum Detectable Activity	Frequency	Requirement
1471	1.5 Method Validation	1.5.2.1 Minimum Detectable Activity	Frequency	Requirement
1472	1.5 Method Validation	1.5.2.1 Minimum Detectable Activity	MDA Definition	Requirement
1473	1.5 Method Validation	1.5.2.2 Detection Limits for SDWA		
1474	1.5 Method Validation	1.5.2.2 Detection Limits for SDWA	Method Selection	Requirement
1475	1.5 Method Validation	1.5.2.2 Detection Limits for SDWA	Detection Limit Definition	Requirement

1476	1.5 Method Validation	1.5.3 Precision and Bias		
1477	1.5 Method Validation	1.5.3 Precision and Bias	Reference Method	Requirement
1478	1.5 Method Validation	1.5.3 Precision and Bias	Non Reference Method	Procedure
1479	1.5 Method Validation	1.5.3 Precision and Bias	Evaluation	Procedure
1480	1.5 Method Validation	1.5.3 Precision and Bias	Evaluation	Requirement
1481	1.5 Method Validation	1.5.3 Precision and Bias	Processing	Requirement
1482	1.5 Method Validation	1.5.3 Precision and Bias	Example	
1483	1.5 Method Validation	1.5.3 Precision and Bias	Example	Option
1484	1.5 Method Validation	1.5.4 Measurement Uncertainty		
1485	1.5 Method Validation	1.5.4 Measurement Uncertainty	All Measurements	Requirement
1486	1.5 Method Validation	1.5.4 Measurement Uncertainty	Comparison	Requirement
1487	1.5 Method Validation	1.5.4 Measurement Uncertainty	Precision criterion	Requirement
1488	1.5 Method Validation	1.5.4 Measurement Uncertainty	Combined Standard Uncertainty	Requirement
1489	1.5 Method Validation	1.5.4 Measurement Uncertainty	Combined Standard Uncertainty	Calculation
1490	1.5 Method Validation	1.5.5 Selectivity		
1491	1.5 Method Validation	1.5.5 Selectivity	Evaluation	Requirement
1492	1.6 DOC	1.6.1 General		
1493	1.6 DOC	1.6.1 General		
1494	1.6 DOC	1.6.1 General	Initial DOC	Requirement
1495	1.6 DOC	1.6.1 General	Ongoing DOC	Requirement

1496	1.6 DOC	1.6.1 General	DOC	Exception
1497	1.6 DOC	1.6.1 General	DOC	Record
1498	1.6 DOC	1.6.1 General	Documentation	Record
1499	1.6 DOC	1.6.1 General	Frequency	Requirement
1500	1.6 DOC	1.6.1 General	Documentation	Requirement
1501	1.6 DOC	1.6.1 General	Data	Record
1502	1.6 DOC	1.6.2 Initial DOC		
1503	1.6 DOC	1.6.2 Initial DOC	DOC Frequency	Requirement
1504	1.6 DOC	1.6.2 Initial DOC	DOC Frequency	Requirement
1505	1.6 DOC	1.6.2 Initial DOC	DOC Frequency	Requirement
1506	1.6 DOC	1.6.2 Initial DOC	Documentation	Record
1507	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents
1508	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents
1509	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents
1510	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents
1511	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents
1512	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents
1513	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents
1514	1.6 DOC	1.6.2 Initial DOC	Procedure	Requirement
1515	1.6 DOC	1.6.2 Initial DOC	Procedure	Option
1516	1.6 DOC	1.6.2 Initial DOC	Procedure	Option
1517	1.6 DOC	1.6.2 Initial DOC	Procedure	Option

1518	1.6 DOC	1.6.2 Initial DOC	Procedure	Option
1519	1.6 DOC	1.6.2 Initial DOC	Procedure	Option
1520	1.6 DOC	1.6.2 Initial DOC	Procedure	Option
1521	1.6 DOC	1.6.2 Initial DOC	Procedure	Option
1522	1.6 DOC	1.6.2 Initial DOC	Procedure	Option
1523	1.6 DOC	1.6.2 Initial DOC	Procedure	Option
1524	1.6 DOC	1.6.3 Ongoing DOC		
1525	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Requirement
1526	1.6 DOC	1.6.3 Ongoing DOC	Competence	Requirement
1527	1.6 DOC	1.6.3 Ongoing DOC		
1528	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option
1529	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option
1530	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option
1531	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option
1532	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option
1533	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option
1534	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option
1535	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option
1536	1.7 Technical Requirements			
1537	1.7.1 Calibration			
1538	1.7.1 Calibration			
1539	1.7.1 Calibration	Initial		

1540	1.7.1 Calibration	Initial		
1541	1.7.1 Calibration	Initial	Multiple/Conflicting Requirements	Requirement
1542	1.7.1 Calibration	Initial	Calibration	Exception
1543	1.7.1 Calibration	Initial	Frequency	Requirement
1544	1.7.1 Calibration	Initial	Frequency	Requirement
1545	1.7.1 Calibration	Initial	Frequency	Requirement
1546	1.7.1 Calibration	Initial	Frequency	Option
1547	1.7.1 Calibration	Initial	Frequency	Procedure
1548	1.7.1 Calibration	Initial	Frequency	Procedure
1549	1.7.1 Calibration	Initial	Reference Standard	Requirement
1550	1.7.1 Calibration	Initial	Standard Characteristics	Requirement
1551	1.7.1 Calibration	Initial		
1552	1.7.1 Calibration	Initial	Processing	Procedure
1553	1.7.1 Calibration	Initial	Calibration Procedure	Record
1554	1.7.1 Calibration	Initial	Data	Record
1555	1.7.1 Calibration	Initial	Quantitation	Requirement
1556	1.7.1 Calibration	Initial	Quantitation	Exception
1557	1.7.1 Calibration	Initial	Second Source Verification	Requirement

1558	1.7.1 Calibration	Initial	Second Source Standard Traceability	Requirement
1559	1.7.1 Calibration	Initial	Acceptance Criteria	Procedure
1560	1.7.1 Calibration	Initial	Applicability	Requirement
1561	1.7.1 Calibration	Initial	Unacceptable Calibration	Corrective Action
1562	1.7.1 Calibration	Initial	Unacceptable Calibration	Requirement
1563	1.7.1 Calibration	Initial	Unacceptable Calibration	Reporting Requirement
1564	1.7.1 Calibration	Initial	Number of Standards	Procedure
1565	1.7.1 Calibration	Calibration Verification		
1566	1.7.1 Calibration	Calibration Verification	Monitoring and Evaluation	Requirement
1567	1.7.1 Calibration	Calibration Verification	Tolerance Charts	Requirement
1568	1.7.1 Calibration	Calibration Verification	Check Sources	Specifications
1569	1.7.1 Calibration	Calibration Verification	Gamma Ray	Frequency
1570	1.7.1 Calibration	Calibration Verification	Gamma Ray	Frequency
1571	1.7.1 Calibration	Calibration Verification	Gamma Ray	Frequency
1572	1.7.1 Calibration	Calibration Verification	Alpha Particle	Frequency
1573	1.7.1 Calibration	Calibration Verification	Alpha Particle	Frequency
1574	1.7.1 Calibration	Calibration Verification	Gas Proportional and Liquid Scintillation Counters	Frequency
1575	1.7.1 Calibration	Calibration Verification	Gas Proportional and Liquid Scintillation Counters	Frequency
1576	1.7.1 Calibration	Calibration Verification	Scintillation Counters	Frequency
1577	1.7.1 Calibration	Background Measurement		
1578	1.7.1 Calibration	Background Measurement	Control chart Evaluation	Requirement
1579	1.7.1 Calibration	Background Measurement	Use	Requirement

1580	1.7.1 Calibration	Background Measurement	Gamma Ray	Frequency
1581	1.7.1 Calibration	Background Measurement	Alpha Particle	Frequency
1582	1.7.1 Calibration	Background Measurement	Gas Proportional	Frequency
1583	1.7.1 Calibration	Background Measurement	Scintillation Counters	Frequency
1584	1.7.1 Calibration	Instrument Contamination Monitoring		
1585	1.7.1 Calibration	Instrument Contamination Monitoring	Monitoring for contamination	Procedure
1586	1.7.1 Calibration	Instrument Contamination Monitoring	Procedure	Details
1587	1.7.2 QC			
1588	1.7.2 QC	General		Procedure
1589	1.7.2 QC	General	Monitoring	Requirement
1590	1.7.2 QC	General	Corrective Action	Requirement
1591	1.7.2 QC	1.7.2.1 Negative Control	Method Blank	
1592	1.7.2 QC	1.7.2.1 Negative Control	Purpose	Requirement
1593	1.7.2 QC	1.7.2.1 Negative Control	Processing	Requirement
1594	1.7.2 QC	1.7.2.1 Negative Control	Blank Assessment	Procedure
1595	1.7.2 QC	1.7.2.1 Negative Control	Reporting	Requirement
1596	1.7.2 QC	1.7.2.1 Negative Control	Frequency	Requirement
1597	1.7.2 QC	1.7.2.1 Negative Control	Matrix Attributes	Requirement
1598	1.7.2 QC	1.7.2.1 Negative Control	Blank Subtraction	Requirement
1599	1.7.2 QC	1.7.2.1 Negative Control	Blank Subtraction	Exception
1600	1.7.2 QC	1.7.2.1 Negative Control	Blank Preparation	Requirement
1601	1.7.2 QC	1.7.2.2 Positive Control	LCS	

1602	1.7.2 QC	1.7.2.2 Positive Control	Purpose	Requirement
1603	1.7.2 QC	1.7.2.2 Positive Control	Evaluation	Requirement
1604	1.7.2 QC	1.7.2.2 Positive Control	Unacceptable LCS	Requirement
1605	1.7.2 QC	1.7.2.2 Positive Control	Frequency	Requirement
1606	1.7.2 QC	1.7.2.2 Positive Control	Matrix Attributes	Requirement
1607	1.7.2 QC	1.7.2.2 Positive Control	Matrix Attributes	Option
1608	1.7.2 QC	1.7.2.2 Positive Control	Matrix Attributes	Option
1609	1.7.2 QC	1.7.2.2 Positive Control	Activity	Requirement
1610	1.7.2 QC	1.7.2.2 Positive Control	LCS Source	Requirement
1611	1.7.2 QC	1.7.2.2 Positive Control	Reference Standard Criteria	Requirement
1612	1.7.2 QC	1.7.2.2 Positive Control	Multiple Isotope Methods	Requirement
1613	1.7.2 QC	1.7.2.2 Positive Control	Multiple Isotope Methods	Requirement
1614	1.7.2 QC	1.7.2.2 Positive Control	Gamma Ray Energy Ranges	Requirement
1615	1.7.2 QC	1.7.2.2 Positive Control	Blank Preparation	Requirement
1616	1.7.2 QC	1.7.2.3 Sample-Specific Controls		
1617	1.7.2 QC	1.7.2.3 Sample-Specific Controls	Matrix Effects	Procedure
1618	1.7.2 QC	1.7.2.3 Sample-Specific Controls	Matrix Effects	Procedure
1619	1.7.2 QC	1.7.2.3 Sample-Specific Controls	Matrix Tracking	Procedure
1620	1.7.2 QC	1.7.2.3 a) Matrix Spikes		

1621	1.7.2 QC	1.7.2.3 a) Matrix Spikes		
1622	1.7.2 QC	1.7.2.3 a) Matrix Spikes	Frequency	Requirement
1623	1.7.2 QC	1.7.2.3 a) Matrix Spikes	Spiked Components	Requirement
1624	1.7.2 QC	1.7.2.3 a) Matrix Spikes	Spiked Components	Requirement
1625	1.7.2 QC	1.7.2.3 a) Matrix Spikes	Insufficient Sample	Requirement
1626	1.7.2 QC	1.7.2.3 a) Matrix Spikes	Activity	Requirement
1627	1.7.2 QC	1.7.2.3 a) Matrix Spikes	Second Source	Requirement
1628	1.7.2 QC	1.7.2.3 a) Matrix Spikes	Reference Standard Criteria	Requirement
1629	1.7.2 QC	1.7.2.3 a) Matrix Spikes	Preparation	Requirement
1630	1.7.2 QC	1.7.2.3 a) Matrix Spikes	Multiple Isotope Methods	Requirement
1631	1.7.2 QC	1.7.2.3 a) Matrix Spikes	Multiple Isotope Methods	Requirement
1632	1.7.2 QC	1.7.2.3 b) Replicates		
1633	1.7.2 QC	1.7.2.3 b) Replicates	Preparation	Requirement
1634	1.7.2 QC	1.7.2.3 b) Replicates	Intended Use	Requirement
1635	1.7.2 QC	1.7.2.3 b) Replicates	Target Analytes	Occurrence
1636	1.7.2 QC	1.7.2.3 b) Replicates	Frequency	Requirement
1637	1.7.2 QC	1.7.2.3 b) Replicates	Sample Source	Requirement
1638	1.7.2 QC	1.7.2.3 b) Replicates	Low-level	Option
1639	1.7.2 QC	1.7.2.3 b) Replicates	LCS Duplicate	Option
1640	1.7.2 QC	1.7.2.3 c) Tracer		
1641	1.7.2 QC	1.7.2.3 c) Tracer	Calculation & Reporting	Requirement
1642	1.7.2 QC	1.7.2.3 c) Tracer	Processing	Requirement
1643	1.7.2 QC	1.7.2.3 c) Tracer	Tracer yield	Requirement

1644	1.7.2 QC	1.7.2.3 c) Tracer	Assessment	Requirement
1645	1.7.2 QC	1.7.2.3 c) Tracer	Corrective Action	Requirement
1646	1.7.2 QC	1.7.2.3 c) Tracer	Reporting	Requirement
1647	1.7.2 QC	1.7.2.3 d) Carrier		
1648	1.7.2 QC	1.7.2.3 d) Carrier	Calculation & Reporting	Requirement
1649	1.7.2 QC	1.7.2.3 d) Carrier	Processing	Requirement
1650	1.7.2 QC	1.7.2.3 d) Carrier	Tracer yield	Requirement
1651	1.7.2 QC	1.7.2.3 d) Carrier	Assessment	Requirement
1652	1.7.2 QC	1.7.2.3 d) Carrier	Corrective Action	Requirement
1653	1.7.2 QC	1.7.2.3 d) Carrier	Reporting	Requirement
1654	1.7.2 QC	1.7.2.4 Data Reduction		
1655	1.7.2 QC	1.7.2.4 Data Reduction	Data Reduction	Procedure
1656	1.7.2 QC	1.7.2.4 Data Reduction	Measurement Uncertainty	Requirement
1657	1.7.2 QC	1.7.2.4 Data Reduction	Uncertainty Type	Requirement
1658	1.7.2 QC	1.7.2.4 Data Reduction	Expanded Uncertainty	Requirement
1659	1.7.2 QC	1.7.2.4 Data Reduction	Procedure Reference	Requirement
1660	1.7.2 QC	1.7.2.5 Reagent Quality, Water Quality, and Checks		
1661	1.7.2 QC	1.7.2.5 Reagent Quality, Water Quality, and Checks	Purity	Requirement
1662	1.7.2 QC	1.7.2.5 Reagent Quality, Water Quality, and Checks	Verification	Requirement
1663	1.7.2 QC	1.7.2.5 Reagent Quality, Water Quality, and Checks	Water Source Quality	Requirement

1664	1.7.2 QC	1.7.2.5 Reagent Quality, Water Quality, and Checks	Water Source Quality	Requirement
1665	1.7.2 QC	1.7.2.5 Reagent Quality, Water Quality, and Checks	Water Source Quality	Requirement
1666	1.7.2 QC	1.7.2.5 Reagent Quality, Water Quality, and Checks	Radionuclide Standards	Procedure
1667	1.7.2 QC	1.7.2.5 Reagent Quality, Water Quality, and Checks	Source	Requirement
1668	1.7.2 QC	1.7.2.5 Reagent Quality, Water Quality, and Checks	Source	Requirement
1669	1.7.2 QC	1.7.2.5 Reagent Quality, Water Quality, and Checks	Commercial Suppliers	Requirement
1670	1.7.2 QC	1.7.2.5 Reagent Quality, Water Quality, and Checks	Certificate of Calibration	Requirement
1671	1.7.2 QC	1.7.2.5 Reagent Quality, Water Quality, and Checks	Deviations from value	Requirement
1672	1.7.2 QC	1.7.2.5 Reagent Quality, Water Quality, and Checks	Value to use	Requirement
1673	1.7.2 QC	1.7.2.5 Reagent Quality, Water Quality, and Checks	Handling, storage and expiration	Procedure
1674	1.7.2 QC	1.7.2.6 Selectivity		
1675	1.7.2 QC	1.7.2.6 Selectivity	Evaluation	Requirement
1676	1.7.2 QC	1.7.2.7 Constant and Consistent Test Conditions		
1677	1.7.2 QC	1.7.2.7 Constant and Consistent Test Conditions	Consistent Operation	Requirement
1678	1.7.2 QC	1.7.2.7 Constant and Consistent Test Conditions	Glassware	Requirement

1679	1.7.2 QC	1.7.2.7 Constant and Consistent Test Conditions	Glassware	Procedure
1680	1.7.2 QC	1.7.2.7 Constant and Consistent Test Conditions	Radiological Control Program	Requirement
1681	1.7.2 QC	1.7.2.7 Constant and Consistent Test Conditions	Radiological Control Program	Procedure
1682	1.7.2 QC	1.7.2.7 Constant and Consistent Test Conditions	Radiological Control Program	Procedure
1683	1.7.2 QC	1.7.2.7 Constant and Consistent Test Conditions	Radiological Control Program	Procedure
1684	1.7.3 Data Acceptance / Rejection Criteria			
1685	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.1 Negative Control		
1686	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.1 Negative Control	Evaluation	Requirement
1687	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.1 Negative Control	Contamination Source	Requirement
1688	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.1 Negative Control	Contamination	Exception
1689	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.1 Negative Control	Contamination	Exception
1690	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.1 Negative Control	Aliquot size compensation	Requirement
1691	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.1 Negative Control	Investigation	Requirement
1692	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.1 Negative Control	Corrective Action	Requirement
1693	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.1 Negative Control	Reporting	Requirement
1694	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.2 Positive Control		
1695	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.2 Positive Control	Evaluation	Requirement
1696	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.2 Positive Control	Calculation	Requirement
1697	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.2 Positive Control	Evaluation	Requirement
1698	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.2 Positive Control	Evaluation	Requirement

1699	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.2 Positive Control	Acceptable Performance	
1700	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.2 Positive Control	Unacceptable Performance	Requirement
1701	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.2 Positive Control	Reporting	Requirement
1702	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 Sample-Specific Controls		
1703	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 a) MS/MSDs		
1704	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 a) MS/MSDs		
1705	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 a) MS/MSDs	Calculation	Requirement
1706	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 a) MS/MSDs	Evaluation	Requirement
1707	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 a) MS/MSDs	Evaluation	Requirement
1708	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 a) MS/MSDs	Corrective Action	Requirement
1709	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 a) MS/MSDs	Reporting	Requirement
1710	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 b) Replicates		
1711	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 b) Replicates		
1712	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 b) Replicates	Calculation	Requirement
1713	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 b) Replicates	Evaluation	Requirement
1714	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 b) Replicates	Evaluation	Requirement
1715	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 b) Replicates	Corrective Action	Requirement
1716	1.7.3 Data Acceptance / Rejection Criteria	1.7.3.3 b) Replicates	Reporting	Requirement
1717	1.7.4 Sample Handling	1.7.4 Sample Handling		
1718	1.7.4 Sample Handling	1.7.4 Sample Handling	Thermal Preservation	Requirement
1719	1.7.4 Sample Handling	1.7.4 Sample Handling	Thermal Preservation	Requirement
1720	1.7.4 Sample Handling	1.7.4 Sample Handling	Thermal Preservation	Exception

1721	1.7.4 Sample Handling	1.7.4 Sample Handling	Thermal Preservation	Exception
1722	1.7.4 Sample Handling	1.7.4 Sample Handling	Chemical Preservation	Procedure

Citation	Does the laboratory comply with this section?
V1M6 1	1.0 RADIOCHEMICAL TESTING
V1M6 1.1	Introduction
V1M6 1.1	This Standard contains detailed quality control requirements for environmental testing activities involving radiochemical measurements. The evaluation of laboratories for this discipline is in conjunction with a quality system as specified in the general requirements module. Adherence to quality systems requirements will ensure that all quality control procedures specified in this module are being followed.
V1M6 1.2	Scope
V1M6 1.2	These requirements apply to laboratories undertaking the examination of environmental samples by radiochemical analysis. Procedures for radiochemical analysis may involve some form of chemical separation followed by detection of the radioactive emissions of the analyte (or indicative daughters) and tracer isotopes where used. Procedures for the determination of radioactive isotopes by mass spectrometry (e.g., ICP-MS or TIMS) or optical (e.g., KPA) techniques are outside the scope of this document.
V1M6 1.2	The essential quality control procedures applicable to radiochemistry measurements are included in this Standard. Additional quality control requirements that are specified by method, regulation or project shall be met by laboratories.
V1M6 1.3	Terms and Definitions
V1M6 1.3	The relevant definitions from TNI, Volume 1, Module 2, Section 3.0 apply. Definitions related to this document, which are used differently or do not exist in the above references are defined below.
V1M6 1.3.1	Additional Terms and Definitions
V1M6 1.3.1	Reserved
V1M6 1.3.2	Exclusions and Exceptions
V1M6 1.3.2	Reserved
V1M6 1.4	Method Selection
V1M6 1.4	A reference method is a method issued by an organization generally recognized as competent to do so. (When ISO refers to a standard method, that term is equivalent to reference method).
V1M6 1.4	When a laboratory is required to analyze a parameter by a specific method due to a regulatory requirement, the parameter/method combination is recognized as a reference method.
V1M6 1.4	If there is not a regulatory requirement for the parameter/method combination, the parameter/method combination is recognized as a reference method if it can be analyzed by another similar reference method of the same matrix and technology, and the inclusion of the parameter in the method meets all required calibration requirements of the method and the quality control requirements of the method to which the parameter is being added. If no QC exists in the method, the laboratory shall adhere to the requirements outlined in the similar method.
V1M6 1.4	When it is necessary to use methods not covered by reference methods, these shall be subject to agreement with the client and shall include a clear specification of the client's requirements and the purpose of the environmental test.
V1M6 1.4	The method developed shall have been validated appropriately before use.
V1M6 1.5	Method Validation
V1M6 1.5.1	Validation of Methods
V1M6 1.5.1 a)	Validation is the confirmation by examination and the objective evidence that the particular requirements for a specific intended use are fulfilled.

V1M6 1.5.1 b)	For reference methods, the minimum detectable activity (Section 1.5.2.1) applies. Evaluating precision and bias is covered in Section 1.5.3.
V1M6 1.5.1 c)	The laboratory shall validate non-reference methods, laboratory-designed/developed methods, reference methods used outside their published scope, and amplifications and modifications of reference methods to confirm that the methods are fit for the intended use.
V1M6 1.5.1 c)	The validation shall be as extensive as is necessary to meet the needs of the given application or field of application.
V1M6 1.5.1 c)	The laboratory shall record the results obtained, the procedure used for the validation, and a statement as to whether the method is fit for the intended use. The minimum requirements for method validation are given in Sections 1.5.2 – 1.5.5.
V1M6 1.5.2	Detectable Activity
V1M6 1.5.2	Detectable Activity - All procedures used shall be documented.
V1M6 1.5.2	Detectable Activity - Documentation shall include the quality system matrix type.
V1M6 1.5.2	Detectable Activity - All supporting data shall be retained.
V1M6 1.5.2.1	Minimum Detectable Activity (MDA)
V1M6 1.5.2.1	The laboratory shall utilize a method that provides an MDA that is appropriate and relevant for the intended use of the data.
V1M6 1.5.2.1	MDAs shall be determined by the protocol in the mandated method.
V1M6 1.5.2.1	If the protocol for determining the MDA is not specified, the selection of the procedure shall reflect instrument limitations and the intended application of the method.
V1M6 1.5.2.1 a)	The laboratory shall determine the MDA for the method for each target analyte of concern in the quality system sample matrices.
V1M6 1.5.2.1 a)	All sample-processing steps of the analytical method shall be included in the determination of the MDA.
V1M6 1.5.2.1 b)	The MDA shall be initially determined for the analytes of interest in each method in a quality system matrix in which there are no target analytes and no interferences at levels that would impact the results.
V1M6 1.5.2.1 c)	The MDA shall be determined each time there is a change in the method that affects how the test is performed
V1M6 1.5.2.1.c)	The MDA shall be determined each time a change in instrumentation occurs that affects the analytical detection capability.
V1M6 1.5.2.1 d)	The MDA is an estimate of the smallest true activity (or activity concentration) of analyte in a sample that ensures a 95% probability of detection, given a detection criterion that ensures only a 5% probability of detection in analyte-free samples.
V1M6 1.5.2.2	Required Detection Limit for Drinking Water Compliance
V1M6 1.5.2.2	Laboratories that analyze drinking-water samples for Safe Drinking Water Act (SDWA) compliance monitoring shall use methods whose detection limits meet the requirements of 40 CFR 141.
V1M6 1.5.2.2	The SDWA detection limit is defined in 40 CFR 141.25(c) as equal to the analyte concentration which can be counted with a precision of plus or minus 100% at the 95% confidence level (1.96σ where σ is the standard deviation of the net counting rate of the sample). The SDWA detection limit is equivalent to the concentration at which the relative standard deviation of the measurement due to counting statistics is 1/1.96.

V1M6 1.5.3	Evaluation of Precision and Bias
V1M6 1.5.3 a)	Reference Methods. The laboratory shall evaluate the precision and bias of a reference method for each analyte of concern for each quality system matrix according to Section 1.6 or alternate documented procedure when the analyte cannot be spiked into the sample matrix and QC samples are not commercially available.
V1M6 1.5.3 b)	Non- Reference Methods. For laboratory-developed methods or non-reference methods that were not in use by the laboratory before July 2003, the laboratory shall have a documented procedure to evaluate precision and bias.
V1M6 1.5.3.b)	The laboratory shall also compare results of the precision and bias measurements with criteria established by the client, given in the reference method, or established by the laboratory.
V1M6 1.5.3 c)	The laboratory shall also evaluate precision and bias in the relevant quality system matrices
V1M6 1.5.3 c)	The laboratory shall process the samples through the entire measurement system for each analyte of interest.
V1M6 1.5.3 d)	An example of a systematic approach to evaluate precision and bias could be the following:
V1M6 1.5.3 d)	Analyze QC samples in triplicate containing the analytes of concern at or near the MDA, at a level near ten (10) times the MDA, and at a mid-range concentration. Process these samples on different days as three (3) sets of samples through the entire measurement system for each analyte of interest. Each day one QC sample at each concentration is analyzed. A separate method blank shall be subjected to the analytical method along with the QC samples on each of the three (3) days. For each analyte, calculate the mean recovery for each day, for each level over days, and for all nine (9) samples. Calculate the relative standard deviation for each of the separate means obtained.
V1M6 1.5.4	Measurement Uncertainty
V1M6 1.5.4	All radiochemical measurements shall provide the uncertainty of each quantitative measurement result.
V1M6 1.5.4	The results of the precision evaluation in Section 1.5.3 shall be compared to the uncertainty estimates as a check on the validity of the uncertainty evaluation procedures.
V1M6 1.5.4	The experimentally observed precision at each testing level shall not be statistically greater than the maximum combined standard uncertainty of the measurement results at that level, although it may be somewhat less.
V1M6 1.5.4	The combined standard uncertainty, when used, is the uncertainty of a measured value expressed as an estimated standard deviation.
V1M6 1.5.4	The combined standard uncertainty is calculated by combining the standard uncertainties of the input estimates.
V1M6 1.5.5	Evaluation of Selectivity
V1M6 1.5.5	The laboratory shall evaluate selectivity, if applicable, by following the checks established within the method.
V1M6 1.6	Demonstration of Capability (DOC)
V1M6 1.6.1	General
V1M6 1.6.1	Prior to acceptance and institution of any method for data reporting, satisfactory initial DOC is required ***(see Section 1.6.2)*** .
V1M6 1.6.1	Thereafter, ongoing DOC (Section 1.6.3), as per the quality control requirements in Section 1.7.3 (such as laboratory control samples) is required.

V1M6 1.6.1	In cases where a laboratory analyzes samples using a method that has been in use by the laboratory for at least one year prior to applying for accreditation, and there have been no significant changes in instrument type, personnel or method, the ongoing DOC shall be acceptable as an initial DOC.
V1M6 1.6.1	The laboratory shall have records on file to demonstrate that an initial DOC is not required.
V1M6 1.6.1	For the initial DOC, appropriate records as discussed in Section 1.6.2 shall be completed.
V1M6 1.6.1	An initial DOC shall be completed each time there is a change in instrument type, personnel, or method ***(see 1.6.2).***
V1M6 1.6.1	All demonstrations shall be documented.
V1M6 1.6.1	All data applicable to the demonstration shall be retained and readily available at the laboratory.
V1M6 1.6.2	Initial DOC
V1M6 1.6.2	An initial DOC shall be made prior to using any method
V1M6 1.6.2	An initial DOC shall be made at any time there is a change in instrument type, personnel or method
V1M6 1.6.2	An initial DOC shall be made any time that a method has not been performed by the laboratory or analyst in a twelve (12) month period.
V1M6 1.6.2.1	The laboratory shall document each initial DOC in a manner such that the following information is readily available for each affected employee:
V1M6 1.6.2.1 a)	analyst(s) involved in preparation and/or analysis;
V1M6 1.6.2.1 b)	matrix;
V1M6 1.6.2.1 c)	analyte(s), class of analyte(s), or measured parameter(s);
V1M6 1.6.2.1 d)	identification of method(s) performed;
V1M6 1.6.2.1 e)	identification of laboratory-specific SOP used for analysis, including revision number;
V1M6 1.6.2.1 f)	date(s) of analysis;
V1M6 1.6.2.1 g)	summary of analyses, including information outlined in Section 1.6.2.2.c).
V1M6 1.6.2.2	If the method or regulation does not specify an initial DOC, the following procedure is acceptable. It is the responsibility of the laboratory to document that other approaches to initial DOC are adequate.
V1M6 1.6.2.2 a)	The analyte(s) shall be diluted in a volume of clean quality system matrix (a sample in which no target analytes or interferences are present at concentrations that will impact the results of a specific method) sufficient to prepare four (4) aliquots at a laboratory specified concentration. Where gamma-ray spectrometry is used to identify and quantify more than one analyte, the laboratory control sample shall contain gamma-emitting radionuclides that represent the low (e.g., 241Am), medium (e.g., 137Cs) and high (e.g., 60Co) energy range of the analyzed gamma-ray spectra. As indicated by these examples, the nuclides need not exactly bracket the calibrated energy range or the range over which nuclides are identified and quantified.
V1M6 1.6.2.2 b)	At least four (4) aliquots shall be prepared and analyzed according to the method either concurrently or over a period of days.
V1M6 1.6.2.2 c)	Using all of the results, calculate the mean recovery in the appropriate reporting units and the standard deviations of the population sample (in the same units) for each parameter of interest. When it is not possible to determine mean and standard deviations, such as for presence/absence and logarithmic values, the laboratory shall assess performance against established and documented criteria.

V1M6 1.6.2.2 d)	Compare the information from (c) above to the corresponding acceptance criteria for precision and accuracy in the method (if applicable) or in laboratory-generated acceptance criteria (if there are not established mandatory criteria). If all parameters meet the acceptance criteria, the analysis of actual samples may begin. If any one of the parameters does not meet the acceptance criteria, the performance is unacceptable for that parameter.
V1M6 1.6.2.2 e)	When one or more of the tested parameters fail at least one of the acceptance criteria, the analyst shall proceed according to i) or ii) below.
V1M6 1.6.2.2 e) i.	Locate and correct the source of the problem and repeat the test for all parameters of interest beginning with b) above.
V1M6 1.6.2.2 e) ii.	Beginning with b) above, repeat the test for all parameters that failed to meet criteria.
V1M6 1.6.2.2 f)	Repeated failure, however, confirms a general problem with the measurement system. If this occurs, locate and correct the source of the problem and repeat the test for all compounds of interest beginning with b).
V1M6 1.6.2.2 g)	When an analyte not currently found on the laboratory's list of accredited analytes is added to an existing accredited method, an initial DOC shall be performed for that analyte. When analytes are added to gamma-ray spectrometry and quantified this is not required.
V1M6 1.6.3	Ongoing DOC
V1M6 1.6.3.1	The laboratory shall have a documented procedure describing ongoing DOC.
V1M6 1.6.3.1	The analyst(s) shall demonstrate ongoing capability by meeting the quality control requirements of the method, laboratory SOP, client specifications, and/or this Standard. It is the responsibility of the laboratory to document that other approaches to ongoing DOC are adequate.
V1M6 1.6.3.2	This on-going demonstration may include one of the following:
V1M6 1.6.3.2 a)	acceptable performance of a blind sample (single blind to the analyst);
V1M6 1.6.3.2 a)	Note: Successful analysis of a blind performance sample on a similar method using the same technology.
V1M6 1.6.3.2 b)	another initial DOC;
V1M6 1.6.3.2 c)	at least four (4) consecutive laboratory control samples with acceptable levels of precision and accuracy.
V1M6 1.6.3.2 c)	The laboratory shall determine the acceptable limits for precision and accuracy prior to analysis.
V1M6 1.6.3.2 c)	The laboratory shall tabulate or be able to readily retrieve four (4) consecutive passing LCS for each method for each analyst each year;
V1M6 1.6.3.2 d)	a documented process of analyst review using QC samples. QC samples can be reviewed to identify patterns for individuals or groups of analysts and determine if corrective action or retraining is necessary;
V1M6 1.6.3.2 e)	if a) through d) are not technically feasible, then analysis of real-world samples with results within predefined acceptance criteria (as defined by the laboratory or method) shall be performed.
V1M6 1.7	Technical Requirements
V1M6 1.7.1	Instrument Calibration
V1M6 1.7.1 a)	Initial Calibration
V1M6 1.7.1 a)	This Section addresses those practices that are necessary for proper calibration of radiation counting instruments for environmental testing involving radioanalytical measurements.

V1M6 1.7.1 a)	This Section specifies the essential elements that shall define the procedures and documentation for initial instrument calibration and continuing instrument calibration verification to ensure that the data shall be of known quality and be appropriate for a given regulation or decision. This Standard does not specify detailed procedural steps (“how to”) for calibration, but establishes the essential elements for selection of the appropriate technique(s). This approach allows flexibility and permits the employment of a wide variety of analytical procedures and statistical approaches currently applicable for calibration.
V1M6 1.7.1 a)	If more stringent standards or requirements are included in a mandated method or regulation, the laboratory shall demonstrate that such requirements are met. If it is not apparent which standard is more stringent, then the requirements of the mandated method or regulation are to be followed.
1.7.1 a)	Given that radiation detection efficiency is essentially independent of sample activity at all but high activity levels (where dead time becomes significant), the requirements for calibration ranges of standards, of data reporting in calibration range, and the number of calibration standards are not applicable to radiochemical method calibrations except for mass attenuation in gas-proportional counting and sample quench in liquid scintillation counting.
V1M6 1.7.1 a)	Nuclear counting instruments are subject to calibration prior to initial use
V1M6 1.7.1 a)	Nuclear counting instruments are subject to calibration when the instrument is placed back into service after major repairs and the instrument’s response has changed as determined by a performance check
V1M6 1.7.1 a)	Nuclear counting instruments are subject to calibration when the instrument’s response exceeds predetermined acceptance criteria for the instrument quality control.
V1M6 1.7.1 a)	Instruments may also be recalibrated on a regular frequency even in the absence of these conditions.
V1M6 1.7.1 a)	The frequency of calibration shall be described in the laboratory method SOP if not specified in the method.
V1M6 1.7.1 a)	A specific frequency (e.g., annually) or calibrations based on observations from the associated control or tolerance chart, shall be specified in the laboratory method SOP.
V1M6 1.7.1 a)	Instrument calibration shall be performed with reference standards as defined in Section 1.7.2.5.c).
V1M6 1.7.1 a)	The standards shall have the same general characteristics (i.e., geometry, homogeneity, density, etc.) as the associated samples.
V1M6 1.7.1 a)	The following items are essential elements of initial instrument calibration:
V1M6 1.7.1 a) i.	The details of the initial instrument calibration procedures including calculations, acceptance criteria and associated statistics shall be included or referenced in the method SOP.
V1M6 1.7.1 a) i.	When initial instrument calibration procedures are referenced in the method, then the referenced material shall be retained by the laboratory and be available for review.
V1M6 1.7.1 a) ii.	Sufficient raw data records shall be retained to permit reconstruction of the initial instrument calibration (e.g., calibration date, method, instrument, analysis date, each analyte name, analyst’s initials or signature;
V1M6 1.7.1 a) iii.	Sample results shall be quantitated from the initial instrument calibration
V1M6 1.7.1 a) iii.	Sample results may not be quantitated from any continuing instrument calibration verification unless otherwise required by regulation, method, or program.
V1M6 1.7.1 a) iv.	All initial instrument calibrations shall be verified with a standard obtained from a second manufacturer or lot if the lot can be demonstrated from the manufacturer as prepared independently from other lots.

V1M6 1.7.1 a) iv.	Traceability shall be to a national standard, when commercially available.
V1M6 1.7.1 a) v.	Criteria for the acceptance of an initial instrument calibration shall be established (e.g., correlation coefficient or relative percent difference).
V1M6 1.7.1 a) v.	The criteria used shall be appropriate to the calibration technique employed.
V1M6 1.7.1 a) vi.	If the initial instrument calibration results are outside established acceptance criteria, corrective actions shall be performed
V1M6 1.7.1 a) vi.	If the initial instrument calibration results are outside established acceptance criteria all associated samples re-analyzed.
V1M6 1.7.1 a) vi.	If re-analysis of the samples is not possible, data associated with an unacceptable initial instrument calibration shall be reported with appropriate data qualifiers.
V1M6 1.7.1 a) vii.	If a reference or mandated method does not specify the number of calibration standards, the laboratory shall have a written procedure for determining the number of points for establishing the initial instrument calibration.
V1M6 1.7.1 b)	Instrument Calibration Verification (Performance Checks)
V1M6 1.7.1 b)	Performance checks shall be performed using appropriate check sources and monitored with control charts or tolerance charts to ensure that the instrument is operating properly, the detector response has not significantly changed, and therefore the instrument calibration has not changed.
V1M6 1.7.1 b)	The same check source used in the preparation of the tolerance chart or control chart at the time of calibration shall be used in the calibration verification of the instrument (performance checks).
V1M6 1.7.1 b)	The check sources shall provide adequate counting statistics for a relatively short count time and the source should be sealed or encapsulated to prevent loss of activity and contamination of the instrument and laboratory personnel.
V1M6 1.7.1 b) i.	For gamma-ray spectroscopy systems, performance checks for detection efficiency shall be performed on a day-of-use basis.
V1M6 1.7.1 b) i.	For gamma-ray spectroscopy systems, performance checks for energy calibration shall be performed on a day-of-use basis.
V1M6 1.7.1 b) i.	For gamma-ray spectroscopy systems, performance checks for peak resolution shall be performed on a day-of-use basis.
V1M6 1.7.1 b) ii.	For alpha-particle spectroscopy systems, the performance check for energy calibration shall be performed on a weekly basis,
V1M6 1.7.1 b) ii.	and the performance check for detection efficiency shall be performed on at least a monthly basis.
V1M6 1.7.1 b) iii.	For gas-proportional and liquid scintillation counters, the performance check for detection efficiency shall be performed on a day-of-use basis.
V1M6 1.7.1 b) iii.	For batches of samples that uninterruptedly count for more than a day, a performance check may be performed instead at the beginning and end of the batch as long as this time interval is no greater than one week.
V1M6 1.7.1 b) iv.	For scintillation counters the calibration verification for detection efficiency shall be performed on a day-of-use basis.
V1M6 1.7.1 c)	Background Measurement
V1M6 1.7.1 c)	Background measurements shall be made on a regular basis and monitored using control charts or tolerance charts to ensure that a laboratory maintains its capability to meet required measurement quality objectives. This background measurement is not the short term check for contamination that is addressed in 1.7.1 d).
V1M6 1.7.1 c)	The background measurement values must be subtracted from the total measured activity in the determination of the sample activity.

V1M6 1.7.1 c) i.	For gamma-ray spectroscopy systems, background measurements shall be performed on at least a monthly basis.
V1M6 1.7.1 c) ii.	For alpha-particle spectroscopy systems, background measurements shall be performed on at least a monthly basis.
V1M6 1.7.1 c) iii.	For gas-proportional counters background measurements shall be performed on at least a weekly basis.
V1M6 1.7.1 c) iv.	For scintillation counters, background measurements shall be performed each day of use.
V1M6 1.7.1 d)	Instrument Contamination Monitoring
V1M6 1.7.1 d)	The laboratory shall have a written procedure for monitoring radiation measurement instrumentation for radioactive contamination.
V1M6 1.7.1 d)	The procedure shall indicate the frequency of the monitoring and shall indicate criteria, which initiates corrective action.
V1M6 1.7.2	Quality Control for Radiochemistry
V1M6 1.7.2	The laboratory shall have quality control procedures for monitoring the validity of environmental tests undertaken as specified in this Section. ***(see requirements below)***
V1M6 1.7.2	This monitoring shall be planned and reviewed.
V1M6 1.7.2	The failure of any QC sample analysis and the corrective actions taken shall be noted in the laboratory report for the associated samples.
V1M6 1.7.2.1	Negative Control – Method Performance: Method Blank
V1M6 1.7.2.1 a)	The method blank is used to assess the preparation batch for possible contamination during the preparation and processing steps or for other low-level bias.
V1M6 1.7.2.1 a)	The method blank shall be processed along with and under the same conditions as the associated samples to include all steps of the analytical procedure.
V1M6 1.7.2.1 a)	Procedures shall be in place to determine if a method blank result is significantly different from zero.
V1M6 1.7.2.1 a)	Any affected samples associated with a failed method blank shall be reprocessed for analysis or the results reported with appropriate data-qualifying codes.
V1M6 1.7.2.1 b)	The method blank shall be analyzed at a minimum of one (1) per preparation batch, which shall be a maximum of twenty (20) field samples, for all radiochemical methods except gross alpha/beta in solid matrices and gamma-ray spectrometry.
V1M6 1.7.2.1 c)	The method blank shall consist of a quality system matrix that is similar to the associated samples and is known to be as free of the analytes of interest as possible.
V1M6 1.7.2.1 c)	There shall be no subtraction of the method blank result from the sample results in the associated preparation or analytical batch unless permitted by method or program.
V1M6 1.7.2.1 c)	This requirement does not preclude corrections for background radiation (e.g., instrument background, analyte in the tracer or carrier, reagent impurities, peak overlap, etc.) to all analyzed samples, both program/project submitted and internal quality control samples. However, these corrections shall not depend on the result of the method blank analysis, whose purpose is to check for uncorrected contamination or other low-level bias.
V1M6 1.7.2.1 c)	The method blank sample shall be prepared with aliquot size similar to that of the routine samples for analysis.
V1M6 1.7.2.2	Positive Control – Method Performance: Laboratory Control Sample (LCS)

V1M6 1.7.2.2 a)	The LCS is used to evaluate the performance of the total analytical system, including all preparation and analysis steps.
V1M6 1.7.2.2 a)	Results of the LCS are compared to established criteria and, if found to be outside of these criteria may indicate that the analytical system is “out of control.”
V1M6 1.7.2.2 a)	Any affected samples associated with an out-of-control LCS shall be reprocessed for reanalysis or the results reported with appropriate data qualifying codes.
V1M6 1.7.2.2 b)	The LCS shall be analyzed at a minimum of one per preparation batch. Exceptions would be for those analytes for which no spiking solutions are available.
V1M6 1.7.2.2 c)	The LCS is a quality system matrix, known to be free of analytes of interest, spiked with known and verified concentrations of analytes.
V1M6 1.7.2.2 c)	NOTE: The matrix spike may be used in place of this control as long as the acceptance criteria are as stringent as for the LCS.
V1M6 1.7.2.2 d)	Alternatively the LCS may consist of a medium containing known and verified concentrations of analytes or as Certified Reference Material (CRM). The components to be spiked shall be as specified by the mandated method or regulation or as requested by the client.
V1M6 1.7.2.2 e)	The activity of the laboratory control sample shall be: (1) at least ten (10) times the MDA, and (2) at a level comparable to that of routine samples when such information is available if the sample activities are expected to exceed ten times the MDA.
V1M6 1.7.2.2 f)	The laboratory standards used to prepare the laboratory control sample shall be from a source independent of the laboratory standards used for instrument calibration,
V1M6 1.7.2.2 f)	The laboratory standards used to prepare the laboratory control sample shall meet the requirements for reference standards provided in Section 1.7.5.2.c).
V1M6 1.7.2.2 g)	Where a radiochemical method, other than gamma-ray spectroscopy, has more than one reportable analyte isotope (e.g. plutonium, 238Pu and 239Pu, using alpha-particle spectrometry), only one of the analyte isotopes need be included in the laboratory control sample at the indicated activity level.
V1M6 1.7.2.2 g)	However, where more than one analyte is detectable, each shall be assessed against the specified acceptance criteria.
V1M6 1.7.2.2 h)	Where gamma-ray spectrometry is used to identify and quantify more than one analyte, the laboratory control sample shall contain gamma-emitting radionuclides that represent the low (e.g., 241Am), medium (e.g., 137Cs) and high (e.g., 60Co) energy range of the analyzed gamma-ray spectra. As indicated by these examples, the nuclides need not exactly bracket the calibrated energy range or the range over which nuclides are identified and quantified.
V1M6 1.7.2.2 i)	The laboratory control sample shall be prepared with similar aliquot size to that of the routine samples for analyses.
V1M6 1.7.2.3	Sample-Specific Controls
V1M6 1.7.2.3	The laboratory shall document procedures for determining the effect of the sample matrix on method performance.
V1M6 1.7.2.3	These procedures relate to the analyses of quality system matrix specific quality control (QC) samples and are designed as data quality indicators for a specific sample using the designated method.
V1M6 1.7.2.3	Examples of matrix-specific QC include: Matrix Spike (MS); Matrix Spike Duplicate (MSD); and replicates. The laboratory shall have procedures in place for tracking, managing, and handling matrix-specific QC criteria including spiking appropriate components at appropriate concentrations, calculating recoveries and relative percent difference, evaluating and reporting results based on performance of the QC samples.
V1M6 1.7.2.3 a)	Matrix Spike

V1M6 1.7.2.3 a) i.	Matrix spikes indicate the effect of the sample matrix on the accuracy of the results generated using the selected method. The results of this analysis shall be one of the quality control measures used to assess the batch.
V1M6 1.7.2.3 a) ii.	The frequency of the analysis of matrix spikes are as specified by the method or may be determined as part of the contract review process.
V1M6 1.7.2.3 a) iii.	The components to be spiked shall be as specified by the mandated method.
V1M6 1.7.2.3 a) iii.	Any permit specified analytes, as specified by regulation or client requested analytes shall also be included.
V1M6 1.7.2.3 a) iv.	The lack of sufficient sample aliquot size to perform a matrix spike shall be noted in the laboratory report.
V1M6 1.7.2.3 a) v.	The activity of the matrix spike analytes(s) shall be greater than five times the MDA.
V1M6 1.7.2.3 a) vi.	The laboratory standards used to prepare the matrix spike shall be from a source independent of the laboratory standards used for instrument calibration,
V1M6 1.7.2.3 a) vi.	The laboratory standards used to prepare the matrix spike shall meet the requirements for reference standards of Section 1.7.2.5.c).
V1M6 1.7.2.3 a) vii.	The matrix spike shall be prepared by adding a known activity of target analyte after sub-sampling if required but before any chemical treatment (e.g., chemical digestion, dissolution, separation, etc.).
V1M6 1.7.2.3 a) vii.	Where a radiochemical method, other than gamma-ray spectroscopy, has more than one reportable analyte isotope (e.g. plutonium, 238Pu and 239Pu, using alpha-particle spectrometry), only one of the analyte isotopes need be included in the matrix spike sample at the indicated activity level.
V1M6 1.7.2.3 a) vii.	However, where more than one analyte is detectable, each shall be assessed against the specified acceptance criteria.
V1M6 1.7.2.3 b)	Replicates / Matrix Spike Duplicates / Laboratory Control Sample Duplicates
V1M6 1.7.2.3 b) i.	Replicates are defined as replicate aliquots of the same sample taken through the entire analytical procedure.
V1M6 1.7.2.3 b) i.	The results from replicate analysis indicate the precision of the results for the specific sample using the selected method.
V1M6 1.7.2.3 b) i.	Replicates provide the most useful measure of precision when target analytes are found in the sample chosen for replication.
V1M6 1.7.2.3 b) ii.	The frequency of the analysis of matrix replicates and duplicates are as specified by the method or may be determined as part of the contract review process.
V1M6 1.7.2.3 b) iii.	Replicates are performed on replicate aliquots of actual samples.
V1M6 1.7.2.3 b) iv.	For low-level samples (less than approximately three times the MDA) the laboratory may analyze a laboratory control samples duplicate or a replicate matrix spike (matrix spike and a matrix spike duplicate) to determine reproducibility within a preparation batch in place of a sample replicate.
V1M6 1.7.2.3 b) iv.	In addition based on project or program requirements, the laboratory may analyze a laboratory control sample duplicate or a matrix spike duplicate in place of a sample replicate.
V1M6 1.7.2.3 c)	Tracer
V1M6 1.7.2.3 c)	For those methods that employ a tracer for yield determination, each sample result shall have an associated tracer yield calculated and reported.
V1M6 1.7.2.3 c)	The tracer shall be added to the sample after subsampling, if required, but before any chemical treatment (e.g., chemical digestion, dissolution, separation, etc.) unless otherwise specified by the method.
V1M6 1.7.2.3 c)	The tracer yield for each sample result shall be one of the quality control measures to be used to assess the associated sample result acceptance.

V1M6 1.7.2.3 c)	The tracer yield shall be assessed against the specific acceptance criteria specified in the method.
V1M6 1.7.2.3 c)	When the specified tracer yield acceptance criteria are not met, the specified corrective action and contingencies shall be followed.
V1M6 1.7.2.3 c)	The occurrence of a failed tracer yield and the actions taken shall be noted in the laboratory report to the client.
V1M6 1.7.2.3 d)	Carrier
V1M6 1.7.2.3 d)	For those methods that utilize a carrier for yield determination, each sample shall have an associated carrier yield calculated and reported.
V1M6 1.7.2.3 d)	The carrier shall be added to the sample after subsampling, if required, but before any chemical treatment (e.g., chemical digestion, dissolution, separation, etc.) unless otherwise specified by the method.
V1M6 1.7.2.3 d)	The carrier yield for each sample shall be one of the quality control measures to be used to assess the associated sample result acceptance.
V1M6 1.7.2.3 d)	The carrier yield shall be assessed against the specific acceptance criteria specified in the laboratory method SOP.
V1M6 1.7.2.3 d)	When the specified carrier yield acceptance criteria are not met, the specified corrective action and contingencies shall be followed.
V1M6 1.7.2.3 d)	The occurrence of a failed carrier yield and the actions taken shall be noted in the laboratory report to the client.
V1M6 1.7.2.4	Data Reduction
V1M6 1.7.2.4 a)	The procedures for data reduction, such as use of linear regression, shall be documented.
V1M6 1.7.2.4 b)	Measurement Uncertainties. Each result shall be reported with its measurement uncertainty. The report should clearly explain the uncertainty. At a minimum the report shall:
V1M6 1.7.2.4 b) i.	indicate whether the uncertainty is the combined standard uncertainty (“one sigma”) or an expanded uncertainty; and
V1M6 1.7.2.4 b) ii.	for expanded uncertainties, indicate the coverage factor (k) and optionally the approximate level of confidence.
V1M6 1.7.2.4 c)	The procedures for determining the measurement uncertainty shall be documented and shall be consistent with the ISO Guide 98: 1995, Guide to the Expression of Uncertainty in Measurement (GUM) and with the recommendations of Chapter 19 of the Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP) Volume I (EPA 402-B-04-001A), Volume II (EPA 402-B-04-001B), Volume III (EPA 402-B-04-001C), July 2004.
V1M6 1.7.2.5	1.7.2.5 Reagent Quality, Water Quality, and Checks
V1M6 1.7.2.5 a)	In methods where the purity of reagents is not specified, reagents shall be analytical reagent grade or better. Reagents of lesser purity than those specified by the method shall not be used.
V1M6 1.7.2.5 a)	The labels on the container should be checked to verify that the purity of the reagents meets the requirements of the particular method. Such information shall be available.
V1M6 1.7.2.5 b)	The quality of water sources shall be monitored

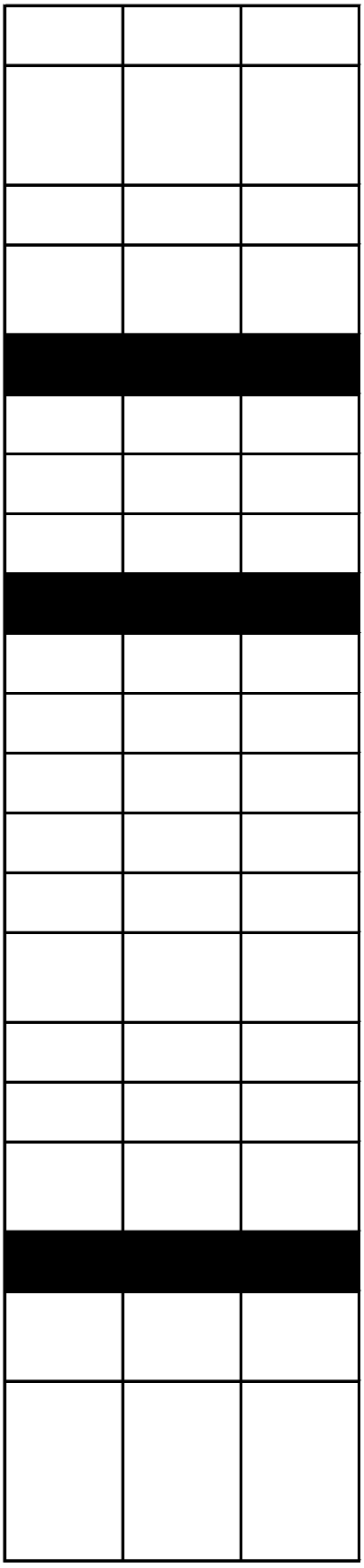
V1M6 1.7.2.5 b)	The quality of water sources shall be documented
V1M6 1.7.2.5 b)	The quality of water sources shall meet method specified requirements.
V1M6 1.7.2.5 c)	The quality control program shall establish and maintain provisions for radionuclide standards. ***(1.7.2.5 c) iii.)***
V1M6 1.7.2.5 c) i.	Reference standards that are used in a radiochemical laboratory shall be obtained from NIST or suppliers who participate in supplying NIST standards or NIST traceable radionuclides.
V1M6 1.7.2.5 c) i.	Any reference standards purchased outside the United States shall be traceable back to each country's national standards laboratory.
V1M6 1.7.2.5 c) i.	Commercial suppliers of reference standards shall conform to ANSI N42.22 to assure the quality of their products.
V1M6 1.7.2.5 c) ii.	Reference standards shall be accompanied with a certificate of calibration whose content is as described in ANSI N42.22 - 1995, Section 8, Certificates.
V1M6 1.7.2.5 c) iii.	Laboratories should consult with the supplier if the lab's verification of the activity of the reference traceable standard indicates a noticeable deviation from the certified value.
V1M6 1.7.2.5 c) iii.	The laboratory shall use only the decay-corrected certified value.
V1M6 1.7.2.5 c) iii.	The laboratory shall have a written procedure for handling, storing, and establishing expiration dates for reference standards.
V1M6 1.7.2.6	Selectivity
V1M6	The laboratory shall evaluate selectivity by following the checks established within the method.
V1M6 1.7.2.7	Constant and Consistent Test Conditions
V1M6 1.7.2.7 a)	The laboratory shall assure that the test instruments consistently operate within the specifications required of the application for which the equipment is used.
V1M6 1.7.2.7 b)	Glassware Cleaning. Glassware shall be cleaned to meet the sensitivity requirements of the method.

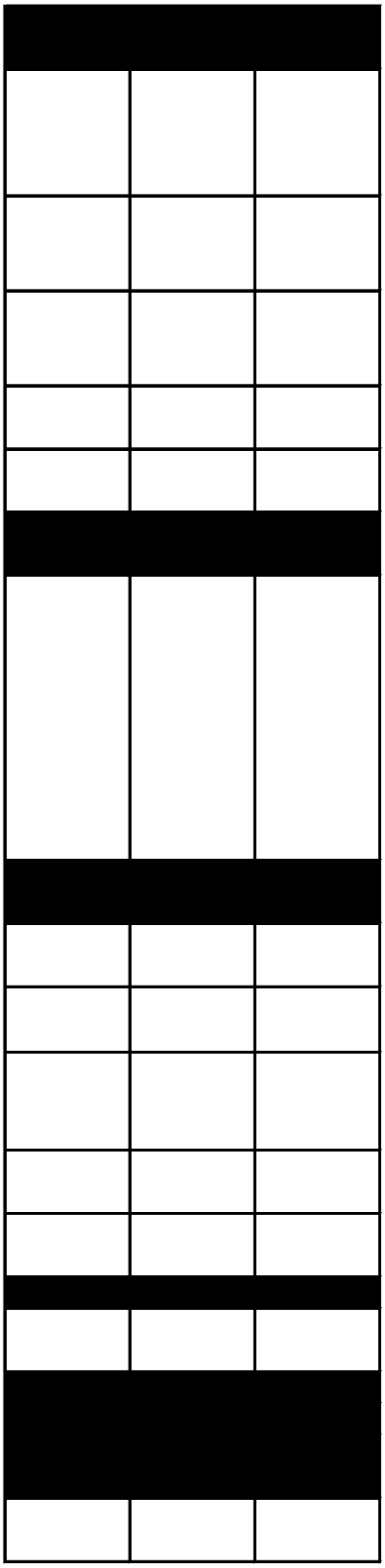
V1M6 1.7.2.7 b)	Any cleaning and storage procedures that are not specified by the method shall be documented in laboratory records and SOPs. Note that some applications may require single-use glassware.
V1M6 1.7.2.7 c)	Radiological Control Program. The laboratory shall maintain a radiological control program that addresses analytical radiological control.
V1M6 1.7.2.7 c)	The program shall address the procedures for segregating samples with potentially widely varying levels of radioactivity.
V1M6 1.7.2.7 c)	The radiological control program shall explicitly define how low-level and high-level samples will be identified, segregated and processed in order to prevent sample cross-contamination.
V1M6 1.7.2.7 c)	The radiological control program shall include the measures taken to monitor and evaluate background activity or contamination on an ongoing basis.
V1M6	Data Acceptance/Rejection Criteria
V1M6	Negative Control – Method Performance: Method Blank
V1M6 1.7.3.1 a)	While the goal is to have no statistically significant difference from zero, each method blank shall be critically evaluated as to the nature of the interference and the effect on the analysis of each sample within the batch.
V1M6 1.7.3.1 a)	The source of contamination or other bias shall be investigated and measures taken to minimize or eliminate the problem and affected samples reprocessed or data shall be appropriately qualified if:
V1M6 1.7.3.1 a) i.	the absolute value of the activity of a targeted analyte in the blank exceeds three times its combined standard uncertainty, AND is greater than 1/10 of the activity measured in any sample; or
V1M6 1.7.3.1 a) ii.	the method blank result otherwise affects the sample results as per the method requirements or the project-specific measurement quality objectives.
V1M6 1.7.3.1 b)	The acceptance criteria for samples associated with a failed method blank shall be calculated in a manner that compensates for sample results based on differing aliquot sizes.
V1M6 1.7.3.1 c)	When a blank result is determined to be significantly different from zero, the cause shall be investigated and measures taken to minimize or eliminate the problem.
V1M6 1.7.3.1 c)	Samples associated with a failed blank shall be evaluated as to the best corrective action for the samples (e.g., reprocessing or data qualifying codes).
V1M6 1.7.3.1 d)	The occurrence of a failed method blank and any associated corrective action shall be noted in the laboratory report to the client.
V1M6 1.7.3.2	Positive Control – Method Performance: Laboratory Control Sample (LCS)
V1M6 1.7.3.2 a)	a) The results of the individual batch LCS are calculated in percent recovery or other appropriate statistical technique that allows comparison to established acceptance criteria. ***(1.7.3.2.b)***
V1M6 1.7.3.2 a)	The laboratory shall document the calculation.
V1M6 1.7.3.2 b)	The individual LCS is compared to the acceptance criteria as published in the mandated method.
V1M6 1.7.3.2 b)	Where there are no established criteria, the laboratory shall determine internal criteria and document the method used to establish the limits or utilize client specified assessment criteria.

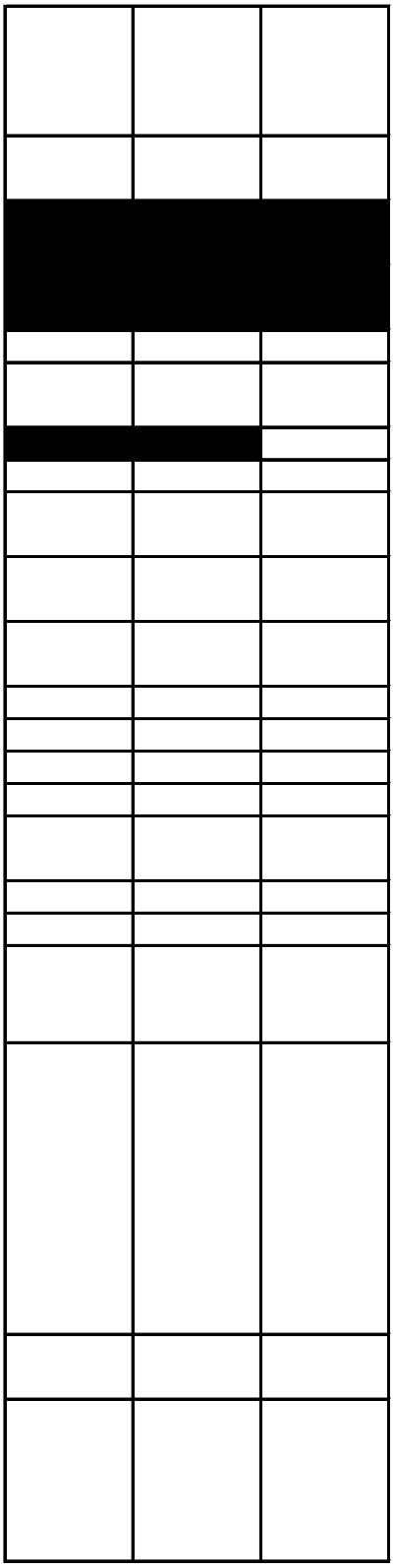
V1M6 1.7.3.2 c)	An LCS that is determined to be within the criteria effectively establishes that the analytical system is in control and validates system performance for the samples in the associated batch.
V1M6 1.7.3.2 c)	Samples analyzed along with an LCS determined to be “out of control” shall be considered suspect and the samples reprocessed and re-analyzed or the data reported with appropriate data qualifying codes.
V1M6 1.7.3.2 d)	The occurrence of a failed LCS and any associated actions shall be noted in the laboratory report to the client.
V1M6 1.7.3.3	Sample-Specific Controls
V1M6 1.7.3.3 a)	Matrix Spike; Matrix Spike Duplicates
V1M6 1.7.3.3 a) i.	The results from matrix spike/matrix spike duplicate are primarily designed to assess the precision and accuracy of analytical results in a given matrix and are expressed as percent recovery (%R), relative percent difference (RPD), or other appropriate statistical technique that allows comparison to established acceptance criteria.
V1M6 1.7.3.3 a) i.	The laboratory shall document the calculation for %R, RPD or other statistical treatment used.
V1M6 1.7.3.3 a) ii.	The results are compared to the acceptance criteria as published in the mandated test method.
V1M6 1.7.3.3 a) ii.	Where there are no established criteria, the laboratory shall determine internal criteria and document the method used to establish the limits.
V1M6 1.7.3.3 a) ii.	For matrix spike results outside established criteria, corrective action shall be documented or the data reported with appropriate data qualifying codes.
V1M6 1.7.3.3 a) iii.	The occurrence of a failed matrix spike and any associated actions shall be noted in the laboratory report to the client.
V1M6 1.7.3.3 b)	Replicates
V1M6 1.7.3.3 b) i.	The results from replicates are primarily designed to assess the precision of analytical results in a given matrix and are expressed as relative percent difference (RPD) or another statistical treatment (e.g., normalized differences).
V1M6 1.7.3.3 b) ii.	The laboratory shall document the calculation for relative percent difference or other statistical treatments.
V1M6 1.7.3.3 b) iii.	Results are compared to the acceptance criteria as published in the mandated method.
V1M6 1.7.3.3 b) iii.	Where there are no established criteria, the laboratory shall determine internal criteria and document the method used to establish the limits.
V1M6 1.7.3.3 b) iii.	For replicate results outside established criteria, corrective action shall be documented or the data reported with appropriate data qualifying codes.
V1M6 1.7.3.3 b) iv.	The occurrence of a failed replicate and any associated actions shall be noted in the laboratory report to the client.
V1M6	Sample Handling
V1M6 1.7.4 a)	All samples that require thermal preservation shall be considered acceptable if the arrival temperature of a representative sample container is either within 2°C of the required temperature or the method specified range.
V1M6 1.7.4 a)	For samples with a specified temperature of 4°C, samples with a temperature ranging from just above the freezing temperature of water to 6°C shall be acceptable.
V1M6 1.7.4 a) i.	Samples that are delivered to the laboratory on the same day they are collected may not meet the requirements of Section 1.7.4.a. In these cases, the samples shall be considered acceptable if the samples were received on ice.

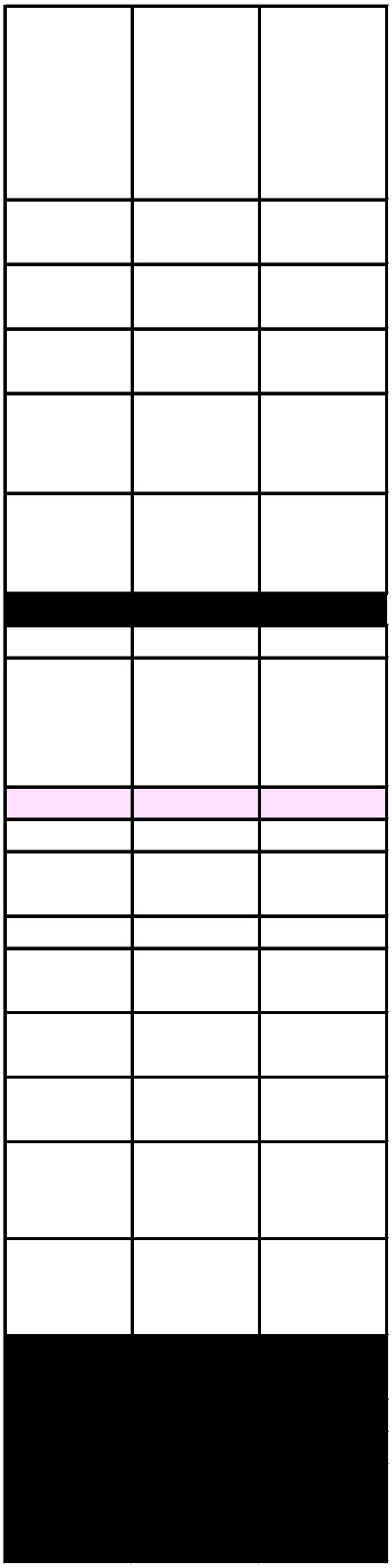
V1M6 1.7.4 a) ii.	If sample analysis is begun within fifteen (15) minutes of collection, thermal preservation is not required. Thermal preservation is not required in the field if the laboratory receives and refrigerates the sample within fifteen (15) minutes of collection.
V1M6 1.7.4 b)	The laboratory shall implement procedures for checking chemical preservation using readily available techniques, such as pH or chlorine, prior to or during sample preparation or analysis.

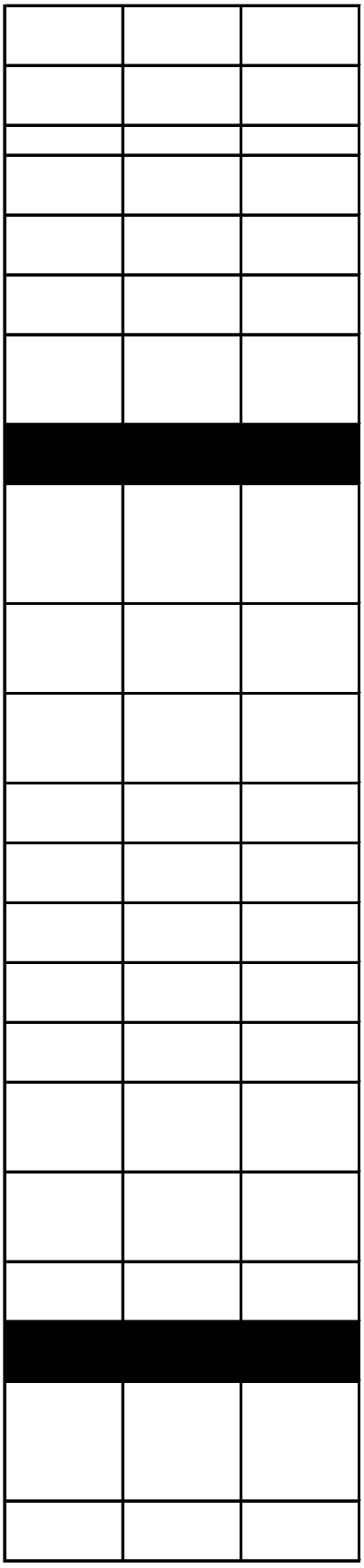
Yes	No	N/A
[redacted]		
[redacted]		

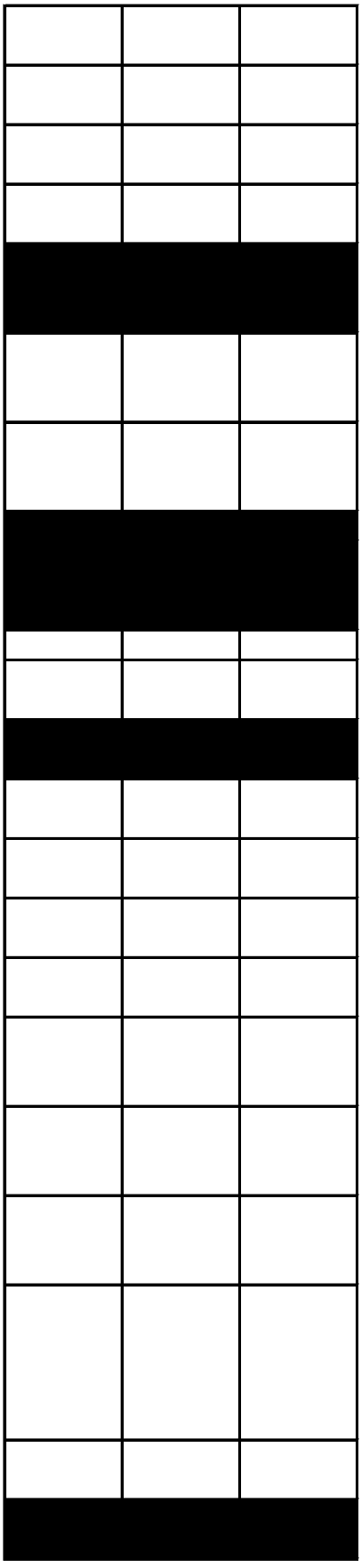


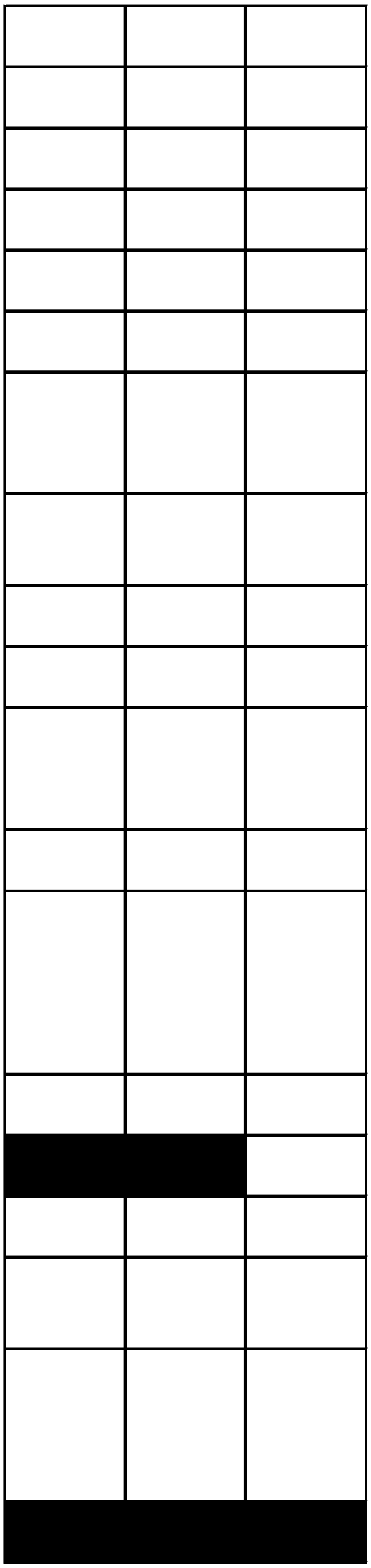


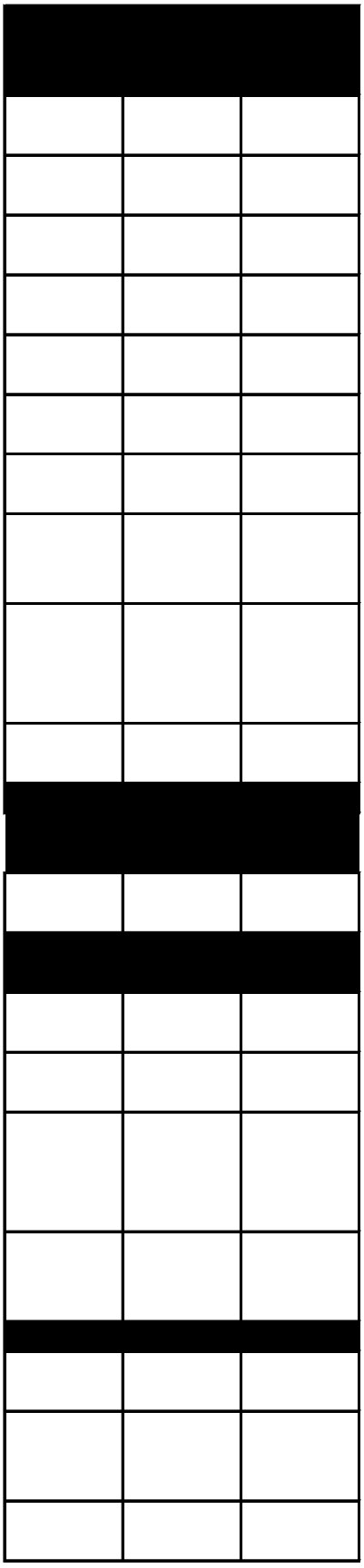


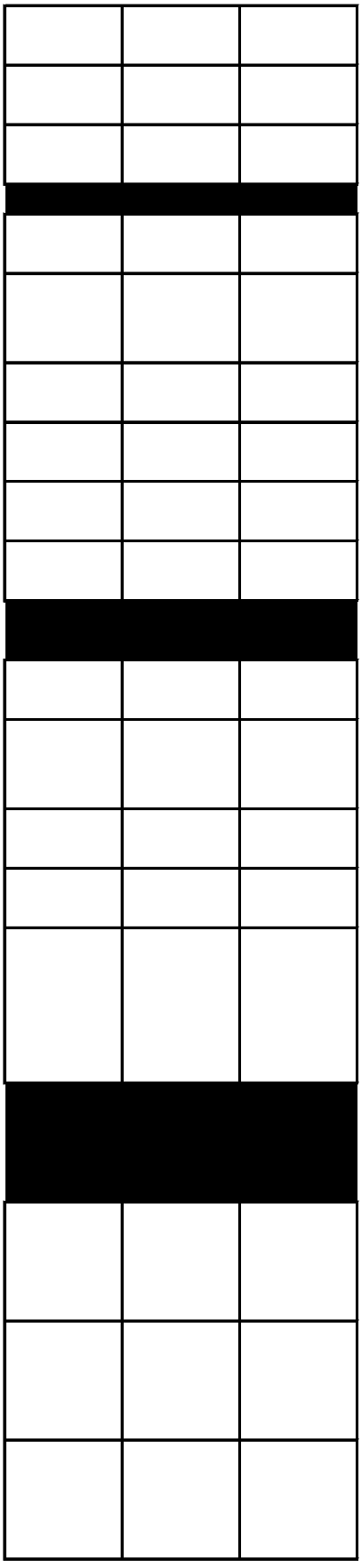


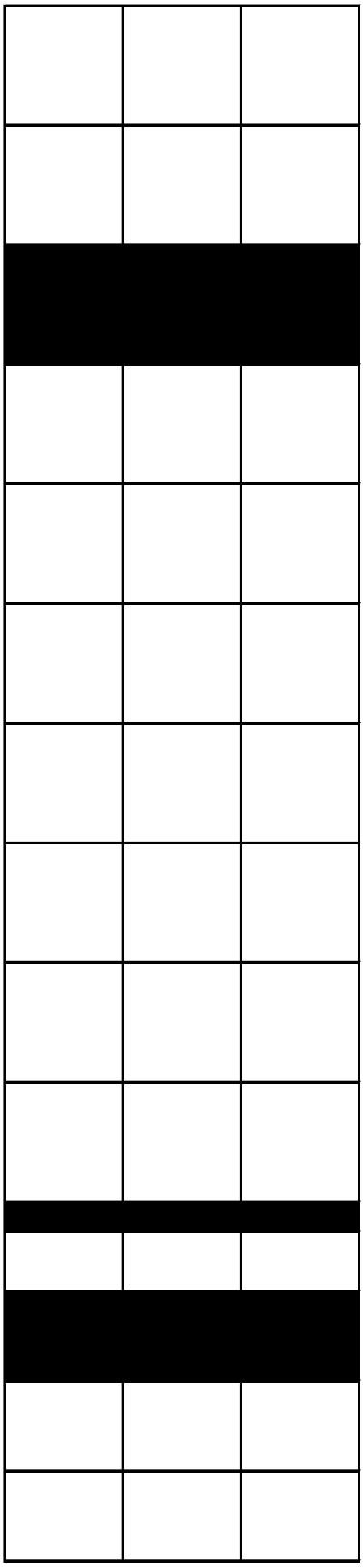


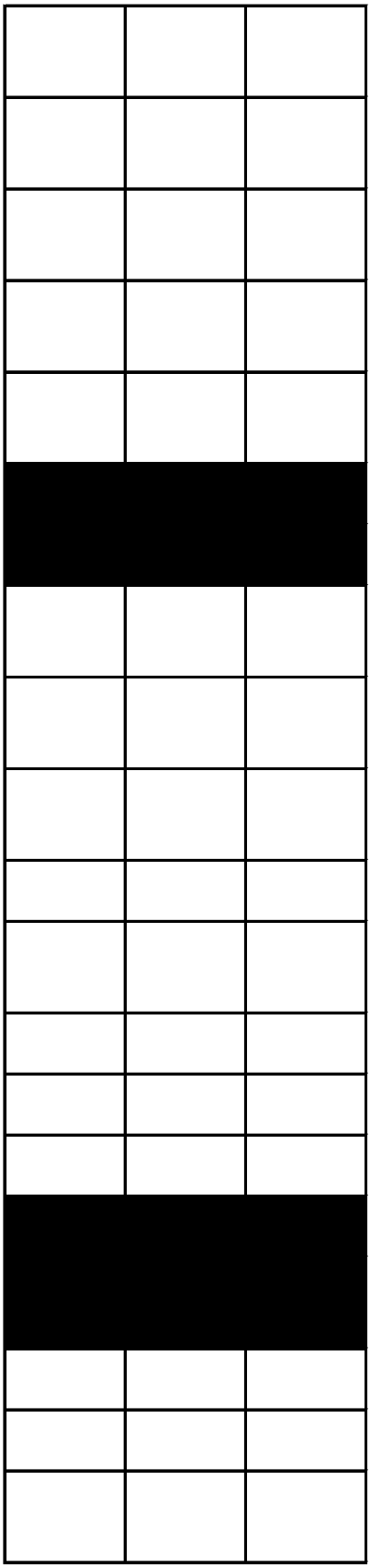


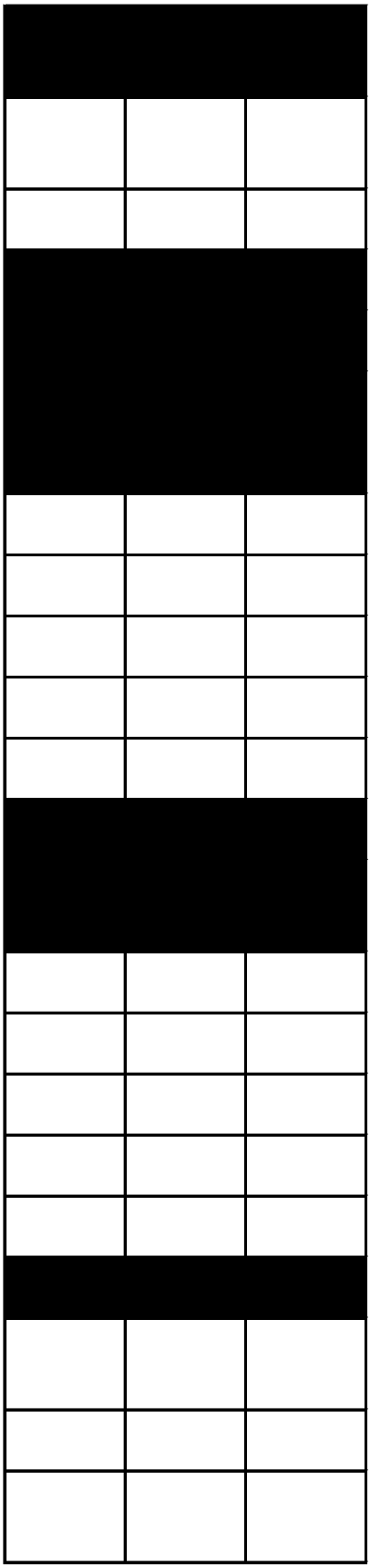












ID	Major Topic	Topic	Subject	Category
1723				
1724	1.1 Introduction			
1725	1.1 Introduction			
1726	1.2 Scope			
1727	1.2 Scope			
1728	1.2 Scope			
1729	1.3 Terms and Definitions			
1733	1.3 Terms and Definitions			
1731	1.3 Terms and Definitions			
1732	1.3 Terms and Definitions			
1730	1.3 Terms and Definitions			
1734	1.4 Method Selection			
1735	1.4 Method Selection			
1736	1.4 Method Selection	Non Reference Method	Customer Communication	Requirement
1737	1.4 Method Selection	Non Reference Method	Validation	Requirement
1738	1.4 Method Selection	Non Reference Method	Assessment	Requirement
1739	1.5 Method Validation			
1740	1.5 Method Validation			
1741	1.6 DOC			
1742	1.6 DOC	1.6.1 General		
1743	1.6 DOC	1.6.1 General		
1744	1.6 DOC	1.6.1 General	Ongoing DOC	Requirement

1745	1.6 DOC	1.6.1 General	DOC	Exception
1746	1.6 DOC	1.6.1 General		
1747	1.6 DOC	1.6.1 General		
1748	1.6 DOC	1.6.1 General	DOC Performance	Option
1749	1.6 DOC	1.6.1 General	Documentation	Requirement
1750	1.6 DOC	1.6.2 Initial DOC		
1751	1.6 DOC	1.6.2 Initial DOC	Frequency	Requirement
1752	1.6 DOC	1.6.2 Initial DOC	Frequency	Requirement
1753	1.6 DOC	1.6.2 Initial DOC	Documentation	Record
1754	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents
1755	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents
1756	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents
1757	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents
1758	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents
1759	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents
1760	1.6 DOC	1.6.2 Initial DOC	DOC Record	Contents
1761	1.6 DOC	1.6.2 Initial DOC	Procedure	Requirement
1762	1.6 DOC	1.6.2 Initial DOC	DOC Procedure	Option
1763	1.6 DOC	1.6.3 Ongoing DOC		
1764	1.6 DOC	1.6.3 Ongoing DOC	Documentation	Procedure
1765	1.6 DOC	1.6.3 Ongoing DOC	Analyst	Requirement
1766	1.6 DOC	1.6.3 Ongoing DOC	Alternate Procedures	Requirement
1767	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option
1768	1.6 DOC	1.6.3 Ongoing DOC	Procedure	Option
1769	1.7 Technical Requirements			

1770	1.7 Technical Requirements	1.7.1 Quality Control		
1771	1.7 Technical Requirements	1.7.1 Quality Control		
1772	1.7 Technical Requirements	1.7.1 Quality Control	Result Review	Requirement
1773	1.7 Technical Requirements	1.7.1 Quality Control	Planned Review	Requirement
1774	1.7 Technical Requirements	1.7.1 Quality Control	Planned Review	Option
1775	1.7 Technical Requirements	1.7.1 Quality Control	Planned Review	Option
1776	1.7 Technical Requirements	1.7.1 Quality Control	Planned Review	Option
1777	1.7 Technical Requirements	1.7.1 Quality Control	Planned Review	Option
1778	1.7 Technical Requirements	1.7.1.1 Essential QC		
1779	1.7 Technical Requirements	1.7.1.1 Essential QC		
1780	1.7 Technical Requirements	1.7.1.1 Essential QC	Methods	Requirement
1781	1.7 Technical Requirements	1.7.1.1 Essential QC	Quality Control	Procedure
1782	1.7 Technical Requirements	1.7.1.1 Essential QC	Positive and Negative Controls	Topic
1783	1.7 Technical Requirements	1.7.1.1 Essential QC	Variability	Topic
1784	1.7 Technical Requirements	1.7.1.1 Essential QC	Method Capability	Topic
1785	1.7 Technical Requirements	1.7.1.1 Essential QC	Formulae Selection	Topic
1786	1.7 Technical Requirements	1.7.1.1 Essential QC	Reagent and Standard Selection	Topic
1787	1.7 Technical Requirements	1.7.1.1 Essential QC	Selectivity	Topic
1788	1.7 Technical Requirements	1.7.1.1 Essential QC	Constant and Consistent Test Conditions	Topic
1789	1.7 Technical Requirements	1.7.1.1 Essential QC	Evaluation	Requirement
1790	1.7 Technical Requirements	1.7.1.1 Essential QC	Acceptance Criteria	Procedure
1791	1.7 Technical Requirements	1.7.1.1 Essential QC	QC Procedures	Requirement

1792	1.7 Technical Requirements	1.7.1.1 Essential QC	Different QC Procedures	Requirement
1793	1.7 Technical Requirements	1.7.1.2 Positive and Negative Controls		
1794	1.7 Technical Requirements	1.7.1.2 a) Positive Control	Reference Toxicants	
1795	1.7 Technical Requirements	1.7.1.2 a) Positive Control	Reference Toxicants	Requirement
1796	1.7 Technical Requirements	1.7.1.2 a) Positive Control	Frequency	Requirement
1797	1.7 Technical Requirements	1.7.1.2 a) Positive Control	Frequency	Requirement
1798	1.7 Technical Requirements	1.7.1.2 a) Positive Control	Tests Performed Monthly	Requirement
1799	1.7 Technical Requirements	1.7.1.2 a) Positive Control	Tests Performed > 1 Month	Requirement
1800	1.7 Technical Requirements	1.7.1.2 a) Positive Control	Outside Source Sensitivity	Requirement
1801	1.7 Technical Requirements	1.7.1.2 a) Positive Control	Outside Source Sensitivity	Exception
1802	1.7 Technical Requirements	1.7.1.2 a) Positive Control	Specific SRT	
1803	1.7 Technical Requirements	1.7.1.2 a) Positive Control	Specific SRT	Requirement
1804	1.7 Technical Requirements	1.7.1.2 a) Positive Control	SRT in Test	Requirement
1805	1.7 Technical Requirements	1.7.1.2 a) Positive Control	SRT Dilution Factor	Requirement
1806	1.7 Technical Requirements	1.7.1.2 a) Positive Control	Method Requirements	Requirement
1807	1.7 Technical Requirements	1.7.1.2 b) Negative Controls		
1808	1.7 Technical Requirements	1.7.1.2 b) Negative Controls	Method Negative Controls	Requirement
1809	1.7 Technical Requirements	1.7.1.2 b) Negative Controls	Frequency	Requirement
1810	1.7 Technical Requirements	1.7.1.2 b) Negative Controls	Additional Controls	Option
1811	1.7 Technical Requirements	1.7.1.3 Variability		

1812	1.7 Technical Requirements	1.7.1.3 Variability	Precision	Requirement
1813	1.7 Technical Requirements	1.7.1.4 Test Sensitivity		
1814	1.7 Technical Requirements	1.7.1.4 Test Sensitivity	PMSD	Requirement
1815	1.7 Technical Requirements	1.7.1.4 Test Sensitivity	Point Estimates	Requirement
1816	1.7 Technical Requirements	1.7.1.5 Reagents and Standards		
1817	1.7 Technical Requirements	1.7.1.5 Reagents and Standards	Grade of Reagents	Requirement
1818	1.7 Technical Requirements	1.7.1.5 Reagents and Standards	SRT Grade	
1819	1.7 Technical Requirements	1.7.1.5 Reagents and Standards	Preparation	Record
1820	1.7 Technical Requirements	1.7.1.5 Reagents and Standards	Chemical Tests	Requirement
1821	1.7 Technical Requirements	1.7.1.5 Reagents and Standards	Water	Requirement
1822	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions		
1823	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Separation of Tasks	Requirement
1824	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Laboratory Facilities	Requirement
1825	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Air Quality	Requirement
1826	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Taxonomic ID	Requirement
1827	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Taxonomic ID	Record
1828	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Outside Source ID	Requirement
1829	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Chemical and Physical Tests	Requirement
1830	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Results and Calibration	Record

1831	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Temperature	Requirement
1832	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Temperature control equipment	Requirement
1833	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Average Daily Temperature	Requirement
1834	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Frequency	Requirement
1835	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Continuous Loggers	Requirement
1836	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Water	Requirement
1837	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Dilution Water	Requirement
1838	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Water Testing	Requirement
1839	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Food	Requirement
1840	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Food Evaluation	Procedure
1841	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Bioaccumulation	Requirement
1842	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Chamber	Requirement
1843	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Chamber	Requirement
1844	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Feeding Regimen	Requirement
1845	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Feeding Frequency	Requirement
1846	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Organism Health	Requirement

1847	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Equipment Construction	Requirement
1848	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Light Intensity	Requirement
1849	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Light Intensity Measurements	Requirement
1850	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Photoperiod	Requirement
1851	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Photoperiod Frequency	Requirement
1852	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Light Intensity Measurements	Requirement
1853	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Organism Health and Culturing	Record
1854	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Organism Health and Culturing Records	Contents
1855	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Specification for outside sources	Requirement
1856	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Specification for outside sources	Requirement
1857	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Specification for outside sources	Record
1858	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Age/age range	Requirement
1859	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Supporting Information	Record
1860	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Holding time	Requirement
1861	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Replicates	Requirement

1862	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Control Population Distribution	Requirement
1863	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	C dubia culturing	Requirement
1864	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	DO and pH	Requirement
1865	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Tolerance range for solids	Requirement
1866	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Unacceptable Test Conditions	Requirement
1867	1.7 Technical Requirements	1.7.1.6 Constant & Consistent Test Conditions	Acceptability	Requirement
1868	1.7 Technical Requirements	1.7.2 Data Acceptance / Rejection		
1869	1.7 Technical Requirements	1.7.2.1 Positive Controls		
1870	1.7 Technical Requirements	1.7.2.1 Positive Controls	Control Performance and Endpoints	Record
1871	1.7 Technical Requirements	1.7.2.1 Positive Controls	Precisions Evaluation	Requirement
1872	1.7 Technical Requirements	1.7.2.1 Positive Controls	ICp, Ecp Criteria	Requirement
1873	1.7 Technical Requirements	1.7.2.1 Positive Controls	NOEC, NOAEC Criteria	Requirement
1874	1.7 Technical Requirements	1.7.2.1 Positive Controls	Point Estimates	Requirement
1875	1.7 Technical Requirements	1.7.2.1 Positive Controls	Hypothesis Tests	Requirement
1876	1.7 Technical Requirements	1.7.2.1 Positive Controls	Control Chart Exceedances	Requirement
1877	1.7 Technical Requirements	1.7.2.1 Positive Controls	Evaluation of Exceedances	Requirement

1878	1.7 Technical Requirements	1.7.2.1 Positive Controls	Acceptance/ Rejection Criteria	Procedure
1879	1.7 Technical Requirements	1.7.2.1 Positive Controls	Corrective Action	Requirement
1880	1.7 Technical Requirements	1.7.2.1 Positive Controls	Intra-laboratory Precision	Requirement
1881	1.7 Technical Requirements	1.7.2.2 Negative Controls		
1882	1.7 Technical Requirements	1.7.2.2 Negative Controls	Criteria	Requirement
1883	1.7 Technical Requirements	1.7.2.3 Statistical Method Selection		
1884	1.7 Technical Requirements	1.7.2.3 Statistical Method Selection	Analysis Method	Requirement
1885	1.7 Technical Requirements	1.7.2.3 Statistical Method Selection	Plotting Data	Requirement
1886	1.7 Technical Requirements	1.7.3 Sample Handling		
1887	1.7 Technical Requirements	1.7.3 Sample Handling	Preservation	Requirement

Citation	Does the laboratory comply with this section?
V1M7	TOXICITY TESTING
V1M7 1	Introduction
V1M7 1.1	This Standard applies to laboratories measuring the toxicity and/or bioaccumulation of contaminants in effluents (whole effluent toxicity or WET), receiving waters, sediments, elutriates, leachates and soils. In addition to the essential quality control standards described below, some methods may have additional or other requirements based on factors such as the type of organism evaluated and contain detailed quality control requirements for toxicity testing activities. The evaluation of laboratories for this discipline is in conjunction with a quality system as specified in the general requirements module. Adherence to quality systems requirements will ensure that all quality control procedures specified in this module are being followed.
V1M7 1.2	Scope
V1M7 1.2	The essential quality control procedures applicable to toxicity measurements are included in this Standard.
V1M7 1.2	Additional quality control requirements that are specified by method, regulation or project shall be met by laboratories.
V1M7 1.3	Terms and Definitions
V1M7 1.3.2	Exclusions and Exceptions
V1M7 1.3.1	Additional Terms and Definitions
V1M7 1.3.1	When referred to in this module, “sensitivity” relates to the meaning referenced in the accredited method.
V1M7 1.3	The relevant definitions from TNI, Volume 1, Module 2, Section 3.0 apply. Definitions related to this document, which are used differently or do not exist in the above references are defined below.
V1M7 1.3.2	Reserved
V1M7 1.4	Method Selection
V1M7 1.4	When it is necessary to use testing methods not covered by an approved method, these shall be subject to agreement with the data user and shall include a clear specification of the data user’s requirements and the purpose of the environmental test.
V1M7 1.4	The method developed shall have been validated appropriately before use.
V1M7 1.4	The characteristics of validated methods (e.g., the uncertainty of the results, limit of repeatability and/or reproducibility, robustness against external influences and/or cross-sensitivity against interference from the matrix of the sample/test object), as assessed for the intended use, shall be relevant to the users’ needs.
V1M7 1.5	Method Validation
V1M7 1.5	Validation is the confirmation by examination and the objective evidence that the particular requirements for a specific intended use are fulfilled.
V1M7 1.6	Demonstration of Capability (DOC)
V1M7 1.6.1	General
V1M7 1.6.1	Prior to acceptance and institution of any method for data reporting, satisfactory initial DOC is required ***(see Section 1.6.2)*** .
V1M7 1.6.1	Thereafter, ongoing DOC (Section 1.6.3), as per the quality control requirements in Section 1.7.1.2 is required.

V1M7 1.6.1	In cases where a laboratory analyzes samples using a method that has been in use by the laboratory for at least one year prior to applying for accreditation, and there have been no significant changes in personnel or method, the ongoing DOC shall be acceptable as an initial DOC. The laboratory shall have records on file to demonstrate that an initial DOC is not required.
V1M7 1.6.1	For the initial DOC, appropriate records as discussed in Section 1.6.2.1 shall be completed. ***(1.6.2.1)***
V1M7 1.6.1	An initial DOC shall be completed each time there is a change in personnel, or method.***(1.6.2)***
V1M7 1.6.1	In general, this demonstration does not test the performance of the method in real world samples. However, before any results are reported, the initial DOC shall be performed. An initial DOC may be completed by a group of analysts and is for situations in which several individuals perform part of a set of activities that would produce a testing result.
V1M7 1.6.1	All demonstrations shall be documented. All data applicable to the demonstration shall be retained and readily available at the laboratory.
V1M7 1.6.2	Initial DOC
V1M7 1.6.2	An initial DOC shall be made prior to using any method.
V1M7 1.6.2	An initial DOC shall be made at any time there is a significant change in personnel or method or any time that a method has not been performed by the laboratory or analyst in a twelve (12) month period.
V1M7 1.6.2.1	The laboratory shall document each initial DOC in a manner such that the following information is available for each affected employee:
V1M7 1.6.2.1 a)	analyst(s) involved in preparation and/or analysis;
V1M7 1.6.2.1 b)	matrix;
V1M7 1.6.2.1 c)	species and endpoint(s);
V1M7 1.6.2.1 d)	identification of method(s) performed;
V1M7 1.6.2.1 e)	identification of laboratory-specific SOP used for analysis, including revision number;
V1M7 1.6.2.1 f)	date(s) of analysis;
V1M7 1.6.2.1 g)	summary of analyses, including information outlined in Section 1.6.2.2.
V1M7 1.6.2.2	If the method or regulation does not specify an initial DOC, the following procedure is acceptable. It is the responsibility of the laboratory to document that other approaches to initial DOC are adequate.
V1M7 1.6.2.2	Each analyst shall meet the quality control requirements as specified in Section 1.7.1.2.
V1M7 1.6.3	Ongoing DOC
V1M7 1.6.3	The laboratory shall have a documented procedure describing ongoing DOC.
V1M7 1.6.3	The analyst(s) shall demonstrate on-going capability by meeting the quality control requirements of the method, laboratory SOP, client specifications, and/or this Standard.
V1M7 1.6.3	It is the responsibility of the laboratory to document that other approaches to on-going demonstration of capability are adequate.
V1M7 1.6.3	This on-going demonstration may include performing another initial demonstration of capability as per 1.6.2.
V1M7 1.6.3	A documented process of analyst review using QC samples can serve as the annual on-going demonstration of capability. QC samples shall be reviewed to identify patterns for individuals or groups of analysts and determine if corrective action or retraining is necessary.
V1M7 1.7	Technical Requirements

V1M7 1.7.1	Quality Control
V1M7 1.7.1	The laboratory shall have quality control procedures for monitoring the validity of environmental tests undertaken. ***(see requirements listed in 1.7.1)***
V1M7 1.7.1	The resulting data shall be recorded in such a way that trends are detectable and, where practicable, statistical techniques shall be applied to the reviewing of the results.
V1M7 1.7.1	This monitoring shall be planned and reviewed and may include, but not be limited to, the following:
V1M7 1.7.1 b)	participation in inter-laboratory comparison or proficiency-testing program;
V1M7 1.7.1 c)	replicate tests using the same or different methods;
V1M7 1.7.1 d)	retesting of retained samples; and
V1M7 1.7.1 e)	correlation of results for different characteristics of a sample (for example, total phosphate should be greater than or equal to orthophosphate).
V1M7 1.7.1.1	Essential Quality Control Procedures
V1M7 1.7.1.1	These general quality control principles shall apply, where applicable, to all testing laboratories. The manner in which they are implemented is dependent on the types of tests performed by the laboratory and are further described in this module.
V1M7 1.7.1.1	The standards for any given test type shall assure that the applicable principles are addressed:
V1M7 1.7.1.1 a)	All laboratories shall have detailed written protocols in place to monitor the following quality controls:
V1M7 1.7.1.1 a) i)	positive and negative controls to monitor tests such as blanks, spikes, reference toxicants;
V1M7 1.7.1.1 a) ii)	tests to define the variability and/or repeatability of the laboratory results such as replicates;
V1M7 1.7.1.1 a) iii)	measures to evaluate method capability, such as percent minimum significant difference (PMSD);
V1M7 1.7.1.1 a) iv)	selection of appropriate formulae to reduce raw data to final results such as regression and statistical analyses;
V1M7 1.7.1.1 a) v)	selection and use of reagents and standards of appropriate quality;
V1M7 1.7.1.1 a) vi)	measures to assure the selectivity of the test for its intended purpose; and
V1M7 1.7.1.1 a) vii)	measures to assure constant and consistent test conditions (both instrumental and environmental) where required by the method such as temperature, humidity, light or specific equipment conditions.
V1M7 1.7.1.1 b)	All quality control measures shall be assessed and evaluated on an ongoing basis, and quality control acceptance criteria shall be used to determine the usability of the data.
V1M7 1.7.1.1 c)	The laboratory shall have procedures for the development of acceptance/rejection criteria where no method or regulatory criteria exist.
V1M7 1.7.1.1 d)	The quality control protocols specified by the laboratory's method manual shall be followed.

V1M7 1.7.1.1 d)	The laboratory shall ensure that the essential standards outlined in this document or regulations (whichever are more stringent) are incorporated into their method manuals. When it is not apparent which is more stringent, the QC in the regulations is to be followed.
1.7.1.2	Positive and Negative Controls
V1M7 1.7.1.2 a)	Positive Control. Reference toxicant tests demonstrate a laboratory's ability to obtain consistent results with the method and evaluate the overall health and sensitivity of test organisms over time.
V1M7 1.7.1.2 a) i)	The laboratory shall demonstrate its ability to obtain consistent results with standard reference toxicants (SRT).
V1M7 1.7.1.2 a) ii)	Ongoing laboratory performance shall be demonstrated by performing routine SRT testing for each method, species and endpoint in accordance with the minimum frequency requirements specified in Section 1.7.1.2.a)iii).
V1M7 1.7.1.2 a) iii)	The frequency of ongoing laboratory reference toxicant testing shall be as follows unless the method specifically requires less frequent SRT tests (e.g., sediment tests).
V1M7 1.7.1.2 a) iii)	For methods conducted at a frequency of monthly or greater, SRT tests shall be conducted monthly.
V1M7 1.7.1.2 a) iii)	For methods and species commonly used in the laboratory, but which are tested at a frequency of less than monthly, SRT tests shall be conducted concurrently with the environmental test.
V1M7 1.7.1.2 a) iii)	If the test organisms are obtained from an outside source, the sensitivity of each batch of organisms received from a supplier shall be determined via a concurrent SRT test
V1M7 1.7.1.2 a) iii)	If the test organisms are obtained from an outside source, the sensitivity of each batch of organisms received from a supplier shall be determined via a concurrent SRT test unless the supplier can provide control chart data for the last five SRT tests using the same SRT and test conditions. Supplied SRT data may not be older than six (6) months.
V1M7 1.7.1.2 a) iv)	These standards do not currently specify a particular reference toxicant and dilution series.
V1M7 1.7.1.2 a) iv)	However, if the regulation identifies a reference toxicant or dilution series for a particular test, the laboratory shall follow the specified requirements.
V1M7 1.7.1.2 a) iv)	All reference toxicant tests conducted for a given method and species shall use the same reference toxicant, test concentrations, dilution water and data analysis methods.
V1M7 1.7.1.2 a) iv)	A dilution factor of 0.5x or greater shall be used for both acute and chronic tests.
V1M7 1.7.1.2 a) v)	The reference toxicant tests shall be conducted following the procedures required in the method.
V1M7 1.7.1.2 b)	Negative Controls – Control, Brine Control, Control Sediment, Control Soil or Dilution Water
V1M7 1.7.1.2 b) i)	The standards for the use, type and frequency of testing of negative controls are specified by the methods and by permit or regulation and shall be followed.
V1M7 1.7.1.2 b) i)	A negative control is included with each test to evaluate test performance and the health and sensitivity of the specific batch of organisms.
V1M7 1.7.1.2 b) ii)	Appropriate additional negative controls shall be included when sample adjustments (for example addition of thiosulfate for dechlorination) or solvent carriers are used in the test.
V1M7 1.7.1.3	Variability and/or Reproducibility

V1M7 1.7.1.3	Intra-laboratory precision shall be determined on an ongoing basis through the use of further reference toxicant tests and related control charts as described above.
V1M7 1.7.1.4	Test Sensitivity
V1M7 1.7.1.4 a)	The PMSD shall be calculated according to the formula specified by the method and reported with the test results.
V1M7 1.7.1.4 b)	Point estimates: (LCp, ICp, or ECp) – Confidence intervals shall be reported as a measure of the precision around the point estimate value, when the calculation is possible.
V1M7 1.7.1.5	Selection and Use of Reagents and Standards
V1M7 1.7.1.5 a)	The grade of all reagents used in toxicity tests is specified in the method except the reference standard.
V1M7 1.7.1.5 a)	All reference standards shall be prepared from chemicals that are analytical reagent grade or better.
V1M7 1.7.1.5 a)	The preparation of all standards and reference toxicants shall be documented.
V1M7 1.7.1.5 b)	All standards and reagents associated with chemical measurements, such as dissolved oxygen, pH or specific conductance, shall comply with the Chemistry Module.
V1M7 1.7.1.5 c)	Only reagent-grade water collected from distillation or de-ionization units is used to prepare reagents.
V1M7 1.7.1.6	Constant and Consistent Test Conditions
V1M7 1.7.1.6 a)	If closed refrigerator-sized incubators are used, culturing and testing of organisms shall be separated to avoid cross-contamination.
V1M7 1.7.1.6 b)	Laboratory space shall be adequate for the types and numbers of tests performed. The building shall provide adequate cooling, heating and illumination for conducting testing and culturing; hot and cold running water shall be available for cleaning equipment.
V1M7 1.7.1.6 c)	Air used for aeration of test solutions, dilution waters and cultures shall be free of oil and fumes.
V1M7 1.7.1.6 d)	The laboratory or a contracted outside expert shall positively identify test organisms to species on an annual basis.
V1M7 1.7.1.6 d)	The taxonomic reference (citation and page(s)) and the names(s) of the taxonomic expert(s) shall be kept on file at the laboratory.
V1M7 1.7.1.6 d)	When organisms are obtained from an outside source the supplier shall provide this same information.
V1M7 1.7.1.6 e)	Equipment used for routine support measurements of chemical and physical parameters such as pH, DO, conductivity, salinity, alkalinity, hardness, chlorine, ammonia and weight shall be calibrated, and/or standardized per manufacturer’s instructions.
V1M7 1.7.1.6 e)	All measurements and calibrations shall be documented.

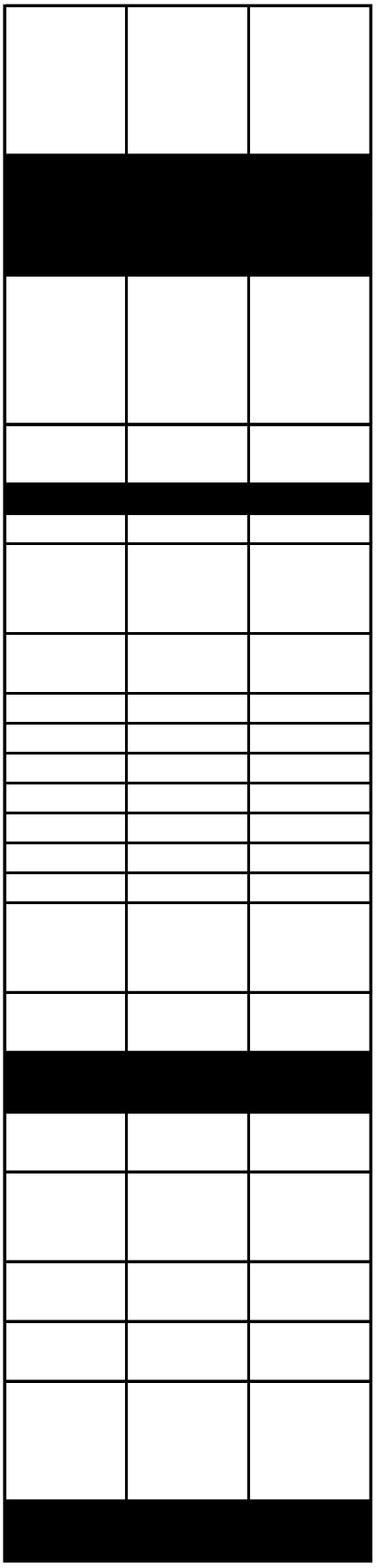
V1M7 1.7.1.6 f)	Test temperature shall be maintained as specified for the method.
V1M7 1.7.1.6 f)	Temperature control equipment shall be adequate to maintain the required test temperature(s).
V1M7 1.7.1.6 f)	The average daily temperature of the test solutions shall be maintained within method specified range.
V1M7 1.7.1.6 f)	The minimum frequency of measurement shall be once per twenty-four (24) hour period. The test temperature for continuous-flow toxicity tests shall be recorded and monitored continuously.
V1M7 1.7.1.6 f)	Where electronic data loggers are used, temperature shall be monitored at a frequency sufficient to capture temporal variations of the environmental control system.
V1M7 1.7.1.6 g)	Reagent grade water, prepared by any combination of distillation, reverse osmosis, ion exchange, activated carbon and particle filtration, shall meet the method specified requirements.
V1M7 1.7.1.6 h)	The quality of the standard dilution water used for testing or culturing shall be sufficient to allow satisfactory survival, growth and reproduction of the test species as demonstrated by routine reference toxicant tests and negative control performance.
V1M7 1.7.1.6 h)	Water used for culturing and testing shall be analyzed for toxic metals and organics whenever the minimum acceptability criteria for control survival, growth or reproduction are not met and no other cause, such as contaminated glassware or poor stock, can be identified.
V1M7 1.7.1.6 i)	The quality of the food used for testing or culturing shall be sufficient to allow satisfactory survival, growth and reproduction of the test species as demonstrated by routine reference toxicant tests and negative control performance.
V1M7 1.7.1.6 i)	The quality of the food used for testing or culturing shall be sufficient to allow satisfactory survival, growth and reproduction of the test species as demonstrated by routine reference toxicant tests and negative control performance. The laboratory shall have written procedures for the evaluation of food acceptance.
V1M7 1.7.1.6 j)	A subset of organisms used in bioaccumulation tests shall be analyzed at the start of the test (baseline) for the target compounds to be measured in the bioaccumulation tests.
V1M7 1.7.1.6 k)	Test chamber size and test solution volume shall be as specified in the method.
V1M7 1.7.1.6 k)	Test chamber size and test solution volume shall be as specified in the method. All test chambers used in a test shall be identical.
V1M7 1.7.1.6 l)	Test organisms shall be fed the quantity and type food or nutrients specified in the method. T
V1M7 1.7.1.6 m)	All organisms in a test shall be from the same source and lot. Where available, certified seeds are used for soil tests.
V1M7 1.7.1.6 n)	All organisms used in tests, or used as broodstock to produce neonate test organisms (for example cladocerans and larval fish), shall appear healthy, show no signs of stress or disease and exhibit acceptable survival (90% or greater) during the twenty-four (24) hour period immediately preceding use in tests.

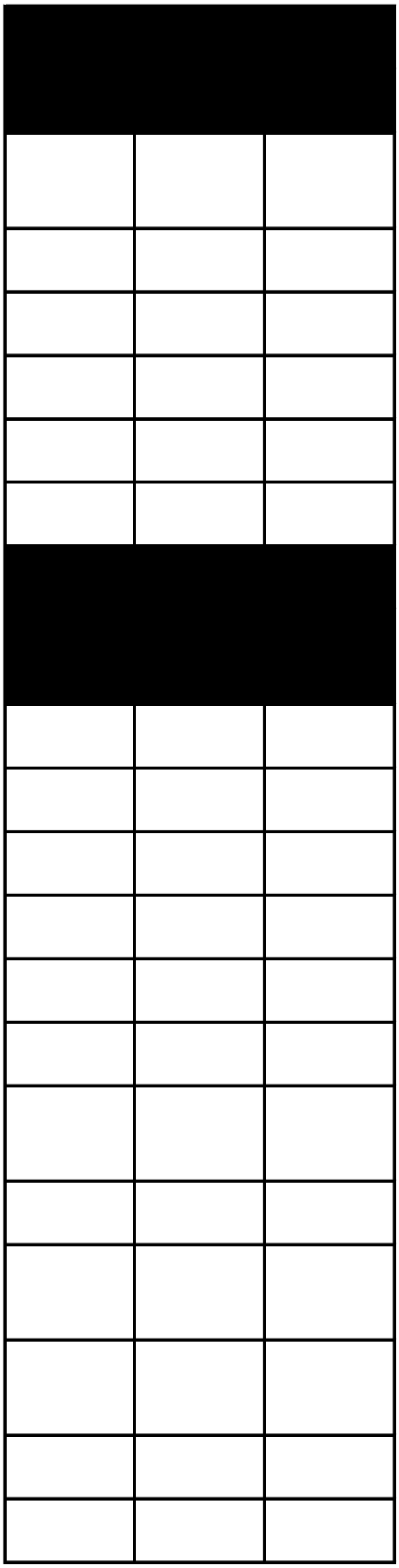
V1M7 1.7.1.6 o)	All materials used for test chambers, culture tanks, tubing, etc. and coming in contact with test samples, solutions, control water, sediment or soil or food shall be non-toxic and cleaned as described in the methods. Materials shall not reduce or add to sample toxicity. Appropriate materials for use in toxicity testing and culturing are described in the methods.
V1M7 1.7.1.6 p)	Light intensity shall be maintained as specified in the methods.
V1M7 1.7.1.6 p)	Measurements shall be made and recorded on a yearly basis.
V1M7 1.7.1.6 p)	Photoperiod shall be maintained as specified in the methods
V1M7 1.7.1.6 p)	Photoperiod shall be shall be documented at least quarterly.
V1M7 1.7.1.6 p)	For algal and plant tests, the light intensity shall be measured and recorded at the start of each test.
V1M7 1.7.1.6 q)	The health and culturing conditions of all organisms used for testing shall be documented by the testing laboratory. Such documentation shall include culture conditions (e.g. salinity, hardness, temperature, pH) and observations of any stress, disease or mortality.
V1M7 1.7.1.6 q)	The health and culturing conditions of all organisms used for testing shall be documented by the testing laboratory. Such documentation shall include culture conditions (e.g. salinity, hardness, temperature, pH) and observations of any stress, disease or mortality.
V1M7 1.7.1.6 q)	When organisms are obtained from an outside source, the laboratory shall obtain written documentation of these water quality parameters and biological observations for each lot of organism received. T
V1M7 1.7.1.6 q)	These observations shall adequately address the twenty-four (24) hour time period referenced in item 1.7.1.6 n) above.
V1M7 1.7.1.6 q)	The laboratory shall also record each of these observations and water quality parameters upon the arrival of the organisms at the testing laboratory.
V1M7 1.7.1.6 r)	Age and the age range of the test organisms shall be as specified in the method.
V1M7 1.7.1.6 r)	Supporting information, such as hatch dates and times, times of brood releases and metrics (for example, chironomid head capsule width) shall be documented.
V1M7 1.7.1.6 s)	The maximum holding time of effluents (elapsed time from sample collection to first use in a test) shall not exceed thirty-six (36) hours; samples may be used for renewal up to seventy-two (72) hours after first use except as prescribed by the method and approved by the regulatory agency having authority for program oversight.
V1M7 1.7.1.6 t)	All tests shall have at least the minimum number of replicates per treatment as prescribed by the method.

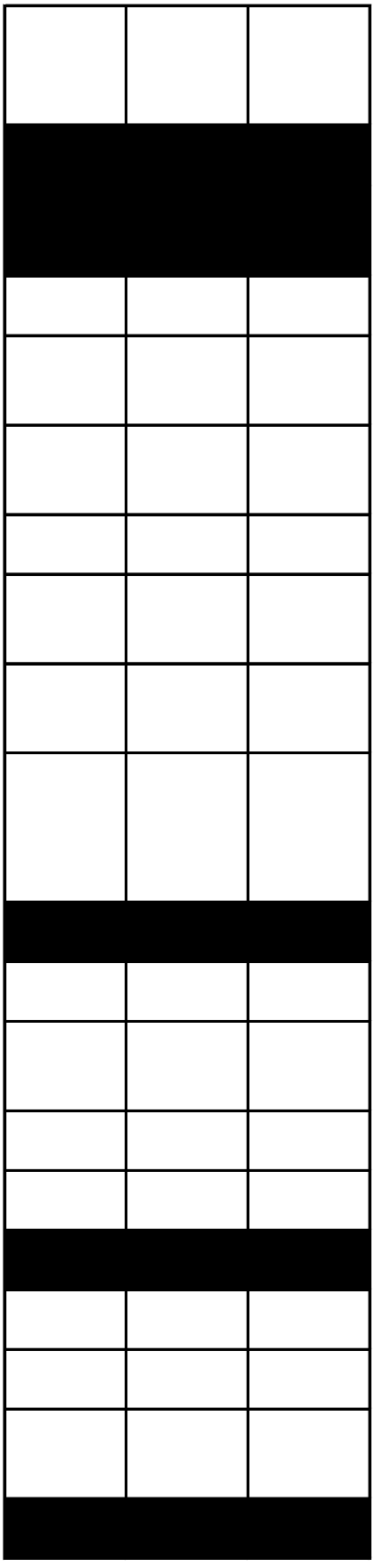
V1M7 1.7.1.6 u)	The control population of Ceriodaphnia in chronic effluent or receiving water tests shall contain no more than 20% males.
V1M7 1.7.1.6 v)	The culturing of C. dubia shall be adequate such that blocking by parentage can be established.
V1M7 1.7.1.6 w)	Dissolved oxygen and pH in aquatic tests shall be within acceptable range at test initiation. Minimal aeration is provided to tests if acceptable dissolved oxygen concentrations cannot be otherwise maintained.
V1M7 1.7.1.6 x)	Test soils or sediments shall be within the geochemical tolerance range of the test organism.
V1M7 1.7.1.6 y)	An individual test may be conditionally acceptable if temperature, dissolved oxygen, pH and other specified conditions fall outside specifications, depending on the degree of the departure and the objectives of the tests (see test conditions and test acceptability criteria specified for each method).
V1M7 1.7.1.6 y)	The acceptability of the test shall depend on the experience and professional judgment of the technical director and the permitting authority.
V1M7 1.7.2	Data Acceptance/Rejection Criteria
V1M7 1.7.2.1	Positive Controls
V1M7 1.7.2.1	A laboratory shall record the control performance and statistical endpoints (such as NOEC or ECp) for each method and species on control charts.
V1M7 1.7.2.1	The laboratory shall also evaluate precision (i.e. coefficient of variation, CV) for these tests against method specific or laboratory-derived criteria to determine validity of the testing result.
V1M7 1.7.2.1	For endpoints that are point estimates (ICp, ECp), control charts are constructed by plotting the cumulative mean and the control limits, which consist of the upper and lower 95% confidence limits (+/- 2 standard deviations).
V1M7 1.7.2.1	For endpoints from hypothesis tests (NOEC, NOAEC) the values are plotted directly, and the control limits consist of one concentration interval above and below the concentration representing the central tendency (i.e. the mode).
V1M7 1.7.2.1	For endpoints that are point estimates the cumulative mean CV is calculated. These values are maintained on control charts.
V1M7 1.7.2.1	For endpoints from hypothesis tests, the PMSD is calculated. These values are maintained on control charts.
V1M7 1.7.2.1	Control chart limits are expected to be exceeded occasionally regardless of how well a laboratory performs. Acceptance limits for point estimates (ICp, ECp) that are based on 95% confidence limits should theoretically be exceeded for one in twenty tests. Depending on the dilution factor and test sensitivity, control charts based on hypothesis test values (NOEC, NOAEC) may be expected to be exceeded on a similar frequency.
V1M7 1.7.2.1	Test results that fall outside of control chart limits at a frequency of 5% or less, or which fall just outside control chart limits (especially in the case of highly proficient laboratories which may develop relatively narrow acceptance limits over time), are not rejected de facto. Such data are evaluated in comparison with control chart characteristics including the width of the acceptance limits and the degree of departure of the value from acceptance limits.

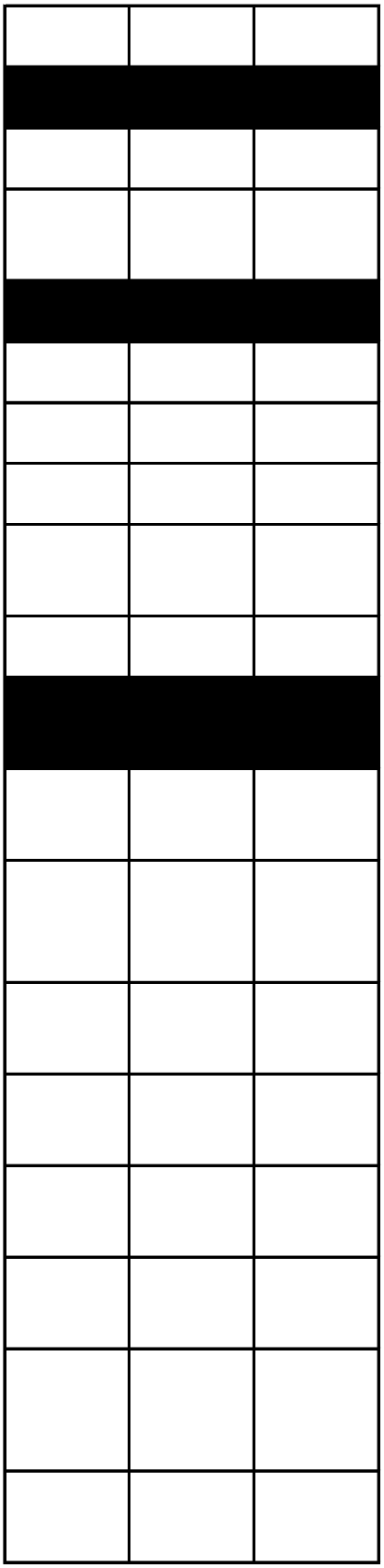
V1M7 1.7.2.1	Laboratories shall develop acceptance/rejection policies, consistent with the methods, for SRT data which considers source of test organisms, the direction of the deviation, test dilution factor, test sensitivity (for hypothesis test values), testing frequency, out-of-control test frequency, relative width of acceptance limits, inter-test CV, and degree of difference between test results and acceptance limits.
V1M7 1.7.2.1	In the case of reference toxicant data which fails to meet control chart acceptance criteria, the test data are examined for defects, corrective action taken and the test repeated if necessary, using a different batch of organisms or the data is qualified.
V1M7 1.7.2.1	Intra-laboratory precision is determined on an ongoing basis through the use of control charts. The control charts shall be plotted as point estimate values, such as EC25 for chronic tests and LC50 for acute tests, or as appropriate hypothesis test values, such as the NOEC or NOAEC, over time within a laboratory.
V1M7 1.7.2.2	Negative Controls
V1M7 1.7.2.2	The test acceptability criteria specified in the method shall be achieved for both the reference toxicant and the effluent or environmental sample toxicity test. The criteria shall be calculated and shall meet the method specified requirements for performing toxicity tests.
V1M7 1.7.2.3	Selection of Appropriate Statistical Analysis Methods
V1M7 1.7.2.3 a)	Methods of data analysis and reporting as specified by language in the regulation, permit, or the method shall be followed as required.
V1M7 1.7.2.3 b)	Toxicity data shall be plotted on semi-logarithmic graph paper, relating time, mortality, and effluent concentration to verify computational results.
V1M7 1.7.3	Sample Handling
V1M7 1.7.3	All samples shall be chilled to 0-6°C during or immediately after collection except as prescribed by the method and approved by the regulatory agency having authority for program oversight.

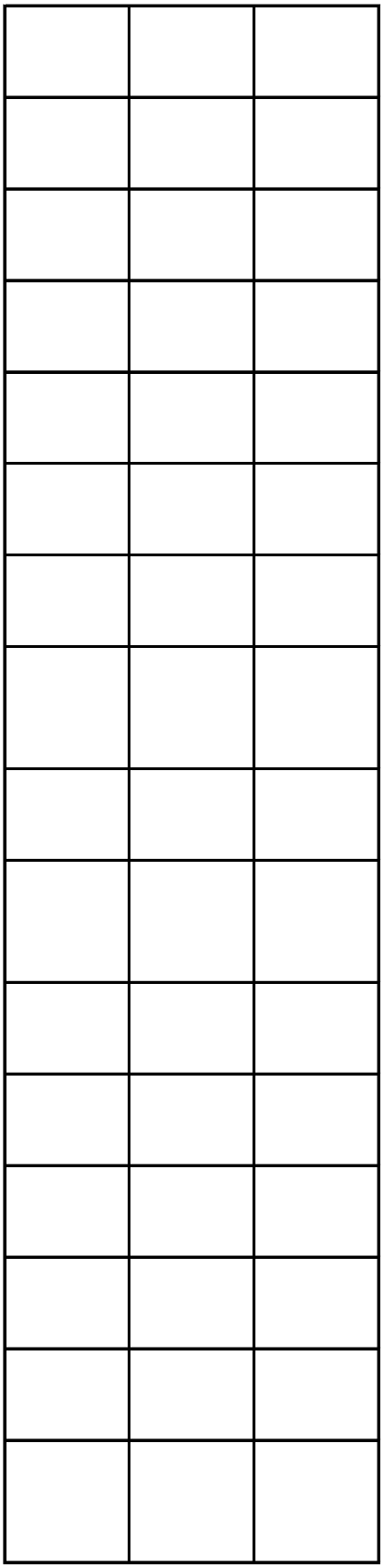
Yes	No	N/A
[redacted]		
[redacted]		

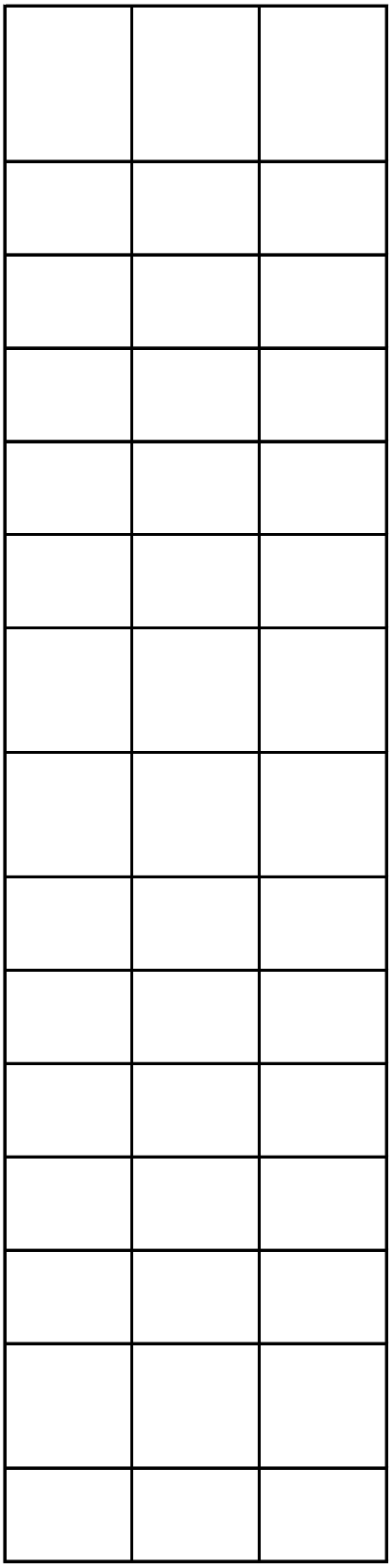


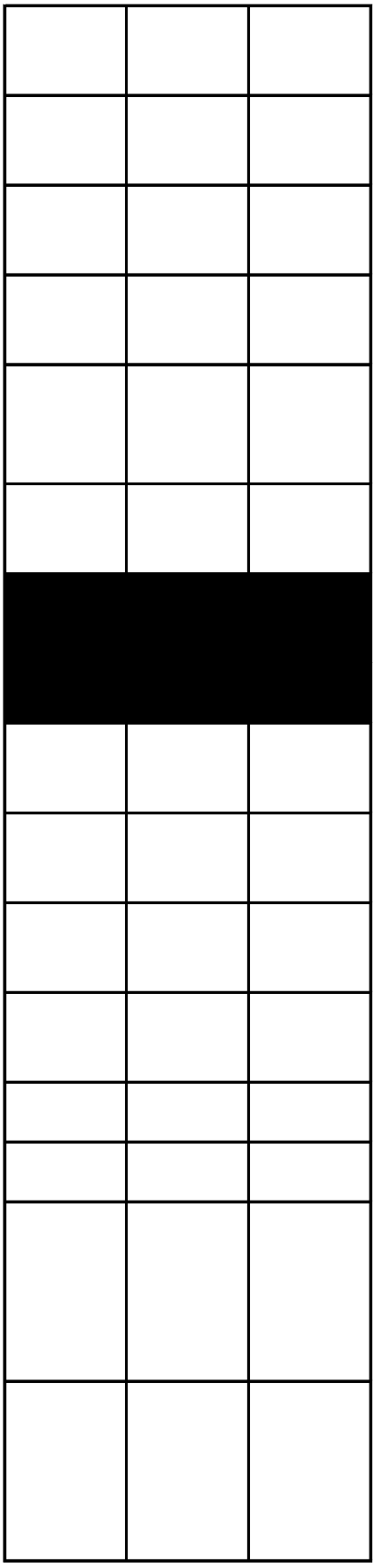












ATTACHMENT 4

LABORATORY CHAIN OF CUSTODY FORMS

Chain of Custody Record

Eurofins TestAmerica, Seattle
5755 8th Street East

Tacoma, WA 98424-1317
phone 253.922.2310 fax 253.922.5047

eurofins | Environment Testing TestAmerica

Regulatory Program: ☐ DW ☐ NPDES ☐ RCRA ☐ Other:

TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica

Client Contact	**Project Manager:**	COC No:
Your Company Name here	**Email:** / **Tel/Fax:**	**Site Contact:** / **Lab Contact:**	**Date:** / **Carrier:**	_____ of _____ COCs / TALS Project #:
Address	**Analysis Turnaround Time**	Sampler:
City/State/Zip	☐ CALENDAR DAYS ☐ WORKING DAYS	**For Lab Use Only:**
(xxx) xxx-xxxx Phone	TAT if different from Below _____	Walk-in Client:
(xxx) xxx-xxxx FAX	☐ 2 weeks	Lab Sampling:
Project Name:	☐ 1 week	
Site:	☐ 2 days	Job / SDG No.:
P O #	☐ 1 day	

Sample Identification	Sample Date	Sample Time	Sample Type (C=Comp, G=Grab)	Matrix	# of Cont.	Filtered Sample (Y / N)	Perform MS / MSD (Y / N)																Sample Specific Notes:

Preservation Used: 1= Ice, 2= HCl; 3= H2SO4; 4=HNO3; 5=NaOH; 6= Other _____

Possible Hazard Identification:
Are any samples from a listed EPA Hazardous Waste? Please List any EPA Waste Codes for the sample in the Comments Section if the lab is to dispose of the sample.

☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)

☐ Return to Client ☐ Disposal by Lab ☐ Archive for _____ Months

Special Instructions/QC Requirements & Comments:

Custody Seals Intact: ☐ Yes ☐ No | Custody Seal No.: | Cooler Temp. (°C): Obs'd:_____ Corr'd:_____ Therm ID No.:_____

Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Relinquished by:	Company:	Date/Time:	Received in Laboratory by:	Company:	Date/Time:

Sample Collection/Receipt Sheet

Turn-around _____ days

TELEDYNE BROWN ENGINEERING, INC.
A Teledyne Technologies Company

Company:
Name: _____
email: _____
Phone:

Lab. No.	Sample ID	Station Code	Sample Matrix	Start date	Start time	Stop date	Stop time	Sample Size	Analysis	Comments	Sample Size Units
			SS						GAMMA,PB-210	Cs-137	
			SS						GAMMA,PB-210	Cs-137	
			SS						GAMMA,PB-210	Cs-137	
			SS						GAMMA,PB-210	Cs-137	
			SS						GAMMA,PB-210	Cs-137	
			SS						GAMMA,PB-210	Cs-137	
			SS						GAMMA,PB-210	Cs-137	
			SS						GAMMA,PB-210	Cs-137	
			SS						GAMMA,PB-210	Cs-137	
			SS						GAMMA,PB-210	Cs-137	
			SS						GAMMA,PB-210	Cs-137	

Collected by: _____ Date: _____

Shipped by: _____ Date: _____

Received by: _____ Date: _____

ATTACHMENT 5

LABORATORY SOPS

Procedure	Number: TBE-2007	Revision: 9
	Issue Date: 03/29/2002	Revision Date: 12/28/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 12/28/2019
Subject:	Gamma-Emitting Radioisotope Analysis	

TELEDYNE BROWN ENGINEERING
ENVIRONMENTAL SERVICES

TBE-2007

Revision 9

Gamma-Emitting Radioisotope Analysis

Prepared by: Keith O. Jeter — **Date:** 12/28/17
Keith O. Jeter
Laboratory Operations Manager

Reviewed by: Sharon L Northcutt — **Date:** 12/28/17
Sharon Northcutt
Quality Assurance Manager

Approved by: Keith O. Jeter — **Date:** 12/28/17
Keith O. Jeter
Laboratory Operations Manager

Procedure	Number: TBE-2007	Revision: 9
	Issue Date: 03/29/2002	Revision Date: 12/28/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 12/28/2019
Subject:	Gamma-Emitting Radioisotope Analysis	

Intentionally Left Blank

Procedure	Number: TBE-2007	Revision: 9
	Issue Date: 03/29/2002	Revision Date: 12/28/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 12/28/2019
Subject:	Gamma-Emitting Radioisotope Analysis	

Table of Contents

Page

DOCUMENT ISSUE AND REVISION CONTROL FORM 4
1.0 SCOPE AND APPLICABILITY 5
2.0 SUMMARY OF METHOD 5
3.0 DEFINITIONS 6
4.0 HEALTH AND SAFETY 6
5.0 CAUTIONS 7
6.0 INTERFERENCES 7
7.0 PERSONNEL QUALIFICATIONS 7
8.0 EQUIPMENT AND SUPPLIES 8
8.1 Apparatus and Materials 8
8.2 Evaporation Supplies 8
9.0 PROCEDURE 9
9.1 Detection Capability 9
9.2 Sample Selection 11
9.3 Sample Preparation 11
9.3.1 Milk, Water and Urine 11
9.3.2 Water (Larger Volumes) 11
9.3.3 AP Filters 12
9.3.4 Vegetation, Biological and Solid Samples 12
9.3.5 Charcoal Cartridges 13
9.4 Count Room 13
9.5 Calculation of Sample Activity, Error and MDA 14
10.0 DATA AND RECORD MANAGEMENT 14
11.0 QUALITY CONTROL AND QUALITY ASSURANCE 14
12.0 REFERENCES 15

Procedure	Number: TBE-2007	Revision: 9
	Issue Date: 03/29/2002	Revision Date: 12/28/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 12/28/2019
Subject:	Gamma-Emitting Radioisotope Analysis	

DOCUMENT ISSUE AND REVISION CONTROL FORM

DOCUMENT: TBE-2007 Gamma-Emitting Radioisotope Analysis

SECTION: Environmental Analysis Department

COVERAGE: Environmental Analysis Program

ISSUE AND REVISIONS	PAGES	PREPARED BY	DATE	EFFECTIVE DATE	APPROVED BY
Revision 1	Sections 1.0, 2.4-.5, added 9.1.3, changed 9.3-.4 & 10.1, deleted 9.5-.6, 11.7 & Appendix	Bill Meyer	09/30/04	09/30/04	Bill Meyer
Revision 2	Sections 10.1, 11.1, 11.3-.7, deleted 11.8-.9	Bill Meyer	10/20/05	11/08/05	Keith Jeter
Revision 3	Sections 3.8, 4.3, 4.7, 11.6, 11.7	Lynne Perry	11/07/07	11/07/07	Keith Jeter
Revision 4	Sections 7.3, 9.2.1, 9.6.6.1-.2 (combined & revised), 10.1, 10.3, 11.7	Lynne Perry	09/02/08	09/02/08	Keith Jeter
Revision 5	Section 9.3.6.1	Lynne Perry	09/02/10	09/02/10	Keith Jeter
Revision 6	Sections 9.3.4.3, 9.3.5.1, 9.3.6, 9.4, 9.4.1.1-.4, 9.5, TOC, 1st Table A	Lynne Perry	08/12/11	08/12/11	Keith Jeter
Revision 7	Sections 2.2, 3.8, 7.3, 8.1-.2, 9.1.3.4, 9.3, 9.3.1.2, 9.3.2.4, 9.3.2.7-.8, 9.3.3.1, 9.3.4.1, 9.3.4.3, 9.3.5.1, 9.4.1.1, 9.4.1.2.3, 10.1-.2, 11.3, 11.7	Lynne Perry	08/12/13	08/12/13	Keith Jeter
Revision 8	Sections 3.5, 4.4, 8.1, 9.3.1.2, 9.3.2.8, 9.3.3.1, 9.3.4.3, 9.3.5.1	Lynne Perry	08/12/15	08/12/15	Keith Jeter
Revision 9	Sections 3.5, 4.4, 9.2.1-.2, 9.3.1, 12 (added TBE procedures)	Sharon Northcutt	12/28/17	12/28/17	Keith Jeter

Procedure	Number: TBE-2007	Revision: 9
	Issue Date: 03/29/2002	Revision Date: 12/28/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 12/28/2019
Subject:	Gamma-Emitting Radioisotope Analysis	

1.0 SCOPE AND APPLICABILITY

1.1 This procedure presents the methods for determining gamma or x-ray emitting radioisotopes by high purity germanium detectors with high resolution spectrometry in specific media: air particulate filters, charcoal filters, milk, water, vegetation, soil/sediments, biological media, etc.

2.0 SUMMARY OF METHOD

2.1 No chemical separation and purification procedures are required for gamma ray analysis. This is a nondestructive analysis, and after completion of the assay, the aliquot can be used for other analyses. However, to identify a specific target gamma or x-ray emitter, chemical separation can be employed to isolate the desired gamma emitter(s) when other gamma emitters are present in high concentrations.

2.2 GEOMETRIES. Each sample to be assayed is put into a standard geometry for gamma counting such as 1-liter wrap-around Marinelli containers, 300-mL or 150-mL bottles, charcoal cartridge or 2-inch filter paper source geometries. Calibration and counting efficiencies of the gamma counting system for these geometries are determined with standard (known) radionuclide activity traceable to the National Institute of Standards and Technology (NIST).

To improve the sensitivity for measurement of gamma emitting radionuclides in water matrices, the sample can be evaporated from any known volume and the residue collected in a standard geometry.

2.3 COUNTING. Samples are counted on a germanium detector connected to dedicated data acquisition and data computation systems. All resultant spectra are stored electronically.

2.4 CALCULATION. The analysis of each sample consists of calculating the specific activities and detection limits of all requested radionuclides. Results are calculated using a counting efficiency curve derived by analyzing multiple nuclide standards prepared in the same counting geometry.

Procedure	Number: TBE-2007	Revision: 9
	Issue Date: 03/29/2002	Revision Date: 12/28/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 12/28/2019
Subject:	Gamma-Emitting Radioisotope Analysis	

2.5 CHEMICAL SEPARATION:

- Ce-141 and Ce-144 are separated using TBE-2004, "Cerium-141 and Cerium-144 by Radiochemical Separation".
- Fe-55 is separated using procedure TBE-2006, "Iron-55 Activity in Various Matrices".
- I-125 and I-129 are separated using procedure TBE-2012, "Radioiodine in Various Matrices".
- Ni-59 is separated using TBE-2013, "Radionickel Activity in Various Matrices".

3.0 DEFINITIONS

3.1	HP	High Purity
3.2	HPGE	High Purity Germanium
3.3	KeV	Kilo Electron Volts
3.4	MDA	Minimum Detectable Activity
3.5	SDS	Safety Data Sheet
3.6	NIST	National Institute of Standards and Technology
3.7	TBE-ES	Teledyne Brown Engineering – Environmental Services

3.8 See procedure TBE-1004, "Definitions".

4.0 HEALTH AND SAFETY

4.1 As required when appropriate, personnel performing this procedure are required to wear the following protective equipment: laboratory coats, safety glasses, and disposable gloves.

4.2 When using or preparing reagents that consist of concentrated caustic or acidic materials, or solutions producing excessive heat, the analyst is required to wear an apron over his/her laboratory coat and an appropriate face shield over his/her safety glasses.

4.3 All potentially hazardous chemicals or hazardous reagents must be prepared and used only in a hood.

Procedure	Number: TBE-2007	Revision: 9
	Issue Date: 03/29/2002	Revision Date: 12/28/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 12/28/2019
Subject:	Gamma-Emitting Radioisotope Analysis	

4.4 SDS's are available in electronically on all laboratory workstations. Refer to these for other specific safety instructions for chemicals and reagents.

4.5 Appropriate precautions, as specified in the TBE-ES Radiation Protection Program Manual, will be followed when handling radioactive material.

4.6 Before commencing any laboratory work activities at TBE-ES, all employees receive orientation and training on the TBE Knoxville Facility Safety Manual, and TBE Radiation Worker Training, as applicable.

4.7 Gamma detector caves, particularly those on rollers, present a pinch hazard and could result in partial loss of finger(s). Extreme caution is required when opening and closing gamma detector caves.

5.0 CAUTIONS

5.1 N/A.

6.0 INTERFERENCES

6.1 N/A.

7.0 PERSONNEL QUALIFICATIONS

7.1 It is the responsibility of the analyst to heed any precautions noted by the procedure, to adhere to the instructions contained in the procedure, to report any deviation from this procedure, and to perform this procedure independently only when formally qualified.

7.2 It is the responsibility of the analyst performing this procedure to inspect worksheets and/or logbooks for accuracy and completeness, samples for correct volume and size, labels and tags for accuracy, equipment for correct operation, and to ensure that all calibrations for equipment used are current and not expired.

7.3 Analysts performing this procedure must be trained, qualified, and certified in accordance with the TBE-ES Quality Assurance Manual and procedure TBE-1007, "Training, Qualification and Certification of Personnel". Procedure specific training documentation for designated analysts is maintained in the QA office.

Procedure	Number: TBE-2007	Revision: 9
	Issue Date: 03/29/2002	Revision Date: 12/28/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 12/28/2019
Subject:	Gamma-Emitting Radioisotope Analysis	

7.4 Analysts in training may perform this procedure only under the direct supervision or observation of a technician certified to perform this procedure.

8.0 EQUIPMENT AND SUPPLIES

8.1 Apparatus and Materials

- Balance
- Bottles, 300-mL, 150-mL or as required
- Charcoal cartridges
- Filter paper, 2-inch for air particulates
- Gamma-Ray Spectrometer consisting of high resolution germanium detectors connected to data acquisition and computation systems. For each detector, 2048 channels (1 KeV per channel) or 4096 channels (0.5 KeV per channel) are assigned for pulse height analysis).
- Graduated cylinders
- Marinelli containers: 1-Liter, 4-Liter
- Photon detector, low energy for lower energy gamma and x-rays
- Pipettes, transfer
- Planchets, nylon
- Sample container geometries, as appropriate

8.2 Evaporation Supplies

- Aerosol, laboratory
- Beakers, 1-, 2-, 4-liter graduated, or others as required
- Deionized water
- Heat lamps
- Hood, fume
- Hot plate
- Marking pens
- Nitric Acid (HNO_3), concentrated

- Parafilm
- Planchets, 2-inch stainless steel
- Trays, fiber for samples

9.0 PROCEDURE

9.1 Detection Capability

9.1.1 Gamma ray spectroscopy, using a germanium detector, provides a high resolution method of distinguishing many gamma emitting nuclides in a single sample.

9.1.2 Each of the most commonly observed nuclides listed below has at least one gamma ray with a unique energy. Consequently, each nuclide in the table may be identified in the presence of any or all of the others. The table below lists the nominal detectable limits for three of the standard sample container geometries.

Gamma Spectroscopy Detection Sensitivities [a] by High Resolution Germanium for Environmental Samples

Nuclide	Milk and Water [b] (pCi/L)	Animal, Fish, Soil Vegetation, etc. (pCi/g)	Filters (pCi/total filter)
Be-7	50	0.2	20
K-40	80	0.4	50
Mn-54	5	0.2	2
Co-58	5	0.2	2
Fe-59	10	0.4	3
Co-60	5	0.2	2
Zn-65	10	0.4	5
Zr-95-Nb-95	5	0.4	3
Ru-103	5	0.2	2
Ru-106	50	0.2	20
I-131	15	0.1	4
Cs-134	5	0.2	2
Cs-137	5	0.2	2
Ba-140/La-140	10	0.2	3
Ce-141	10	0.1	3
Ce-144	40	0.2	20
Ra-226	80	0.1	10
Th-228	10	0.2	10

a These detection levels assume minimal delay between collection and counting, and appropriate sample size.

b For water samples that have been pre-concentrated by evaporation onto a planchet, divide the values by the volume of water represented in the filter geometry.

Ce-141/Ce-144 Minimum Detectable Activity (MDA)

Matrix	MDA [a]	Sigma Level [b]	Sample Volume	Chem Yield	Counting Interval (hour)	Counting Efficiency (cpm)	Backgd (cpm)
Ce-141 [c]	$7x10^{-6}$ µCi/mL	4.66	10 mL	0.80	6		
	$4x10^{-5}$ µCi/g	4.66	2 g	0.80	6		
Ce-144 [d]	$3x10^{-5}$ µCi/mL	4.66	10 mL	0.80	6		
	$2x10^{-4}$ µCi/g	4.66	2 g	0.80	6		

a Assumes there is minimal delay between collection and counting

b Sigma multiplier will be 4.66 unless otherwise specified by the customer

c Half-life for Ce-141 is 32.5 days; therefore, delay in counting would significantly increase the MDA

d Half-life for Ce-144 is 284 days; therefore, delay in counting would increase the MDA

9.1.3 I-125 and I-129 Detection Capability

9.1.3.1 The minimum detectable activity (MDA) is nominally 1.0 pCi/sample for I-129 and 0.6 pCi/sample for I-125 at the 4.66 sigma level. These figures are based on a counting interval of 100 minutes. Counting efficiencies are nominally 0.3 for I-129 and I-125. The half-life of I-129 is so long (1.7×10^7 yr) that radioactive decay need not be considered. These detection limits and counting parameters are nominal values only. For a given sample, calculations are based on the actual values of each parameter used.

9.1.3.2 Detection limits may be expressed on a mass or volume basis by dividing the above MDA values by the sample aliquots represented in the counting vial. Thus, if 30 mL of liquid is analyzed, the nominal detection limit is 30 pCi/L for I-129 and 20 pCi/L for I-125. If 300 mL of environmental water is concentrated tenfold by evaporation, the nominal MDA is 3 pCi/L for I-129 and 2 pCi/L for I-125.

9.1.3.3 For solid samples, a nominal 20 gram aliquot would result in MDAs of 0.05 pCi/gm for I-129 and 0.03 pCi/gm for I-125. The detection limits for charcoal air filters may be calculated by dividing the nominal MDA values by the volume of air passed through the filters.

9.1.3.4 A limitation on this analysis is that large amounts of other radionuclides in the sample can obscure the integration region so that the spectrum cannot be interpreted. In this case, radiochemical separation of iodine must be

Procedure	Number: TBE-2007	Revision: 9
	Issue Date: 03/29/2002	Revision Date: 12/28/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 12/28/2019
Subject:	Gamma-Emitting Radioisotope Analysis	

performed such as described in procedure TBE-2012, "Radioiodine in Various Matrices".

9.2 Sample Selection

9.2.1 Using the Request for Analysis with the LIMS number or the Outstanding Nuclide List, locate the sample in the appropriate storage area and return to the work area.

9.2.2 Create a workgroup in LIMS and proceed to Section 9.3 (below). Refer to TBE-6008 for aliquotting information.

9.3 Sample Preparation

A laboratory sample for this procedure is defined as the material collected for analysis. A test source is prepared from laboratory sample material for the purpose of determining its radioactive constituents. This is accomplished by putting the laboratory sample in a geometry suitable for the counting instrument, in this case a standard geometry that is user-friendly to the gamma spectrometer. The geometries used for the test source should be identical to the geometry of the calibration source, to the extent possible. Important considerations in preparing test sources for gamma-ray spectrometry are geometry (shape), size, and homogeneity (uniformity) of source. In general, samples should fill or nearly fill the container used for counting.

9.3.1 Milk, Water and Urine

9.3.1.1 Shake the sample container to thoroughly mix the sample. Measure sample using graduated cylinder, pipette or similar measuring device. Label sample container, verify that client sample label matches newly labeled container. If samples are weighed, tare sample container, add sample, and reweigh. Use appropriate container for sample size and required detection levels

9.3.1.2 Enter weight or volume, measuring device ID, date, and initials on LIMS aliquot screen. Generate gamma data sheet and transfer, with the samples, to the count room. (See Section 9.4, Count Room)

9.3.2 Water (Larger Volumes)

9.3.2.1 Water samples can be concentrated to achieve lower detection levels.

9.3.2.2 Mark the sample ID number with a laboratory marking pen onto a clean beaker.

9.3.2.3 Shake the sample container to distribute any particulate matter evenly. Measure the sample using a graduated cylinder or similar device. Decant the sample into a beaker. Enter the sample volume, measuring device, data and analyst's initials into LIMS.

9.3.2.4 Add approximately 1 mL concentrated HNO_3 to the sample. Place the beaker on a moderate (approximately 200°F) hot plate.

9.3.2.5 Evaporate the sample until the volume is reduced to the desired level. Take care to reduce hot plate temperature as the sample volume decreases in order to avoid loss by spattering from the beaker. Remove from hot plate and allow the sample to cool.

9.3.2.6 Transfer the solution from each sample beaker to its appropriate container for gamma analysis. Rinse the beaker sparingly with deionized water from a wash bottle and collect the washings in the container.

9.3.2.7 When using a planchet as a final container, place the filled planchets in the fiber sample tray under heat lamps in the fume hood. Add 1 drop of laboratory aerosol to each planchet. Evaporate to dryness. Remove and allow to cool. After the planchet is cool, stretch parafilm over the planchet.

9.3.2.8 Generate gamma datasheet and transfer, with the sample, to the count room (see Section 9.4, Count Room).

9.3.3 AP Filters

9.3.3.1 Place in petri dish. Enter the volume (100%), date and analyst's initials on the LIMS aliquot screen. Generate gamma datasheet and transfer, with the samples, to the count room (see Section 9.4, Count Room).

9.3.4 Vegetation, Biological and Solid Samples

9.3.4.1 Check customer specifications to determine if sample should be dried before analysis. If samples are to be dried, determine percent moisture (see TBE-2028, "Moisture Content of Various Matrices").

9.3.4.2 Tare sample counting container. Load sample and weigh. Record weight, balance ID, date and initials on LIMS Aliquot Screen

NOTE: FOR SOLID SAMPLES USING THE 300 mL BOTTLE GEOMETRY, THE OPTIMAL WEIGHT OF SOLIDS IS 350 – 380 GRAMS.

9.3.4.3 Generate gamma data sheet and transfer, with the samples, to count room (see Section 9.4.Count Room).

9.3.5 Charcoal Cartridges

9.3.5.1 If allowed by customer contract, group charcoal cartridges in groups of up to 5. Cartridges should be taped to a ring with one cartridge in the center and/ or up to 4 cartridges around the center ring, otherwise no prep is necessary. Generate gamma data sheet and transfer, with the cartridges, to the count room (see Section 9.4, Count Room).

9.4 Count Room

9.4.1.1 If the paperwork does not have sample volumes, return the paperwork and samples to the sample preparation technician and have the paperwork corrected.

9.4.1.2 After receipt of prepared sample place sample on a shielded HPGE detector. Record detector ID on gamma data sheet. For samples where geometry is not clearly defined, note the geometry used on the gamma worksheet. Attach the gamma run log to the raw data for review purposes. Start counting on the detector. Enter the client ID, LIMS number, volume, units, geometry and appropriate background. Volume entry should conform to the following rules:

9.4.1.2.1 All volumes should be entered in the reporting units required by the customer. Convert all volumes to appropriate units before entering into the gamma system.

9.4.1.2.2 If required by the customer, volumes are adjusted by the efficiency of the charcoal cartridge.

9.4.1.2.3 For nuclides that are chemically separated before analysis (Fe-55, I-129, Ce-144, Ce-141, Ni-59, and occasionally Cs-137), normalized volumes (volumes corrected for chemical recovery) are entered into the gamma program.

9.4.1.3 Place a completed copy of the gamma worksheet in the run log notebook.

9.4.1.4 Gamma count for a period of time that will meet the required sensitivity of measurement.

9.4.1.5 After the counting period, the data acquisition system performs a peak search and identification of nuclides and the program calculates the activity, error, and minimum detectable activity of the nuclides in the gamma library.

9.5 Calculation of Sample Activity, Error and MDA

9.5.1 All calculations are from commercial gamma system software.

10.0 DATA AND RECORD MANAGEMENT

10.1 Data and records management is per procedure TBE-1003, "Control and Retention of Quality Assurance Records".

10.2 All laboratory data and ancillary information shall be documented in LIMS and/or laboratory logbooks or appropriate worksheets. Appropriate supervisory personnel shall review bound logbook entries and worksheets as required by the TBE-ES Quality Assurance Manual and procedure TBE-1007, "Training, Qualification and Certification of Personnel".

10.3 Corrections to recorded data in logbooks or on worksheets shall be noted by drawing through the incorrect data with a single line and recording the date of the correction and the initials of the person making the correction. The correct data will be recorded in an unambiguous location in the immediate proximity of the incorrect data. Unless obvious, an explanation for the change is also required. Correction to recorded data in the electronic logbook requires a reason in order to save the change in LIMS.

11.0 QUALITY CONTROL AND QUALITY ASSURANCE

11.1 Sample collection, reagents and standards preparation, quality control and data acceptance, sample preparation and instrument procedures, calculations, precision and accuracy, reporting of

results, attachments and references, as they apply to this procedure, are discussed in other procedures.

11.2 From a health and safety perspective, the TBE Knoxville Facility Safety Manual shall guide execution of this procedure.

11.3 Analysis blanks and spikes shall be run to meet customer requirements. See procedure TBE-4005, "Quality Control Samples – Blanks, Spikes and Duplicates".

11.4 Sample duplicates shall be run to meet customer requirements or as required by the TBE-ES laboratory QC program.

11.5 A matrix spike consisting of a sample spiked with an appropriate standard (NIST traceable when possible) shall be run to meet customer requirements or as required by the TBE-ES laboratory QC program.

11.6 If any batch control sample fails laboratory established quality control criteria or fails to meet specific customer contract requirements, the samples comprising the controlled batch shall be reanalyzed.

11.7 Control samples may be statistically analyzed following the guidance of procedure TBE-4011, "Quality Calculation and Charting (Accuracy, Precision, Recovery, Efficiency, Control Charts and Data Quality Objectives").

12.0 REFERENCES

12.1 TBE Knoxville Facility Safety Manual, current revision.

12.2 TBE-ES Procedure TBE-1003, "Control and Retention of Quality Assurance Records", current revision.

12.3 TBE-ES Procedure TBE-1007, "Training, Qualification and Certification of Personnel", current revision.

12.4 TBE-ES Procedure TBE-2004, "Cerium-141 and Cerium-144 by Radiochemical Separation", current revision.

12.5 TBE-ES Procedure TBE-2006, "Iron-55 Activity in Various Matrices", current revision.

12.6 TBE-ES Procedure TBE-2012, "Radioiodine in Various Matrices", current revision.

Procedure	Number: TBE-2007	Revision: 9
	Issue Date: 03/29/2002	Revision Date: 12/28/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 12/28/2019
Subject:	Gamma-Emitting Radioisotope Analysis	

12.7 TBE-ES Procedure TBE-2013, "Radionickel Activity in Various Matrices", current revision.

12.8 TBE-ES Procedure TBE-2028, "Moisture Content of Various Matrices", current revision.

12.9 TBE-ES Procedure TBE-3003, "Calibration and Control of Alpha and Beta Counting Instruments", current revision.

12.10 TBE-ES Procedure TBE-4005, "Quality Control Samples – Blanks, Spikes, Duplicates", current revision.

12.11 TBE-ES Procedure TBE-4011, "Quality Calculation and Charting (Accuracy, Precision, Recovery, Efficiency, Control Charts and Data Quality Objectives", current revision.

12.12 TBE-ES Procedure TBE-6008, "LIMS Training", current revision.

12.13 TBE-ES Quality Assurance Manual, current revision.

12.14 TBE-ES Radiation Protection Program Manual, current revision.

12.15 U.S. Environmental Protection Agency, EPA-600/4-80-032, *Prescribed Procedures for Measurement of Radioactivity in Drinking Water,* Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, August 1980. Procedures, except SM-19-7110B, are based on Method 901.1 "Gamma Emitting Radionuclides," augmented for non-aqueous matrices by TBE-ES technical personnel.

12.16 U.S. Nuclear Regulatory Commission, Regulatory Guide 4.15, revision 1, February 1979; Quality Assurance for Radiological Monitoring Programs (Normal Operations) – Effluent Streams and the Environment.

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES

TBE-2015

Revision 6

Lead-210 Activity in Various Matrices

Prepared by: Susan Ogletree — Chemist — **Date:** 04/26/17

Reviewed by: Brandy Bicoll — Quality Assurance Manager — **Date:** 4/24/17

Approved by: Keith O. Jeter — Laboratory Operations Manager — **Date:** 4/24/17

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

Table of Contents

Page

1.0 SCOPE AND APPLICABILITY 4
2.0 SUMMARY OF METHOD 4
3.0 DEFINITIONS 4
4.0 HEALTH AND SAFETY 4
5.0 CAUTIONS 5
6.0 INTERFERENCES 5
7.0 PERSONNEL QUALIFICATIONS 5
8.0 EQUIPMENT AND SUPPLIES 6
8.1 Apparatus and Materials 6
8.2 Standards and Reagents 6
9.0 PROCEDURE 7
9.1 Detection Capability 7
9.2 Sample Selection 8
9.3 Sample Preparation 8
9.4 Chemical Separation and Purification 9
9.5 Mounting of Precipitate 10
9.6 Sample Counting 12
9.7 Yield Tracer Counting 12
9.8 Calculation of the Sample Activity or of the MDA 12
10.0 DATA AND RECORD MANAGEMENT 13
11.0 QUALITY CONTROL AND QUALITY ASSURANCE 13
12.0 REFERENCES 14

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

DOCUMENT ISSUE AND REVISION CONTROL FORM

DOCUMENT: TBE-2015, Lead-210 Activity in Various Matrices

SECTION: Environmental Analysis Department

COVERAGE: Environmental Analysis Program

ISSUE AND REVISIONS	PAGES	PREPARED BY	DATE	EFFECTIVE DATE	APPROVED BY
Revision 1	Revised 2.2, 4.3, 7.3, 9.2.1, 9.2.2, 10.1, 11.1, 11.3 thru 11.7, and deleted 11.8 thru 11.10	Bill Meyer	10/20/05	11/09/05	Bill Meyer
Revision 2	Sections 3.4, 6.2, 6.3, 8.2, 9.3.6	Lynne Perry	11/15/07	11/15/07	Keith Jeter
Revision 3	Sections 8.1, 8.2, MDA table 9.3.5, 9.3.6, 9.4.5, 9.4.8, 9.5.4, 9.5.5, 9.5.7, 9.5.9, 9.5.10, 9.5.11, 9.6.3, 9.6.4, 9.7.2, 10.1, 10.3, 11.7, 12.2	Lynne Perry	09/09/08	09/09/08	Keith Jeter
Revision 4	Sections 1.1, 5.1, 8.1&2, 9.3 note, 9.3.4, 9.3.6, 9.4.1&2, 9.4.8&9, 9.6, Deleted 9.5.10, 9.7.1	Lynne Perry	10/05/11	10/05/11	Keith Jeter
Revision 5	Sections 2.2, 3.4, 7.3, 5.1, 6.1, 8.1&.2, 9.1-.4, 9.5.10, 9.6 & .7, 10.2, 10.2, 11.7	Lynne Perry	10/22/14	10/22/14	Keith Jeter
Revision 6	Sections 9.1, 9.3.6, 9.3.10, 9.3.11, 9.3.12, 9.4.4	Brandy Bicoll	04/24/17	04/24/17	Keith Jeter

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

1.0 SCOPE AND APPLICABILITY

1.1 This procedure presents the radiochemical beta assay method for determining the leachable lead-210 (Pb-210) activity in sediments and soils.

2.0 SUMMARY OF METHOD

2.1 The Pb-210 activity of soils and sediments is determined radiochemically by separating the daughter product Bi-210 and assaying its beta activity. The method presented here measures the Pb-210 fraction from which Bi-210 may be dissolved by leaching with hydrochloric acid; activity in the interior of mineral grains may be excluded.

2.2 Stable lead and bismuth carriers are added to the dried sample and it is leached with 6 M hydrochloric acid. The sample is then filtered and the filtrate is evaporated, oxidized with nitric acid, and finally dissolved in 1 M Nitric acid. The solution is passed through a TEVA resin column. Lead is eluted first with 4 M hydrochloric acid, and then bismuth is eluted with 5 M Nitric acid. The bismuth is precipitated as the bismuth phosphate and is collected by filtration on a filter disc. The bismuth yield is determined gravimetrically. For samples from areas where stable bismuth or other interfering minerals exist, batch yield tracer samples spiked with Bi-207 may be used to determine the yield. The filter disc is mounted on a nylon planchet and covered with 3 mg/cm^2 aluminum absorber for beta assay in a low level, gas-flow proportional counter.

3.0 DEFINITIONS

3.1 MSDS Material Safety Data Sheet

3.2 NIST National Institute of Standards and Technology

3.3 TBE-ES Teledyne Brown Engineering – Environmental Services

3.4 See procedure TBE-1004, "Definitions".

4.0 HEALTH AND SAFETY

4.1 At a minimum, personnel performing this procedure are required to wear the following protective equipment: laboratory coats, safety glasses, and disposable gloves.

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

4.2 When using or preparing reagents that consist of concentrated caustic or acidic materials, or solutions producing excessive heat, the analyst is required to wear an apron over his/her laboratory coat and an appropriate face shield over his/her safety glasses.

4.3 All potentially hazardous chemicals or hazardous reagents must be prepared and used only in a hood.

4.4 MSDS are available in locations convenient to the laboratories and from the Safety Manager. Refer to these for other specific safety instructions for chemicals and reagents.

4.5 Appropriate precautions, as specified in the TBE-ES Radiation Protection Program Manual, will be followed when handling radioactive material.

4.6 Before commencing any laboratory work activities at TBE-ES, all employees receive orientation and training on the TBE Knoxville Facility Safety Manual, and TBE Radiation Worker Training, as applicable.

5.0 CAUTIONS

5.1 When adding concentrated acids to water do so very slowly since significant heat is generated during dissolution. Prepare acid solution in a hood and cool the solution in an ice bath during dissolution, if required. Wear an apron, gloves and face shield, as appropriate.

6.0 INTERFERENCES

6.1 If samples to be analyzed are from areas of high stable bismuth, the gravimetric yields will be artificially high. Batch yield tracers should be used when analyzing these samples.

7.0 PERSONNEL QUALIFICATIONS

7.1 It is the responsibility of the analyst to heed any precautions noted by the procedure, to adhere to the instructions contained in the procedure, to report any deviation from this procedure, and to perform this procedure independently only when formally qualified.

7.2 It is the responsibility of the analyst performing this procedure to inspect worksheets and/or logbooks for accuracy and completeness, samples for correct volume and size, labels and tags for accuracy, equipment for correct operation, and to ensure that all calibrations for equipment used are current and not expired.

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

7.3 Analysts performing this procedure must be trained, qualified, and certified in accordance with the TBE-ES Quality Assurance Manual and procedure TBE-1007, "Training, Qualification and Certification of Personnel". Procedure specific training documentation for designated analysts is maintained in the QA office.

7.4 Analysts in training may perform this procedure only under the direct supervision or observation of a technician certified to perform this procedure.

8.0 EQUIPMENT AND SUPPLIES

8.1 Apparatus and Materials

- Aluminum foil absorber (3 mg/cm^2)
- Balance, Analytical
- Balance, top loading
- Beakers, 400 mL, 250 mL, 150 mL or as required
- Desiccator
- Filter discs, 2.8 cm fiberglass or equivalent,
- Filter discs, 15 cm fiberglass
- Filter rack
- Funnel, 4" diameter
- Gas flow proportional counting system, low level
- Glass Wool
- Graduated cylinders, 100 mL or as required
- Hot plate
- Ion exchange column with 5.5 mL reservoir
- Magnetic stirring apparatus with stirring bars
- Nylon planchets, retaining rings
- Oven, hot air drying
- Petri dishes, 4-Way partitioned
- Pipettes, volumetric and serological
- Stirring rods
- Watch glasses

8.2 Standards and Reagents

- Ammonium hydroxide (NH_4OH), concentrated: 15 M

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

- Diammonium hydrogen phosphate $(NH_4)_2HPO_4$, 3.2 M:, Dilute 422.5 grams to 1 liter with deionized water
- Bismuth carrier (nominal value 30 mg Bi/mL), standardized. See procedure TBE-2025, "Preparation and Standardization of Carrier Solutions"
- Hydrochloric acid (HCl), concentrated: 12 M
- Hydrochloric acid (HCl), 4 M: Dilute 334 ml of concentrated acid to 1 liter with deionized water
- Hydrochloric acids (HCl), 6 M: Dilute 500 mL of concentrated acid to 1 liter with deionized water
- Lead carrier (nominally 20 mg Pb/mL), standardization is not required. See TBE-2025, "Preparation and Standardization of Carrier Solutions"
- Nitric acid (HNO_3), concentrated: 16 M
- Nitric acid (HNO_3), 1 M: Dilute 62.5 mL of concentrated acid to 1 liter with deionized water (add acid to water with great care)
- Nitric acid (HNO_3), 5 M: Dilute 312 mL of concentrated acid to 1 liter with deionized water (add acid to water with great care)
- TEVA Resin, 5.5 mL bed column or TEVA Cartridge, or equivalent

Use appropriate graduated cylinders and transfer pipettes during the preparation of the solutions cited above.

9.0 PROCEDURE

9.1 Detection Capability

Detection capability depends upon initial sample size, chemical yield, counting interval, and the background and efficiency of the counting instrument. Lower detection limits may be obtained by increasing the sample size or the counting interval.

Lead-210 Minimum Detectable Activity

Matrix	MDA	Sigma Level [a]	Sample Volume	Chem Yield	Counting Interval (minutes)	Counting Efficiency (cpm)	Bkgd (cpm)
Sediments & Soils [b]	0.2 pCi/gm	4.66	5gm	0.5	200	0.29	.75

a Sigma multiplier will be 4.66 unless otherwise specified by the customer

b A representative decay factor of 0.9 allows for one day delay in counting the planchet after lead separation.

c Efficiency of 0.29 for Bi-210 counting using a 3 mg/cm^2 aluminum absorber.

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

9.2 Sample Selection

9.2.1 Using the Request for Analysis with the LIMS number, locate the sample (or sample group) in the sample receiving and storage room. Log the samples out of the Receiving Room and return with them to the laboratory.

9.2.2 Begin entering into LIMS and/or the laboratory logbook the customer name, the sample ID numbers in order, the desired analyses, sample type, the sample preparation date and the initials of the analyst.

9.2.3 If samples to be analyzed are from areas of high stable bismuth, the gravimetric yields will be artificially high. Batch yield tracers should be used when analyzing these samples.

9.3 Sample Preparation

NOTE: Perform % moisture, if required, prior to aliquoting for lead analysis.

9.3.1 Write the sample ID number on the outside of a glass beaker.

9.3.2 Using a clean spatula add approximately 25 grams of sample into the beaker. (If analyses other than Pb-210 are required, additional sample may be decanted to accommodate them.)

9.3.3 Place the beaker in a hot air oven (rheostat setting between 4 and 5) overnight to dry.

9.3.4 After the sample is dry, remove and allow to cool.

9.3.5 Write the sample ID number on a clean 150 mL beaker. Weigh the beaker using a balance and enter this tare weight in LIMS/and or the laboratory logbook. Transfer approximately 2-10 grams of the dried sample to the beaker. Different sample weights may be used as necessary to meet customer requirements. Enter the aliquot weight in LIMS and/or the laboratory logbook. For Work groups requiring batch yield tracers, aliquot three duplicate samples to serve as yield tracers. Record weights in logbook. Spike each yield tracer sample with approximately 1000 pCi of Bi-207 and process samples with the rest of the work group.

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

9.3.6 Add 6 M HCl to the beaker, filling to the 100 mL mark. Using a calibrated pipette add 1.0 mL standardized Bi carrier to the beaker. Using a disposable pipette, add 1 mL Pb carrier to the beaker. Stir the sample with a glass stirring rod.

9.3.7 Cover the beaker with a watch glass and place on a moderate (approximately 200°F) hot plate. Allow the sample to leach for approximately 2 hours. Remove from the hot plate and allow to cool.

9.3.8 Fold a 15 cm fiberglass filter disc in quarters to make a cone and place it in a 4-inch diameter funnel, or equivalent. Write the sample ID number on a clean 400 mL beaker and place it under the funnel in a filter rack. Gravity filter the sample. Rinse the solids with deionized water and collect the washings with the filtrate. Discard the filter and solids.

9.3.9 Add approximately 5 mL HNO_3 to the sample. Place the sample beaker on a moderate (approximately 200°F) hot plate and evaporate to dryness. Check that the sample does not spatter during evaporation and reduce hot plate temperature if necessary.

9.3.10 Add 50 mL of concentrated HNO_3 to the beaker and take to dryness. Dry the samples on a moderate (approximately 200°F) hot plate. Remove the samples when the sample starts to foam. Do not bake the sample.

9.3.11 Add 20 mL of 1 M HNO_3 to the beaker. Warm gently on a lower temperature (approximately 100°F) hot plate to dissolve solids. Note: The solution will become somewhat cloudy and yellow after 15–20 minutes. **Do not allow to go to dryness.**

9.3.12 Add 1M HNO_3 to the beaker to the 50mL mark.

9.3.13 Remove the beaker from the hot plate and allow to cool. Stir the sample with a glass rod to homogenize the sample.

9.3.14 Further filtration may be required. See section 9.4.4

9.4 Chemical Separation and Purification

9.4.1 Obtain a TEVA 5.5 mL gravity flow column or TEVA cartridge, or equivalent.

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

9.4.2 Load the column to the 3 cm mark with resin. Place a small amount of glass wool on top of resin.

9.4.3 Condition the TEVA resin by passing through approximately 2 times the size of the resin bed with 1 M HNO_3 (~ 6 mL).

9.4.4 Pass the sample solution through the column either at gravity flow or 1 mL/min. Collect the effluent in a beaker and discard.

NOTE: If the sample solution appears cloudy, use a powder funnel and 125mm glass fiber filter above the column to prevent solids from clogging the column.

9.4.5 Rinse the beaker with 15 mL (5 bed volumes) of 1 M HNO_3 and add to the TEVA resin. Collect the effluent in a beaker and discard.

9.4.6 Add 30 mL (10 Bed volumes) of 4 M HCl to the TEVA resin. The acid may be added as two sets of 15 mL if the column will not hold the 30 ml. Note date and time of elution as the "milking date" in LIMS. Collect the effluent in a beaker and discard.

9.4.7 Add an additional rinse of 15 ml (5 bed volumes) of 1 M HNO_3 to the TEVA resin. Collect the effluent in a beaker and discard.

9.4.8 Replace the sample collection beaker with a clean labeled beaker.

9.4.9 Elute the Bismuth with 15 mL of 5 M HNO_3.

9.4.10 Add 2.25 mL of 3.2 M $(NH_4)2HPO_4$ to sample.

9.4.11 Precipitate Bismuth with addition of 5.15 mL concentrated NH_4OH.

9.4.12 Mix and wait 15 minutes

9.5 Mounting of Precipitate

Perform the following steps to collect the $BiPO_4$ through gravity filtration. Do NOT vacuum filter.

9.5.1 Prepare a 2.8 cm glass fiber filter disc for each sample by mounting it on a filtration apparatus and rinsing with deionized water and ethanol.

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

9.5.2 Place the prepared discs in 4-way partitioned petri dishes that have been marked with sequence numbers (one number per partition, beginning with 1). Enter a corresponding sequence number beside each sample ID number entry in the laboratory logbook.

9.5.3 Place the petri dishes containing the prepared filters in a hot air oven (rheostat setting between 4 and 5) for 10 minutes or longer to dry. Remove petri dishes and allow to cool in a desiccator.

9.5.4 Weigh the filter discs on the analytical balance, using a clean spatula to handle them. Enter this tare weight beside the corresponding sequence number and sample ID number in LIMS and/or the laboratory logbook. Take care to replace each filter after weighing in the numbered petri dish partition from which it came.

9.5.5 Using LIMS and/or the laboratory logbook to establish the correspondence between sequence number and sample ID number, transfer each sample from its beaker onto the corresponding filter disc using the filtration apparatus. Using a spatula, take the tared filters in sequence number order and transfer to the filtration apparatus. Wet the filter with deionized water and pour the sample onto the filter. Gravity filter the sample.

9.5.6 Rinse the beaker with DI water and pour through the filter. Transfer each filter from the filtration apparatus back to the numbered petri dish partition from which it came. Place the petri dish in a hot air oven (rheostat setting between 4 and 5) for 10 minutes or longer until the filter is dry.

9.5.7 Remove the petri dish and allow to cool in a desiccator. Weigh the filters on the analytical balance and enter the weights beside the corresponding sequence numbers in LIMS and/or the laboratory logbook. Return each filter to its original partition in the petri dish. LIMS automatically calculates the mount weight and carrier yield.

9.5.8 Prepare a label for each sample, showing the analysis, the sample ID number and the customer. Attach each label to a nylon planchet.

9.5.9 Using LIMS and/or the laboratory logbook to establish the correspondence between sample ID number, and sequence number, transfer each filter to its planchet and fix in place with a 2-inch piece of 3 mg/cm^2 aluminum absorber foil and a nylon ring. Trim excess aluminum with a razor blade or scissors.

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

9.5.10 Print the worksheets and submit finished planchets and worksheets to the counting room.

9.6 Sample Counting

Bismuth-210 mounts are typically counted 200 minutes for beta activity in a low level gas flow proportional counter.

9.6.1 Load the filters into the detector holder.

9.6.2 Set the counter timer to 200 minutes and start the counters (different counting intervals may be used).

9.6.3 After all samples in the group have been counted, copy the raw data file and transfer to the appropriate calculation raw data folder. Remove the mounts from the counter trays and place them in the labeled container.

9.7 Yield Tracer Counting

9.7.1 The yield tracer disks are typically counted for 10 minutes on a gamma system (HPGE). The yields are determined by the Bi-207 recovery. The average yield is applied to the entire batch of samples.

9.7.2 The highest and lowest results have to pass the RPD of <30%.

9.8 Calculation of the Sample Activity or of the MDA

9.8.1 Sample activity and the 2-sigma counting error are calculated as follows:

$$\frac{Net\ pCi\ on\ Collection\ Date}{Unit\ Volume\ or\ Weight} = Net\ Activity \pm Counting\ Error$$

or,

$$\frac{Net\ pCi\ on\ Collection\ Date}{Unit\ Volume\ or\ Weight} = \frac{\frac{N}{\Delta t} - \beta}{2.22(v)(y)(DF)(\varepsilon)} \pm \frac{2 \times \sqrt{\frac{\frac{N}{\Delta t} + \beta}{\Delta t}}}{2.22(v)(y)(DF)(\varepsilon)}$$

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

Where:
- N = total counts from sample (counts)
- Δt = counting time for sample (minutes)
- β = background rate of instrument blank (cpm)
- 2.22 = dpm/pCi or: 2.22×10^6 dpm/μCi
- v or w = volume or mass of sample analyzed
- y = yield
- DF = decay factor of Bi-210 from the mid-elution time to the mid-count time
- ε = efficiency of the counter for Bi-210 beta counting, using a 3 mg/cm^2 aluminum absorber
- 2 = sigma multiplier

9.8.2 If no activity is found, the MDA is reported and calculated as follows unless otherwise specified by the customer:

$$MDA = \frac{4.66\sqrt{\frac{\beta}{\Delta t}}}{2.22\,(v)(y)\,(\varepsilon)(DF)}$$

10.0 DATA AND RECORD MANAGEMENT

10.1 Data and records management is per procedure TBE-1003, "Control and Retention of Quality Assurance Records".

10.2 All laboratory data and ancillary information shall be documented in LIMS and/or laboratory logbooks or appropriate worksheets. Appropriate supervisory personnel shall review bound logbook entries as required by the TBE-ES Quality Assurance Manual and procedure TBE-4015, "Documentation of Analytical Laboratory Logbooks".

10.3 Corrections to recorded data in logbooks or on worksheets shall be noted by drawing through the incorrect data with a single line and recording the date of the correction and the initials of the person making the correction. The correct data will be recorded in an unambiguous location in the immediate proximity of the incorrect data. Unless obvious, an explanation for the change is also required. Correction to recorded data in the electronic logbook requires a reason in order to save the change in LIMS.

11.0 QUALITY CONTROL AND QUALITY ASSURANCE

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

11.1 Sample collection, reagents and standards preparation, quality control and data acceptance, sample preparation and instrument procedures, calculations, precision and accuracy, reporting of results, attachments and references, as they apply to this procedure, are discussed in other procedures.

11.2 From a health and safety perspective, the TBE Knoxville Facility Safety Manual shall guide execution of this procedure.

11.3 Analysis blanks and spikes shall be run on each batch, as required by the TBE-ES laboratory QC program.

11.4 Sample duplicates shall be run to meet customer requirements or as required by the TBE-ES laboratory QC program.

11.5 A matrix spike consisting of a sample spiked with an appropriate standard (NIST traceable when possible) shall be run to meet customer requirements or as required by the TBE-ES laboratory QC program.

11.6 If any batch control sample fails laboratory established quality control criteria or fails to meet specific customer contract requirements, the samples comprising the controlled batch shall be reanalyzed.

11.7 Control samples may be statistically analyzed following the guidance of procedure TBE-4011, "Quality Calculations and Charting (Accuracy, Precision, Recovery, Efficiency, Control Charts and Data Quality Objectives".

12.0 REFERENCES

12.1 TBE Knoxville Facility Safety Manual, current version.

12.2 TBE-ES procedure TBE-3003, "Calibration and Control of Alpha and Beta Counting Instruments".

12.3 TBE-ES Quality Assurance Manual, current version.

12.4 TBE-ES Radiation Protection Program Manual, current version.

12.5 U.S. Environmental Protection Agency, August 1980, *Prescribed Procedures for Measurement of Radioactivity in Drinking Water,* EPA-600/4-80-032.

Procedure	Number: TBE-2015	Revision: 6
	Issue Date: 12/05/03 (reissue)	Revision Date: 04/24/2017
Responsible Individual:	Laboratory Production Manager	Review Date: 04/24/2020
Subject:	Lead-210 Activity in Various Matrices	

12.6 U.S. Nuclear Regulatory Commission, Regulatory Guide 4.15, revision 1, February 1979; *Quality Assurance for Radiological Monitoring Programs (Normal Operations) – Effluent Streams and the Environment.*

Procedure	Number: TBE-4005	Revision: 6
	Issue Date: 11/29/04	Revision Date: 12/28/2017
Responsible Individual:	Quality Assurance Manager	Review Date: 12/28/2020
Subject:	Quality Control Samples – Blanks, Spikes and Duplicates	

TELEDYNE BROWN ENGINEERING
ENVIRONMENTAL SERVICES

TBE-4005

Revision 6

Quality Control Samples – Blanks, Spikes and Duplicates

Prepared by: Sharon L Northcutt **Date:** 12/28/17
Sharon Northcutt
Quality Assurance Manager

Reviewed by: Sharon L Northcutt **Date:** 12/28/17
Sharon Northcutt
Quality Assurance Manager

Approved by: Keith O. Jeter **Date:** 12/28/17
Keith O. Jeter
Laboratory Operations Manager

Procedure	Number: TBE-4005	Revision: 6
	Issue Date: 11/29/04	Revision Date: 12/28/2017
Responsible Individual:	Quality Assurance Manager	Review Date: 12/28/2020
Subject:	Quality Control Samples – Blanks, Spikes and Duplicates	

Intentionally Left Blank

Procedure	Number: TBE-4005	Revision: 6
	Issue Date: 11/29/04	Revision Date: 12/28/2017
Responsible Individual:	Quality Assurance Manager	Review Date: 12/28/2020
Subject:	Quality Control Samples – Blanks, Spikes and Duplicates	

Table of Contents

Page

DOCUMENT ISSUE AND REVISION CONTROL FORM 4
1.0 SCOPE AND APPLICABILITY 5
2.0 SUMMARY 5
3.0 DEFINITIONS 5
4.0 PERSONNEL QUALIFICATIONS 5
5.0 PROCEDURE 5
5.1 General 5
5.2 Purposes and Number of Quality Control Samples 5
5.3 Types and Purposes of Quality Control Samples 7
5.3.1 Method Blank Requirements 7
5.3.2 Laboratory Control Samples (Spiked Blanks) 7
5.3.3 Matrix Spikes 9
5.3.4 Matrix Spike Duplicates 10
5.3.5 Tracers/Carriers 11
5.3.6 Duplicates (Replicates) 11
6.0 CRITERIA, CHECKLISTS AND STANDARDS 13
7.0 DATA AND RECORD MANAGEMENT 13
8.0 QUALITY CONTROL AND QUALITY ASSURANCE 13
9.0 REFERENCES 13

Procedure	Number: TBE-4005	Revision: 6
	Issue Date: 11/29/04	Revision Date: 12/28/2017
Responsible Individual:	Quality Assurance Manager	Review Date: 12/28/2020
Subject:	Quality Control Samples – Blanks, Spikes and Duplicates	

DOCUMENT ISSUE AND REVISION CONTROL FORM

DOCUMENT: TBE-4005 Quality Control Samples – Blanks, Spikes and Duplicates

SECTION: Environmental Analysis Department

COVERAGE: Environmental Analysis Program

ISSUE AND REVISIONS	PAGES	PREPARED BY	DATE	EFFECTIVE DATE	APPROVED BY
Original			11/29/04	11/29/04	
Revision 1	Sections 5.2.1, 5.3.3.2, 5.3.3..6.1-.4, 5.3.3.7, 5.3.4.2, 5.3.4.4, 5.3.5.1	Bill Meyer	10/26/05	11/08/05	Lynne Perry
Revision 2	Sections 3.1, 4.1, 5.3.1-.2, 5.3.2.1, 5.3.3, 5.3.3.1, 5.3.4, 5.3.4.1, 5.3.4-.6, 5.3.6.1.1, 5.3.6.2.1, 5.3.7, 5.3.7.2, 7.1	Lynne Perry	09/03/08	09/03/08	Lynne Perry
Revision 3	Sections 5.2.1, 5.3.2.1, 5.3.3.1, 5.3.4.1, 5.3.5.1, 5.3.7.2, 9.2	Lynne Perry	09/02/10	09/02/10	Lynne Perry
Revision 4	Sections 5.3.2.1-.2, 5.3.3.2, 5.3.4.2	Lynne Perry	12/13/11	12/13/11	Lynne Perry
Revision 5	Sections 5.1.1, 5.3.1-.7, 5.3.2.6, 5.3.3.7-.8, 5.3.4.6, 5.3.6.3, 5.3.7.6 (deleted DOE req's in all)	Sharon Northcutt	12/28/17	12/28/17	Sharon Northcutt

Procedure	Number: TBE-4005	Revision: 6
	Issue Date: 11/29/04	Revision Date: 12/28/2017
Responsible Individual:	Quality Assurance Manager	Review Date: 12/28/2020
Subject:	Quality Control Samples – Blanks, Spikes and Duplicates	

1.0 SCOPE AND APPLICABILITY

1.1 This procedure outlines the use of quality control samples (Blanks, Spikes and Duplicates, etc.) used to provide assurance on the quality of analysis data.

2.0 SUMMARY

2.1 Quality control samples are analyzed based on types of analysis, customer requirements and good laboratory practices.

3.0 DEFINITIONS

3.1 See procedure TBE-1004, "Definitions".

4.0 PERSONNEL QUALIFICATIONS

4.1 Quality control samples are prepared and analyzed by personnel trained, qualified and certified as per procedure TBE-1007, "Training, Qualification and Certification of Personnel".

5.0 PROCEDURE

5.1 General

5.1.1 The laboratory standard quality control samples are the blank and blank spike samples analyzed with each batch of client samples for most methods. Matrix spikes and duplicate samples are used for NELAC and other clients when contractually required. Individual method procedures provide guidance on these usages and exceptions.

5.2 Purposes and Number of Quality Control Samples

5.2.1 Purpose – The analysis of quality control samples provides a means to determine the precision and accuracy of the monitoring process and includes both intralaboratory and interlaboratory measurements. The analysis of replicate samples (containing significant detectable activity) provides a means to determine precision; the analysis of samples containing known concentrations of radionuclides provides a means to determine accuracy. The analysis of laboratory blanks provides a means to detect and measure radioactive contamination of analytical samples, a common source of error in radiochemical analysis of low-level samples. The analysis of analytical blanks also

provides information on the adequacy of background subtraction, particularly for environmental samples. The fraction of the analytical effort needed for the analysis of quality control samples depends to a large extent on (1) the mixture of sample types in a particular laboratory in a particular time period and (2) the history of performance of the laboratory in the analysis of quality control samples. Statistical analysis of sample results may be done as described in procedure TBE-4011, "Quality Calculations and Charting (Accuracy, Precision, Recovery, Efficiency, Control charts and Data Quality Objectives)".

5.2.2 The required number of quality control samples is specified by various standards. These are as follows:

5.2.2.1 ANSI N42.23

5.2.2.1.1 The certified inter-laboratory samples, third party quality control samples and the laboratory quality control samples shall be a minimum of 10% of the total sample processing workload by analyte averaged over a calendar year.

5.2.2.2 ANSI N 13.30

5.2.2.2.1 Instruments – A quality control measurement shall be performed prior to the use of a counting instrument and as needed. Quality control samples should be 5% of the total measurements.

5.2.2.2.2 Radiobioassay Procedures – Blanks and spiked samples of each radionuclide of interest shall be run and analyzed to determine bias and precision. Quality control samples shall be a minimum of 5% of total samples analyzed.

5.2.2.3 NELAC Chapter 5 and DOE QSAS

5.2.2.3.1 Method Blank - One (1) per preparation batch.

5.2.2.3.2 Spike Blank - One (1) per preparation batch.

5.2.2.3.3 Matrix Spike - One (1) per preparation batch

Procedure	Number: TBE-4005	Revision: 6
	Issue Date: 11/29/04	Revision Date: 12/28/2017
Responsible Individual:	Quality Assurance Manager	Review Date: 12/28/2020
Subject:	Quality Control Samples – Blanks, Spikes and Duplicates	

EXCEPT:

- If an internal standard or carrier is used.
- If sufficient sample volume is not available.
- For Gross Alpha, Gross Beta and Tritium aqueous samples.

5.2.2.3.4 Replicates - One (1) per preparation batch if there is sufficient sample volume to do so.

5.3 Types and Purposes of Quality Control Samples

5.3.1 Method Blank Requirements

5.3.1.1 The results of this analysis shall be used to assess the batch. While the goal is to have no detectable contaminants, each method blank shall be critically evaluated as to the nature of the interference and the effect on the analysis of each sample within the batch. The method blank result shall be assessed against the following acceptance criteria:

- The concentration of a targeted analyte in the blank is below the reporting limit as established by the test method or by regulation, or is less than 1/10 of the activity measured in any sample;

OR

- The method blank result does not affect the sample results as per the test method requirements or the project-specific measurement quality objectives.

5.3.1.2 When the specified method blank acceptance criteria are not met, the associated samples are rerun, provided enough sample volume is available. If the blank activity is slightly above the MDC and all sample results are negative, reruns are not required. Action taken is documented in the case narrative, as appropriate. If there is a continued problem with blank contamination, then procedures TBE-1010, "Nonconformance Controls" and

TBE-1012, "Corrective and Preventive Action" shall be followed to investigate the cause of the contamination.

5.3.1.3 In the case of gamma spectrometry where the sample matrix is simply aliquoted into a calibrated counting geometry, the method blank shall be of similar counting geometry that is empty or filled to similar volume with deionized water to partially simulate gamma attenuation due to a sample matrix.

5.3.1.4 There shall be no subtraction of the required method blank result from the sample results in the associated preparation or analytic batch unless permitted by method or program.

5.3.1.5 The method blank sample shall be prepared with similar aliquot size to that of the routine samples for analysis and the method blank result and acceptance criteria shall be calculated in a manner that compensates for sample results based upon differing aliquot sizes.

5.3.1.6 The blank results should be compared to the sample specific MDA values to identify false positive results.

5.3.1.7 Blank Acceptance Criteria:

5.3.1.7.1 The MDA of the batch blank shall be less than the RDL.

5.3.1.7.2 If all sample results in the batch are greater than the RDL, then the batch blank MDA shall be less than the activity of the least active sample in the batch of that samples.

5.3.1.7.3 If all of the samples in the batch are less than the RDL, the activity of the blank shall be less than the MDA.

5.3.1.7.4 If some samples are less than the RDL and some are greater than the RDL, then the batch blank activity must be less than the MDA.

5.3.2 Laboratory Control Samples (Spiked Blanks)

5.3.2.1 The results of this analysis shall be used to assess the batch. The laboratory control sample results shall be assessed against client-specified assessment criteria or, if not specified by the client, the following industry accepted internal criteria:

- The % Recovery as calculated from the formula:

$$\%\,\text{Recovery} = \frac{found}{known} \times 100$$

- Acceptance limits are 80% to 120%

- Warning limits are between 70% to 80% and 120% to 130%.

5.3.2.2 When the specified laboratory control sample acceptance criteria are not met, all samples associated with the LCS are rerun. If required, procedures TBE-1010, "Nonconformance Controls" and TBE-1012, "Corrective and Preventive Action" must be followed. The occurrence of failed laboratory control sample acceptance criteria and the actions taken shall be noted in laboratory reports.

5.3.2.3 The activity of the laboratory control sample shall: (1) be at least five (5) times the detection limit or, (2) at a level comparable to that of routine samples if the sample activities are expected to exceed five (5) times the detection limit.

5.3.2.4 The laboratory standards used to prepare the laboratory control sample shall be from a source independent of the laboratory standards used for instrument calibration.

5.3.2.5 Where gamma spectrometry is used to identify and quantitate more than one analyte isotope the laboratory control sample shall contain isotopes that represent the low (e.g. Americium-241), medium (e.g. Cesium-137) and high (e.g. Cobalt-60) energy range of the analyzed gamma spectra. As indicated by these examples the isotopes need not exactly bracket the calibrated energy range or the range over which isotopes are identified and quantitated.

5.3.2.6 The laboratory control sample shall be prepared with similar aliquot size to that of the routine samples for analyses.

5.3.3 Matrix Spikes

5.3.3.1 The results of this analysis shall be used to assess the batch. The matrix spike result shall be assessed against the client-specified assessment criteria or, if not specified by the client, the following industry accepted internal criteria:

- The % Recovery as calculated from the formula:

$$\%\,\mathrm{MS\,Recovery} = \frac{Spiked\ sample\ result - Sample\ result}{Spike\ value} \times 100$$

- Acceptance limits are 60% to 140%
- If the spiked sample activity is ≥ 5 times the spike activity, the MS recovery is not evaluated.

5.3.3.2 When the specified matrix spike acceptance criteria are not met, the original and matrix spike samples are rerun. If required, procedures TBE-1010 and TBE-1012 shall be followed. The occurrence of a failed matrix spike and the actions taken shall be noted in laboratory reports. The lack of sufficient sample aliquot size to perform a matrix spike shall be noted in the laboratory report.

5.3.3.3 The activity of the matrix spike analyte(s) shall be greater than five times the detection limit (LOD).

5.3.3.4 The laboratory standards used to prepare the matrix spike shall be from a source independent of the laboratory standards used for instrument calibration.

5.3.3.5 The matrix spike shall be prepared by adding a known activity of target analyte before any chemical treatment. Where a radiochemical method, other than gamma spectroscopy, has more than one reportable analyte

isotope (e.g. Plutonium, Pu-238 and Pu-239, using alpha spectrometry), only one of the analyte isotopes need be included in the matrix spike sample at the indicated activity level. However, where more than one analyte isotope is present above the specified detection limit each shall be assessed against the specified acceptance criteria.

5.3.4 Matrix Spike Duplicates

5.3.4.1 A matrix spike duplicate is a second portion of a matrix spike. Data from it is used with the first matrix spike data to gain processing and accuracy data. (See 5.3.6.2 for calculation and criteria of matrix spike duplicates.)

5.3.5 Tracers/Carriers

5.3.5.1 Tracers

5.3.5.1.1 For those methods that utilize a tracer (i.e. internal standard) each sample result shall have an associated tracer recovery calculated and reported. The tracer recovery for each sample result shall be one of the quality control measures to be used to assess the associated sample result acceptance. The tracer recovery shall be assessed against the specific acceptance criteria specified in the method procedures. When the specified tracer recovery acceptance criteria are not met, corrective action shall be taken. The occurrence of failed tracer recovery acceptance criteria and the actions taken shall be noted in the laboratory report.

5.3.5.2 Carriers

5.3.5.2.1 For those methods that utilize a carrier, each sample shall have an associated carrier recovery calculated and reported. The carrier recovery for each sample shall be one of the quality control measures to be used to assess the associated sample result acceptance. The carrier recovery shall be assessed against the specific acceptance criteria specified in the method procedures. When the specified carrier recovery acceptance

Procedure	Number: TBE-4005	Revision: 6
	Issue Date: 11/29/04	Revision Date: 12/28/2017
Responsible Individual:	Quality Assurance Manager	Review Date: 12/28/2020
Subject:	Quality Control Samples – Blanks, Spikes and Duplicates	

criteria are not met corrective action shall be taken. The occurrence of failed carrier recovery acceptance criteria and the actions taken shall be noted in the laboratory report.

5.3.6 Duplicates (Replicates)

5.3.6.1 Replicates are a second aliquot of a customer's sample used to help evaluate laboratory precision.

5.3.6.2 The results of this analysis shall be used to assess batch acceptance. The replicate result shall be assessed against client specified assessment criteria or, if not specified by the client, the following industry accepted internal criteria for Relative Percent Difference (RPD):

$$\text{RPD} = \frac{|\textit{Original activity} - \textit{Duplicate activity}|}{(\textit{Original activity} + \textit{Duplicate activity})/2} \text{ X } 100$$

- Waters/liquids – RPD of 30% or less
- Solids – RPD of 50% or less
- If either results is <5 x the Contract Required Detection Limit, the RPD is not evaluated

5.3.6.3 When the specified replicate acceptance criteria are not met, corrective action shall be taken. The corrective action shall consider the fact that sample inhomogeneity may be a cause of the failed replicate acceptance criteria. The occurrence of a failed replicate acceptance criteria and the actions take shall be noted in the laboratory report. For low level samples (less than approximately three times the detection limit) the laboratory may analyze duplicate laboratory control samples or a replicate matrix spike (matrix spike and a matrix spike duplicate) to determine reproducibility within a preparation batch.

5.3.6.4 Replicates should be prepared from samples that are as homogeneous as possible, such as well-stirred or mixed liquid (water or milk) and solids (dried, ground, or screened soil, sediment or vegetation; or the ash of these

Procedure	Number: TBE-4005	Revision: 6
	Issue Date: 11/29/04	Revision Date: 12/28/2017
Responsible Individual:	Quality Assurance Manager	Review Date: 12/28/2020
Subject:	Quality Control Samples – Blanks, Spikes and Duplicates	

materials). These samples may be replicates of monitoring program samples, replicates of reference test materials or both. The size and other physical and chemical characteristics of the replicate samples should be similar to those of single samples analyzed routinely.

5.3.6.5 Obtaining true replicates of all types of samples is not always practicable. For example, obtaining replicate samples of airborne materials usually is not practicable on a routine basis because it requires either a separate sampling system or splitting a single sample (e.g., cutting a filter in half). Use of replicate samplers usually is not economically feasible and splitting of samples results in replicates that do not represent the usual sample size or measurement configuration (counting geometry) for direct measurement.

6.0 CRITERIA, CHECKLISTS AND STANDARDS

6.1 N/A.

7.0 DATA AND RECORD MANAGEMENT

7.1 Data and records management is as per procedure TBE-1003, "Control and Retention of Quality Assurance Records".

8.0 QUALITY CONTROL AND QUALITY ASSURANCE

8.1 QA/QC is as described in this procedure.

9.0 REFERENCES

9.1 TBE-ES Quality Assurance Manual, current version.

9.2 National Environmental Laboratory Accreditation Conference (NELAC), 2003 NELAC Standard, June 5, 2003.

Title: Asbestos Analysis in Soils and Rock: CARB 435 using PLM

Owner: Noah Lazarte

Approvals

01/28/2019	01/23/2019
Kamash Ramanathan Date	Dan Shelby Date
Regional Laboratory Director, West	Regional Quality Assurance Manager
01/28/2019	
Tim Costello Date	
Regional Quality Assurance Manager	

Copyright Information:

This documentation has been prepared by EMLab P&K solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to EMLab P&K upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use if for any other purpose other than that for which it was specifically provided. The user also agrees that where consultants or other outside parties are involved in the evaluation process, access to these documents shall not be given to said parties unless those parties also specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EMLAB P&K IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EMLAB P&K IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 EMLAB P&K, LLC. ALL RIGHTS RESERVED.

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Chlorinated Pesticides [Methods 8081A, 8081B]

Approvals

Signatures on File

Ryan Zboralski Date
Semivolatile Organic Department Manager

Manjit Nijjar Date
Health & Safety Manager / Coordinator

Terri Torres Date
Quality Assurance Manager

Shawn Kusma Date
Business Unit Manager

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Semivolatile Petroleum Products Method for Soil and Water [Method NWTPH-Dx mod]

Approvals

Signatures on File

Ryan Zboralski Date
Semivolatile Organic Department Manager

Stan Palmquist Date
for Manjit Nijjar
Health & Safety Manager / Coordinator

Terri Torres Date
Quality Assurance Manager

Regan McMorris Date
Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. and its affiliates ("TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any other purpose other than that for which it was specifically provided. The user also agrees that where consultants or other outside parties are involved in the evaluation process, access to these documents shall not be given to said parties unless those parties also specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. ALL RIGHTS RESERVED.

Facility Distribution No. 001 **Distributed To:** Lab Intranet

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Acid Digestion of Sediments, Sludges, and Soils [Method 3050B]

Approvals

Signatures on File

Tammy Hua — Date Metals Department Manager	Janet Muchiri — Date Health & Safety Coordinator
Terri Torres — Date Quality Assurance Manager	Shawn Kusma — Date Laboratory Director

Copyright Information:

This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2020 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED.

Facility Distribution No. 001 **Distributed To:** Lab Intranet

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Chlorinated Herbicides by GC/MS [Method 8151A modified]

Approvals

Signatures on File	
Ryan Zboralski Date	Manjit Nijjar Date
Semivolatile Organic Department Manager	Health & Safety Manager / Coordinator
Terri Torres Date	Shawn Kusma Date
Quality Assurance Manager	Business Unit Manager

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED

Facility Distribution No. 001 **Distributed To:** Lab Intranet

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Document Uncontrolled When Printed

Title: Semivolatile Organic Compound (Base/Neutrals and Acids) Analysis by GC/MS [Method 8270D]

Approvals

Signatures on File

Ryan Zboralski Date	Manjit Nijjar Date
Semivolatile Organic Department Manager	Health & Safety Manager / Coordinator
Terri Torres Date	Shawn Kusma Date
Quality Assurance Manager	Business Unit Manager

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED

Facility Distribution No. 001 **Distributed To:** Lab Intranet

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Trace Metals Analysis by ICP [Methods 6010B, 6010C, 6010D, and 200.7]

Approvals

Signatures on File

Stan Palmquist Date
Inorganic Department Manager

Manjit Nijjar Date
Health & Safety Manager / Coordinator

Terri Torres Date
Quality Assurance Manager

Ryan Zboralski Date
Interim Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED

Facility Distribution No. 001 **Distributed To:** Lab Intranet

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Mercury Analysis by CVAA [Methods 245.1, 7470A, 7471A]

Approvals

Signatures on File	
Stan Palmquist Date	Manjit Nijjar Date
Metals Department Manager	Health & Safety Manager / Coordinator
Terri Torres Date	Regan McMorris Date
Quality Assurance Manager	Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED

Facility Distribution No. 001 **Distributed To:** Lab Intranet

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) [Methods 6020, 6020A, 6020B, 200.8]

Approvals

Signatures on File	
Stan Palmquist Date	Manjit Nijjar Date
Metals Department Manager	Health & Safety Manager / Coordinator
Terri Torres Date	Regan McMorris Date
Quality Assurance Manager	Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED

Facility Distribution No. 001 **Distributed To:** Lab Intranet

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Determination of Volatile Organic Compounds by GC/MS [Methods 8260B, 8260C, 624.1]

Approvals

Signatures on File	
Justin McKell — Date	Janet Muchiri — Date
Volatiles Department Manager	Health & Safety Coordinator
Terri Torres — Date	Shawn Kusma — Date
Quality Assurance Manager	Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2020 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Gasoline Range Organics Analysis [Methods 8015B, *8015D*, AK101, NWTPH-Gx]

Approvals

Signatures on File

Justin McKell — Date
Volatiles Department Manager

Stan Palmquist — Date
for Manjit Nijjar
Health & Safety Manager / Coordinator

Terri Torres — Date
Quality Assurance Manager

Regan McMorris — Date
Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories Inc. and its affiliates ("TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any other purpose other than that for which it was specifically provided. The user also agrees that where consultants or other outside parties are involved in the evaluation process, access to these documents shall not be given to said parties unless those parties also specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. ALL RIGHTS RESERVED.

Facility Distribution No. 001 **Distributed To:** Lab Intranet

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Liquid-Liquid Extraction by Separatory Funnel [Methods EPA 3510C and 600 Series]

Approvals

Signatures on File	
Joe Mohammed Date	Manjit Nijjar Date
Semivolatile Organic Department Manager	Health & Safety Manager / Coordinator
Terri Torres Date	Shawn Kusma Date
Quality Assurance Manager	Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED

Facility Distribution No. 001 **Distributed To:** Lab Intranet

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Sonication Extraction Procedure [Methods 3550B and C]

Approvals

Signatures on File

Ryan Zboralski Date
Semivolatile Organic Department Manager

Manjit Nijjar Date
Health & Safety Manager / Coordinator

Terri Torres Date
Quality Assurance Manager

Regan McMorris Date
Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED

Facility Distribution No. 001 **Distributed To:** Lab Intranet

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Microwave Extraction Procedure [Method 3546]

Approvals

Signatures on File	
Ryan Zboralski Date	Manjit Nijjar Date
Semivolatile Organics Department Manager	Health & Safety Manager / Coordinator
Terri Torres Date	Ryan Zboralski Date
Quality Assurance Manager	Interim Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED

Facility Distribution No. 001 **Distributed To:** Lab Intranet

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Determination of Total Organic Carbon in Liquid Matrices [Methods 415.1, 9060, 9060A and SM 5310B]

Approvals (Signature/Date):

Signatures on File	
Stan Palmquist Date	Manjit Nijjar Date
Inorganic Department Manager	Health & Safety Manager / Coordinator
Terri Torres Date	Ryan Zboralski Date
Quality Assurance Manager	Interim Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED

Facility Distribution No. 001 **Distributed To:** Lab Intranet

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Percent Moisture/Percent Solids [Method SM 2540 G]

Approvals

Signatures on File	
Stan Palmquist Date	Stan Palmquist Date
Inorganics Department Manager	for Manjit Nijjar
	Health & Safety Coordinator
Terri Torres Date	Regan McMorris Date
Quality Assurance Manager	Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories Inc. and its affiliates ("TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any other purpose other than that for which it was specifically provided. The user also agrees that where consultants or other outside parties are involved in the evaluation process, access to these documents shall not be given to said parties unless those parties also specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. ALL RIGHTS RESERVED.

Facility Distribution No. 001 **Distributed To:** Lab Intranet

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Anions by Ion Chromatography [Methods 300.0, 9056A]

Approvals

Signatures on File	
Stan Palmquist Date	Manjit Nijjar Date
Inorganic Department Manager	Health & Safety Coordinator
Terri Torres Date	Regan McMorris Date
Quality Assurance Manager	Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED

Facility Distribution No. 001 **Distributed To:** Lab Intranet

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Analysis of Tetra- through Octa Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS by Method 1613B [Method 1613B]

Approvals (Signature/Date):

06/13/2019	06/12/2019
Robert Hrabak Date	Joe Schairer Date
Department Manager	Health & Safety Manager / Coordinator
06/14/2019	06/17/2019
Lisa Stafford Date	Chris Williams Date
Quality Assurance Manager	Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica and its affiliates ("Eurofins TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF EUROFINS TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY EUROFINS TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2019 TESTAMERICA LABORATORIES, INC. d/b/a EUROFINS TESTAMERICA ALL RIGHTS RESERVED.

Facility Distribution No. Uncontrolled **Distributed To:** Sacramento Bids Folder

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: PCB Analysis by HRGC/HRMS [Methods 1668A & 1668C]

Approvals (Signature/Date):

Robert Hrabak — Date
Operations Manager

Joe Schairer — 8/5/16 — Date
Health & Safety Manager / Coordinator

Lisa Stafford — Date
Quality Assurance Manager

Crystal Pollock — 9.1.16 — Date
Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. and its affiliates ("TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2016 TESTAMERICA LABORATORIES, INC. ALL RIGHTS RESERVED.

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: Preparation of Samples for Tetra- through Octa Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS by Method 1613B [Method 1613B]

Approvals (Signature/Date):

Robert Hrabak 8/7/17
Robert Hrabak Date
Technical Manager

Joe Schairer 8/8/17
Joe Schairer Date
Health & Safety Manager / Coordinator

Lisa Stafford 8/15/2017
Lisa Stafford Date
Quality Assurance Manager

Crystal Pollock 8.16.17
Crystal Pollock Date
Laboratory Director

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. and its affiliates ("TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2017 TESTAMERICA LABORATORIES, INC. ALL RIGHTS RESERVED.

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Title: PCB Preparation for Analysis by HRGC/HRMS [Method 1668A & EPA 1668C]

Approvals (Signature/Date):

Robert Hrabak, Technical Director — Date: 7/26/18	Joe Schairer, Health & Safety Manager / Coordinator — Date: 7/30/18
Lisa Stafford, Quality Assurance Manager — Date: 7/25/2018	Chris Williams, Laboratory Director — Date: 8/1/18

Copyright Information:
This documentation has been prepared by TestAmerica Laboratories, Inc. and its affiliates ("TestAmerica"), solely for their own use and the use of their customers in evaluating their qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees not to give access to this document to any third parties including but not limited to consultants, unless such third parties specifically agree to these conditions.

THIS DOCUMENT CONTAINS VALUABLE CONFIDENTIAL AND PROPRIETARY INFORMATION. DISCLOSURE, USE OR REPRODUCTION OF THESE MATERIALS WITHOUT THE WRITTEN AUTHORIZATION OF TESTAMERICA IS STRICTLY PROHIBITED. THIS UNPUBLISHED WORK BY TESTAMERICA IS PROTECTED BY STATE AND FEDERAL LAW OF THE UNITED STATES. IF PUBLICATION OF THIS WORK SHOULD OCCUR THE FOLLOWING NOTICE SHALL APPLY:

©COPYRIGHT 2018 TESTAMERICA LABORATORIES, INC. ALL RIGHTS RESERVED.

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

(b)(4)

Appendix C

Site Health and Safety Plan

DRAFT
PRE-DESIGN INVESTIGATION WORK PLAN
ARKEMA PROJECT AREA

APPENDIX C
SITE HEALTH AND SAFETY PLAN

Prepared for
Legacy Site Services LLC
665 Stockton Drive
Suite 110
Exton, PA 19341

Prepared by

integral consulting inc.
319 SW Washington St.
Suite 1150
Portland, OR 97204

DOF DALTON OLMSTED FUGLEVAND
1001 SW Klickitat
Way Suite 200B
Seattle, WA 98134

June 18, 2020

CONTENTS

LIST OF FIGURES ..... **xi**

LIST OF TABLES ..... **xii**

KEY PROJECT AND SAFETY INFORMATION ..... **xiii**

SITE-SPECIFIC HEALTH AND SAFETY PLAN APPROVAL ..... **xv**

SITE HEALTH AND SAFETY PLAN ACKNOWLEDGMENT ..... **xvi**

1 PROGRAM OVERVIEW **1-1**

1.1 HEALTH AND SAFETY PHILOSOPHY AND PRINCIPLES 1-2
1.1.1 Philosophy 1-3
1.1.2 Principles 1-3
1.2 INTRODUCTION 1-4
1.3 SCOPE AND CONSIDERATIONS 1-5
1.4 APPLICABLE HEALTH AND SAFETY REQUIREMENTS 1-6
1.4.1 Total's Twelve Golden Rules 1-6
1.4.2 Federal 1-10
1.5 PROGRAM ELEMENTS AND OBJECTIVES 1-10
1.6 EMPLOYEE PARTICIPATION AND RECOGNITION 1-11
1.7 IMPLEMENTATION 1-12
1.8 STOP WORK AUTHORITY 1-12
1.9 COVID-19 FIELD MANAGEMENT PLAN 1-13
1.10 OBJECTIVES AND METHODS 1-14

2 ORGANIZATION AND PERSONNEL **2-1**

2.1 HEALTH AND SAFETY ORGANIZATION 2-1
2.2 HEALTH AND SAFETY ROLES AND RESPONSIBILITIES 2-1
2.2.1 LSS (Agent for Owner, Arkema Inc.) 2-1
2.2.2 Health and Safety Officer/Site Supervisor 2-2
2.2.3 Project Manager 2-3
2.2.4 Corporate Health and Safety Manager 2-3
2.2.5 Field Personnel 2-3
2.2.6 Site Workers 2-3
2.2.7 Divers 2-4
2.3 SITE DESCRIPTION 2-4

3 CHEMICAL AND PHYSICAL HAZARD ANALYSIS 3-1
3.1 CHEMICAL HAZARD ASSESSMENT 3-1
3.2 PHYSICAL HAZARD EVALUATION 3-5
4 HEALTH AND SAFETY EDUCATION AND TRAINING 4-1
4.1 GENERAL 4-1
4.2 RESPONSIBILITIES 4-1
4.3 ON-SITE WORKER TRAINING PLAN 4-1
4.3.1 Hazard/Task-Specific Training 4-2
4.3.2 First Aid and CPR Training 4-3
4.3.3 Project-Specific Orientation and Tailgate Talks 4-3
4.3.4 Training for Hazardous Waste Operations 4-4
4.4 MEDICAL SURVEILLANCE AND EVALUATIONS 4-7
4.5 COMPLIANCE MONITORING 4-8
4.6 SUBCONTRACTORS 4-8
5 HAZARD COMMUNICATION 5-1
5.1 PURPOSE AND SCOPE 5-1
5.2 RESPONSIBILITIES 5-1
5.3 CHEMICAL INVENTORY 5-1
5.4 CONTAINER LABELING 5-1
5.5 MATERIAL SAFETY DATA SHEETS/SAFETY DATA SHEETS 5-2
5.6 HAZARD COMMUNICATION TRAINING 5-2
6 PLANNING AND HAZARD CONTROL 6-1
6.1 APPLICATION AND USE OF HASP 6-1
6.1.1 Acknowledgment and Acceptance of Health and Safety Plan 6-1
6.2 CONTRACTOR PRE-START CHECKLIST 6-1
6.3 CRITICAL ANALYSIS OF TASKS 6-2
6.4 JOB HAZARD ANALYSIS 6-3
6.4.1 Description of Job Hazard Analysis 6-3
6.4.2 How to Complete the JHA Form 6-4
6.4.3 List of Possible Hazards 6-4
6.4.4 Job Hazard Analysis Summary 6-6
6.5 HIERARCHY OF CONTROLS 6-7
6.6 COMPETENT PERSONS 6-8
6.7 SUBCONTRACTOR SELECTION 6-8
6.8 ROUTINE INSPECTIONS 6-9

6.9 CONTROL OF EXPOSURE TO HAZARDOUS SUBSTANCES 6-9
6.10 ATMOSPHERIC AND AIR MONITORING 6-10
6.10.1 Air Monitoring 6-10
6.10.2 Weather Conditions and Mobilization of Instrumentation 6-12
6.10.3 Calibration and Maintenance 6-13
6.10.4 Schedule 6-13
6.10.5 Recordkeeping 6-14
6.11 UTILITIES 6-14
6.12 TRAFFIC CONTROL 6-14
6.12.1 Suitable and Compliant Hauling Equipment 6-15
6.13 PERSONAL PROTECTIVE EQUIPMENT 6-15
6.13.1 Use of Personal Protective Equipment 6-15
6.14 BASIC PERSONAL PROTECTIVE EQUIPMENT 6-16
6.14.1 Eye Protection 6-16
6.14.2 Hard Hats 6-17
6.14.3 Foot Protection 6-18
6.14.4 Hand Protection 6-18
6.14.5 High-Visibility Clothing 6-20
6.14.6 Chemical Protective Clothing 6-20
6.14.7 Respirators 6-21
6.14.8 Hearing Protection 6-21
6.14.9 Personal Flotation Devices and Rescue 6-21
6.14.10 Specialized Protective Equipment 6-22
6.14.11 Personal Work Clothing 6-22
6.14.12 Safety Equipment 6-22
6.14.13 Personal Flotation Devices and Rescue 6-23
6.15 LEVELS OF PROTECTION 6-24
7 RESPIRATORY PROTECTION 7-1
7.1 PURPOSE AND SCOPE 7-1
7.2 RESPONSIBILITIES 7-1
7.3 PROCEDURE 7-2
7.3.1 Hazard Evaluation and Selection of Respirators 7-2
7.3.2 Procurement and Issue of Respirators 7-4
7.3.3 Training 7-5
7.3.4 Medical Approval to Use Respiratory Protection 7-5
7.3.5 Respirator Fit Tests 7-6

7.3.6 Use of Air Purifying Respirators 7-6
7.3.7 Cartridge Change-out Schedules 7-7
7.3.8 Supplied Air and Self-Contained Breathing Apparatus 7-7
7.3.9 Inspection and Maintenance Procedures for Self-Contained Breathing Apparatus 7-8
7.3.10 Work Practices for Conditions Immediately Dangerous to Life and Health 7-10
7.3.11 Procedures for Care and Maintenance of Air Purifying Respirators 7-11

8 SAFETY MANAGEMENT PROGRAM 8-1

8.1 REGULAR HEALTH AND SAFETY REPORTING 8-1
8.1.1 Trend Analysis 8-1
8.2 MONTHLY HEALTH AND SAFETY MEETINGS 8-1

9 WORK PRACTICES AND GUIDELINES 9-1

9.1 DEFINABLE FEATURES OF WORK 9-1
9.1.1 Surface and Subsurface Sediment Sampling 9-1
9.1.2 Riverbank Soil Sampling 9-3
9.1.3 Porewater Sampling 9-4
9.1.4 Groundwater Discharge Study 9-5
9.1.5 IDW Management 9-7
9.2 COORDINATION OF ACTIVITIES BETWEEN CONTRACTORS 9-7
9.3 HOUSEKEEPING 9-7
9.4 MANUAL MATERIAL HANDLING 9-8
9.5 ELECTRICAL SAFETY 9-9
9.6 LOCKOUT/TAG OUT 9-11
9.6.1 Definitions 9-11
9.6.2 What Must Be Locked or Tagged Out? 9-12
9.6.3 Lockout/Tag out Procedure 9-12
9.6.4 Training and Inspections 9-13
9.6.5 Special Conditions 9-13
9.7 COMPRESSED GAS CYLINDERS 9-14
9.7.1 Identification and Labeling 9-14
9.7.2 Engineering Controls / Design Considerations 9-14
9.7.3 Using Cylinders 9-14
9.7.4 Storing Cylinders 9-14
9.7.5 Transporting Cylinders 9-14
9.7.6 Piping Incompatibilities and Restrictions 9-15

9.7.7 Emergency Procedures 9-15
9.7.8 Training 9-15
9.8 WORKING AT HEIGHT & FALL PROTECTION 9-15
9.9 EXCAVATIONS 9-18
9.9.1 Pre–Excavation Activities 9-18
9.9.2 During Excavation 9-19
9.10 LADDERS 9-20
9.10.1 Portable Ladders 9-21
9.10.2 Stepladders 9-23
9.10.3 Fixed Ladders 9-23
9.11 TOOLS AND POWER EQUIPMENT 9-24
9.11.1 Hand Tools 9-24
9.11.2 Electric Tools 9-25
9.11.3 Pneumatic Tools 9-26
9.11.4 Engine-Powered Tools 9-27
9.12 WORKING AROUND HEAVY EQUIPMENT 9-27
9.13 WORKING NEAR OR OVER WATER 9-28
9.13.1 U.S. Coast Guard Notification 9-29
9.13.2 General Overwater Safety Guidelines 9-29
9.13.3 Sampling Vessel Operations 9-30
9.13.4 Small Craft Operation 9-30
9.14 FLAMMABLE AND COMBUSTIBLE LIQUIDS 9-31
9.14.1 Storage and Handling 9-31
9.14.2 Outdoor Storage 9-31
9.14.3 Dispensing Flammable and Combustible Liquids 9-32
9.15 HAZARDOUS WASTE SITE CONTROLS 9-33
9.15.1 Access Control 9-33
9.15.2 Work Zones 9-34
9.15.3 Considerations when Establishing Work Zones 9-35
9.15.4 Work Zones Established for the Arkema Project Area 9-36
9.15.5 General Hazardous Waste Site Work Practices 9-38
9.16 DECONTAMINATION AT HAZARDOUS WASTE SITES 9-38
9.16.1 Worker Hygiene and Prevention of Contamination 9-39
9.16.2 Decontamination Equipment Selection 9-40
9.16.3 Decontamination Design 9-40
9.16.4 Personal Protective Equipment for Decontamination Facility Workers 9-41

9.16.5 Decontamination Methods 9-41
9.16.6 Sampling and Monitoring Equipment Decontamination 9-42
9.16.7 Heavy Equipment Decontamination 9-42
9.16.8 Decontamination Water, Disposable PPE, and Site Wastes 9-42
9.17 TRAFFIC AND WORK ZONE SAFETY 9-43
9.17.1 Motor Vehicle Safety 9-44
9.18 HEAVY EQUIPMENT 9-45
9.19 WELDING AND CUTTING 9-46
9.19.1 Gas Welding and Cutting 9-48
9.19.2 Electric Welding 9-49
9.20 DEMOLITION 9-49
9.21 FIRE PROTECTION 9-49
9.22 SCAFFOLDS 9-49
9.23 MECHANIZED PERSONNEL LIFTS 9-49
9.23.1 Pre-Operations 9-49
9.23.2 Power Lines 9-50
9.23.3 Wind and Temperature 9-50
9.23.4 Signs and Warning Labels 9-50
9.23.5 Driving and Crushing Hazards 9-50
9.23.6 Operation 9-50
9.23.7 Barricading, Crushing Hazard 9-50
9.23.8 Transfer to a Structure, Falling Hazard 9-50
9.23.9 Machine Capacity and Tip Hazards 9-50
9.23.10 Improper Use 9-50
9.23.11 Towing and Hauling 9-50
9.24 RIGGING EQUIPMENT 9-51
9.25 CRANES, DERRICKS, AND HOISTING EQUIPMENT 9-52
9.26 SHIPPING INFORMATION 9-53

10 CLIMATE AND TEMPERATURE EXTREMES 10-1

10.1 REGIONAL WEATHER 10-1
10.2 HEAT STRESS 10-1
10.2.1 Hazards Associated with Heat Stress 10-2
10.2.2 Heat Stress Monitoring 10-3
10.2.3 Heat Stress Controls and Prevention 10-4
10.3 COLD STRESS 10-5
10.3.1 Cold Stress Hazards 10-6

10.3.2 Cold Stress Monitoring 10-6
10.3.3 Cold Stress Control and Prevention 10-6
10.4 BIOLOGICAL HAZARDS 10-7
10.4.1 Biological Hazard Communication 10-9
10.4.2 Management of Site Specific Risks Associated with Biological Hazards 10-9

11 HEARING CONSERVATION 11-1

11.1 PURPOSE AND SCOPE 11-1
11.2 DEFINITIONS 11-1
11.3 RESPONSIBILITIES 11-4
11.4 NOISE EXPOSURE LIMITS 11-4
11.5 HEARING PROTECTION METHODS 11-5
11.5.1 Engineering Controls 11-5
11.5.2 Personal Hearing Protection 11-5
11.5.3 Administrative Controls 11-6
11.5.4 Noise Monitoring 11-6
11.5.5 Noise-Measurement Methods 11-7
11.6 MEDICAL SURVEILLANCE PROGRAM 11-8
11.6.1 Program Participation 11-8
11.7 NOISE HAZARD WARNING SIGNS 11-8
11.8 EMPLOYEE TRAINING 11-9
11.8.1 Noise Control Principles 11-9
11.9 RECORDS MAINTENANCE 11-9
11.10 SIGNS AND DECALS 11-10
11.10.1 Noise Hazard Warning Sign Specifications 11-10
11.10.2 Noise Hazard Warning Decal Specifications 11-10

12 EMERGENCY RESPONSE PLAN 12-1

12.1 INTEGRAL'S EMERGENCY RESPONSE PLAN 12-1
12.1.1 EMERGENCY RECOGNITION AND PREVENTION 12-1
12.1.2 EMERGENCY RESPONSE AND NOTIFICATION 12-1
12.1.3 EMERGENCY DECONTAMINATION PROCEDURES 12-3
12.1.4 SITE COMMUNICATIONS 12-3
12.2 EMERGENCY COORDINATOR 12-4
12.3 MEDICAL EMERGENCIES 12-4
12.4 EVACUATION AND COMMUNICATIONS 12-5
12.5 MEDICAL SUPPORT 12-5
12.5.1 Offsite Medical Facility 12-5

12.5.2 First Aid Medical Support....12-5
12.6 FIRE EMERGENCIES....12-6
12.7 SEVERE WEATHER RESPONSE PROCEDURES....12-6
12.7.1 Expected Weather Hazards....12-7
12.8 SPILL RESPONSE AND REPORTING....12-9
12.9 SPILL CONTAINMENT....12-10
13 INCIDENT REPORTING....13-1
13.1 INVESTIGATIONS....13-2
13.1.1 When Investigations Are Conducted....13-2
13.1.2 Purpose and Guidelines of Investigations....13-2
13.2 INCIDENT REPORTING....13-3
13.3 EMPLOYEE'S DUTY....13-4
13.4 LESSONS LEARNED....13-4
14 REFERENCES....14-1

Appendix A. Site Map
Appendix B. Total's Golden Rules Brochure
Appendix C. HSE Recognition
Appendix D. Total's Stop Work Guidance Manual
Appendix E. RETIA USA Near Miss and Incident Notification Procedures
Appendix F. Key Contacts List
Appendix G. (Reserved for) Site Specific H&S Plan(s)
Appendix H. Area of Concern (AOC) Maps
Appendix I. (Reserved for) Contractor Pre-Start Safety Checklist
Appendix J. Total Critical Analysis of Task Procedure & Example
Appendix K. Arkema Project Area Job Hazard Analyses (JHAs)
Appendix L. RETIA USA Utility or Structure Clearance and Isolation Procedure
Appendix M. Glove Comparison Chart
Appendix N. RETIA USA Excavation and Trenching Procedure
Appendix O. (Reserved for) Drowning Site Assessment
Appendix P. Site and Hospital Maps

Appendix Q. Regulatory Notice

Appendix R. Safety Data Sheets (Hexane and Sudan IV)

Appendix S. Safety Guidelines (Cold Stress, Heat Stress, Overwater Safety)

Appendix T. Field Safety Tailgate Briefing Form

Appendix U. COVID-19 Field Management Plan

LIST OF FIGURES

Figure 6-1 Critical Analysis of Tasks Process
Figure 9-1 Portable Ladder Us
Figure 9-2 Fixed Ladder
Figure 9-3 Typical Grounding System
Figure 9-4 Wooden Scaffold Plank Markings (typical)
Figure 9-5 Personnel Lifts Near Power Lines
Figure 9-6 Personnel Lifts Hazards
Figure 13-1 Types of Incidents

LIST OF TABLES

Table 3-1 Volatile Organic Compounds and Semi Volatile Organic Compounds Identified at the Site

Table 3-2 Identified Metals and TPH Contaminants at the Site

Table 3-3 Volatile Contaminate Exposure Calculation

Table 6-1 OSHA Standards for the Use of Personal Protective Equipment

Table 6-2 PPE Ensembles

Table 7-1 Respiratory Protection Factors

Table 7-2 Respiratory Protection Devices

Table 10-1 Suggested Frequency of Physiological Monitoring for Fit and Acclimatized Workers

Table 11-1 Continuous Noise Permissible Exposure Limits

Table 11-2 Impulse Noise Permissible Exposure Limits

KEY PROJECT AND SAFETY INFORMATION

	Name (affiliation)	Work Telephone	Cell Phone
Supervising Contractor	Eron Dodak (Integral)	503-943-3614	503-407-2933
Project Coordinator	Mike Pinto (LSS)	484-875-3465	484-437-1991
Client Safety Director	Fraser Will (RETIA USA)	713-483-5051	832-248-2834
Integral Health and Safety Manager	Matt Behum (Integral)	410-573-1982 ext. 512	443-454-1615
Site Health and Safety Officer/Site Supervisor	Jane Sund (Integral)	503-943-3615	512-779-3172
Alternate Site Safety Officer/Site Supervisor	Andrew Halmstad (Integral)	503-943-3633	503-505-0114

Nearest Hospital

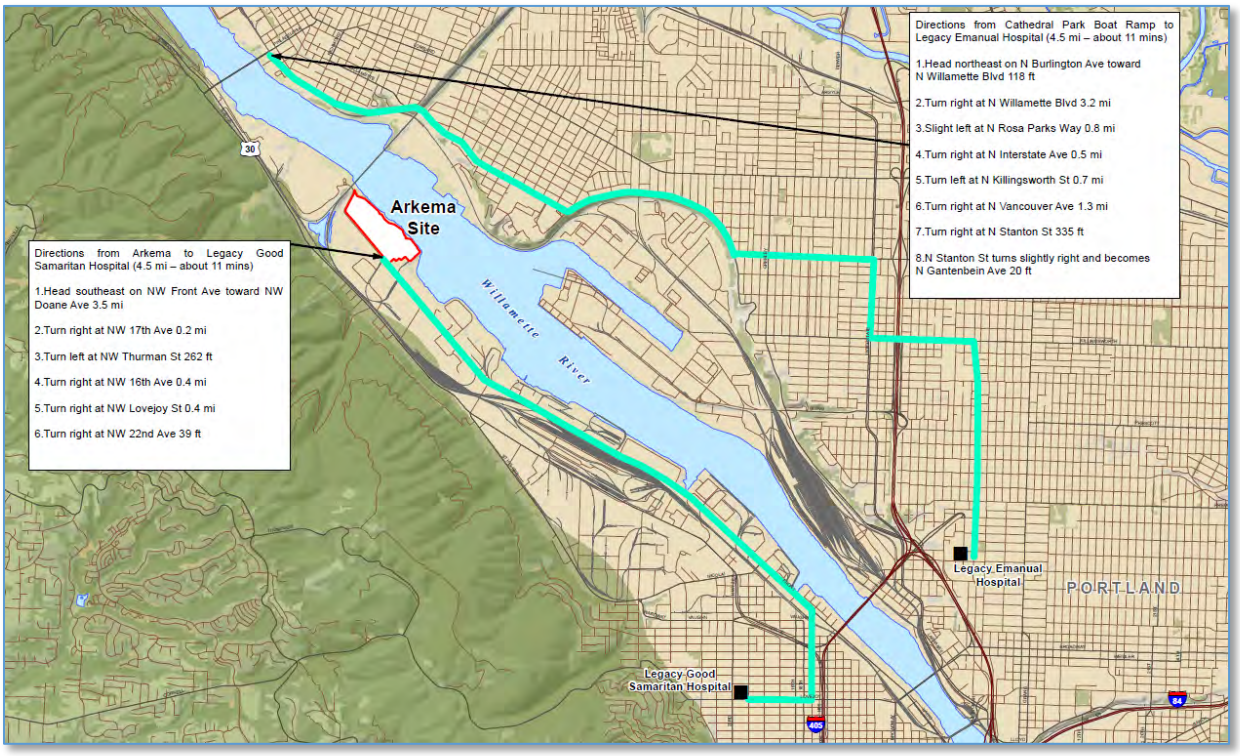
From Arkema Site:

Legacy Good Samaritan Hospital
1015 NW 22nd Avenue
Portland, OR 97210
(503) 413-7711

From Cathedral Park Boat Ramp:

Legacy Emanuel Hospital
2801 Gantenbein Avenue
Portland, OR 97227
(503) 413-2200

See next page for hospital map and directions from the project site.
Site and hospital maps are also included in Appendix A and Appendix P, respectively.


Directions from Cathedral Park Boat Ramp to Legacy Emanual Hospital (4.5 mi – about 11 mins)
1.Head northeast on N Burlington Ave toward N Willamette Blvd 118 ft
2.Turn right at N Willamette Blvd 3.2 mi
3.Slight left at N Rosa Parks Way 0.8 mi
4.Turn right at N Interstate Ave 0.5 mi
5.Turn left at N Killingsworth St 0.7 mi
6.Turn right at N Vancouver Ave 1.3 mi
7.Turn right at N Stanton St 335 ft
8.N Stanton St turns slightly right and becomes N Gantenbein Ave 20 ft
Arkema Site
Directions from Arkema to Legacy Good Samaritan Hospital (4.5 mi – about 11 mins)
1.Head southeast on NW Front Ave toward NW Doane Ave 3.5 mi
2.Turn right at NW 17th Ave 0.2 mi
3.Turn left at NW Thurman St 262 ft
4.Turn right at NW 16th Ave 0.4 mi
5.Turn right at NW Lovejoy St 0.4 mi
6.Turn right at NW 22nd Ave 39 ft
Willamette River
Legacy Emanual Hospital
PORTLAND
Legacy Good Samaritan Hospital
30
405
84

SITE-SPECIFIC HEALTH AND SAFETY PLAN APPROVAL

This site-specific health and safety plan has been reviewed and approved for surface and subsurface sediment sampling, riverbank soil sampling, porewater sampling, a groundwater discharge study, and investigation-derived waste management at the Arkema Project Area in Portland, Oregon. **This HASP does not cover any diving activities, subcontractor construction, or confined space entry activities.**

Project manager	Date
Corporate health and safety manager	Date

SITE HEALTH AND SAFETY PLAN ACKNOWLEDGMENT

In the absence of appropriate subcontractor or consultant health and safety plan(s) (HASPs), and with the written approval of the Integral Consulting Inc. (Integral) corporate health and safety manager, the subcontractor or teaming consultant may utilize the Integral site-specific HASP, provided there is written concurrence from the subcontractor or consultant that they will directly administer the plan for their employees and assume all risks associated with any possible errors or omissions in the plan. **This HASP does not cover any diving activities, subcontractor construction, or confined-space entry activities.** The Integral site-specific HASP is a minimum standard for the site and will be strictly enforced for all Integral personnel and its subcontractors or consultants, where applicable.

I have reviewed the site-specific HASP prepared by Integral, dated June 18, 2020, for the Arkema Project Area fieldwork. The HASP review included a thorough review of TOTAL's Golden Rules presented in Appendix B and TOTAL's Stop Card Program presented in Appendix D. I understand the purpose of the plan, and I consent to adhere to its policies, procedures, and guidelines while an employee of Integral, or its subcontractors or consultants. I have had an opportunity to ask questions regarding this plan, which have been answered satisfactorily by Integral.

Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date

1 PROGRAM OVERVIEW

It is the policy Legacy Site Services LLC (LSS) to provide a safe and healthful work environment that is compliant with applicable regulations. No aspect of the work is more important than protecting the health and safety of all workers. This site-specific Health and Safety Plan (HASP) was developed for pre-design investigation activities being conducted in and adjacent to the Arkema Project Area (approximately river mile 6.9W–7.6W), located in Portland, Oregon. **Appendix A** contains a Site Map. Arkema Inc. is the owner of the property at 6400 NW Front Ave., and LSS, as agent for Arkema Inc., is responsible for overseeing safety and risk management activities at the Arkema site and Arkema Project Area. LSS is part of Total Petrochemicals & Refining USA, Inc. (Total) and affiliated to RETIA USA (RETIA), so this HASP also includes Total's and RETIA's policy, safety rules, and procedures. RETIA is a subsidiary of Total. An organization chart is presented in Appendix F.

The 54-acre Arkema site was closed in 2001 and is currently a large brownfield site. Pre-design investigation activities planned in and adjacent to the Arkema Project Area (Figure 1-2 in Appendix A) includes the following (see Section 9.1 for additional details on the field activities):

- Surface and subsurface sediment sampling
- Riverbank soil sampling
- Porewater sampling
- Groundwater discharge study
- Investigation-derived waste (IDW) management.

The areas of concern are presented in Appendix H. Note that the Arkema Project Area includes all riverbanks from top of the bank to the river.

The purpose for this site-specific HASP is to set forth, in an orderly and logical fashion, appropriate safety procedures to be followed during activities in and adjacent to the Arkema Project Area. The site-specific HASP is intended to ensure a comprehensive and systematic approach to risk identification, hazard anticipation, recognition, and evaluation. This HASP has been prepared in accordance with Oregon Occupational Safety and Health Division safety regulations (OAR 437-004) and federal Occupational Safety and Health Administration (OSHA) safety regulations (29 CFR [Code of Federal Regulations] 1910 and 29 CFR 1926). The federal safety regulations include OSHA's machine guarding standards (29 CFR 1910 Subpart O), if applicable for the type of method chosen to collect the sediment samples. An Oregon OSHA poster is presented in Appendix O. All work shall be performed in accordance with applicable Health & Safety Regulations, and Total's Golden Rules for Safety. A copy of Total's Golden Rule Brochure is provided in **Appendix B**.

This site-wide HASP outlines project-specific Health and Safety (H&S) Program requirements and responsibilities for project contractors. LSS has overall authority to ensure the requirements of this plan are met.

Diving activities will be performed by professional diving subcontractors with appropriate training, certification, and experience.[1] Subcontractors that are contracted to perform fieldwork associated with the sampling (e.g., surface and subsurface sediment sampling, drilling, piezometer installation, text pit excavations, porewater sampling, and seepage meter deployment and retrieval) will develop and follow their own HASPs. However, these plans must be consistent with the provisions outlined in this plan. Company-specific HASPs should include more specific hazards related to their specific scope of work, hazards, and controls. The overall HASP does not relieve subcontractors of their duty to protect their employees by identifying and controlling hazards though implementation of their own programs.

Each contractor and any of their subcontractors, have responsibility for meeting the requirements and responsibilities herein and summarized in Section 2. Perhaps the most essential component of the safety and health program at a hazardous waste site is the development, management, and implementation of the program by a competent health and safety supervisor who has the authority to make timely decisions as worksite conditions rapidly change.

A copy of this HASP must be in the custody of the field crew during field activities. All individuals performing fieldwork must read, understand, and comply with this plan before undertaking field activities. Once the information has been read and understood, the individual must sign the Site Health and Safety Plan Acknowledgment form provided as part of this plan. The signed form will become part of the project file.

This plan may be modified at any time based on the judgment of the Integral site health and safety officer/site supervisor (SHSO/SS) in consultation with the project manager and Integral corporate health and safety manager (CHSM) or designee. Any modification will be presented to the onsite team during a safety briefing and will be recorded in the field logbook.

1.1 HEALTH AND SAFETY PHILOSOPHY AND PRINCIPLES

The project and its contractors affirm the following philosophy and principles as the basis of the H&S Program.

[1] A dive plan will be prepared by the diving subcontractor and submitted to the U.S. Environmental Protection Agency 4 to 6 weeks in advance of the fieldwork.

1.1.1 Philosophy

Total considers health and safety and the protection of the environment as core business values that are prerequisite and essential to the long-term success and sustainability of their business. The project H&S Program is guided by the belief that our people are our greatest asset and that H&S is a key value that must receive support from every employee. Prevention of occupationally related injuries and illnesses is an integral part of the project's goal for exceptional protection of its employees, contractors, and the public, as well as the quality of the environment.

The project shall maintain a H&S Program designed to minimize and control risks to reduce the number of injuries and illnesses, with an ultimate goal of zero accidents and injuries. The H&S Program shall be equal or superior to the standard practices of the industry, and shall provide the appropriate supervision, training, and protective equipment to keep its employees safe and healthful.

Finally, management and staff share responsibility for H&S; all levels are accountable for specific H&S activities. Participation by each site employee is crucial to the overall success of the H&S Program.

1.1.2 Principles

In support of Total's Health Safety Security Environment (HSSE) Quality Charter the following principles will be incorporated:

- Design and operate our facilities to ensure operational safety, optimize resource conservation, reduce waste and emissions, and minimize adverse impact on health and the environment.
- Comply with applicable laws, regulations, codes, and standards, and provide monitoring to ensure compliance.
- Seek continual improvement in health, safety, security, environmental and quality performance with a vision to eliminate accidents and incidents.
- Protect employees, assets, information, and corporate reputation by maintaining comprehensive security systems.
- Establish HSSE quality management systems that include promoting practices beyond regulatory compliance, routine evaluation of system performance and a framework for setting HSSE quality goals, objectives, and targets.
- Integrate the principles of sustainable development into our decision-making.
- Choose suppliers, partners, and contractors that share and adhere to our principles.

- Produce, market, and distribute only those products that, when properly used, will not pose an unacceptable risk to health and the environment while practicing effective product stewardship.
- Communicate to employees, contractors, customers, and the public any known hazards of our products and operations.
- Encourage listening, mutual support, and the sharing and communication of good practices while promoting transparency among stakeholders.
- Support and encourage innovative technology and research programs that promote good science and seek reasonable solutions to HSSE quality challenges.
- Review and test emergency procedures to ensure a prompt and effective response.

The following additional principles are incorporated into site-specific H&S program:

- Occupationally caused injuries and illnesses are preventable.
- Preventing occupationally caused injuries and illnesses is one of our highest responsibilities.
- Management is committed to providing safe working conditions in the office and in the field.
- Appointing well-qualified safety and health personnel who have the authority to make site safety and health decisions.
- Employees have a right to information and training.
- Employees have a right to the results of any H&S inspections or accident investigations conducted.
- Employees have a right to discuss any H&S-related concerns or issues with H&S staff or project management at any time and without fear of reprisal.
- Working safely is a condition of employment and is a shared responsibility between management and staff.
- Injuries and exposures are to be mitigated, managed, and prevented.
- Selecting PPE based on accurate, site-specific job hazard analysis.

1.2 INTRODUCTION

Safety is a core value for Total and is the responsibility of each project employee. Successful relationships in the context of remediation and construction projects are not just a matter of chance. It is the clear and consistent focus on the commitment, collaboration, transparency, and communications needed for success, and relentless efforts to equip and support the field teams

to work in this way that yield positive results. Clarity of purpose, leadership through all levels, respect for each other's roles, and sharing of expertise and learning are not of themselves costly or esoteric but they have been shown to be invaluable for forging effective relationships. Ultimately, however, the successful implementation of the H&S Program depends upon the active focus on the human relationships and ways of integrated activities of managers, H&S staff, and employees. Specific responsibilities are outlined in Section 2.

1.3 SCOPE AND CONSIDERATIONS

A primary consideration for all of operations is the H&S of project personnel. The protection of the public and the environment is also an important consideration in developing and implementing the H&S Program. The application of standardized H&S procedures by trained personnel reduces the possibility of injury or exposure. To be effective, H&S procedures must be:

- Based on available and current information, operational principles, and technical guidance
- Adjustable to site- or task-specific situations and conditions
- Understandable, feasible, and appropriate for site conditions
- Available to site personnel who have been briefed on their use
- Performed, implemented, and used by individuals appropriately trained.

The prevention of occupational injuries and illness is of such consequence that it will be given precedence over project operations always. To the greatest degree possible, project management will provide all mechanical and physical facilities required for personal H&S in keeping with the required standards, the most current professional practices, and applicable regulations.

The project requires management and employee cooperation in all H&S matters. Only through such a cooperative effort can an H&S Program in the best interest of all be established and maintained.

Throughout the course of the remediation project, each Contractor's Company-Specific Health and Safety Plan must provide accurate, detailed descriptions of the contractor's safety and health practices at the site. Boilerplate documents shall be avoided. After the HASP has been implemented, the effectiveness of the control measures selected shall be evaluated.

1.4 APPLICABLE HEALTH AND SAFETY REQUIREMENTS

All contractors are responsible for achieving compliance with applicable Occupational Safety and Health Administration (OSHA) and Client-specific requirements. The following sections describe, at a minimum, these regulations and requirements.

1.4.1 Total's Twelve Golden Rules

Total places great emphasis on the Twelve Golden Rules for Safety (the "Golden Rules"). These are the minimum mandatory safety standards, and which must be strictly abided by always. The Golden Rules for safety at work are intended to be shared and must be fully understood and obeyed by everyone. They are expressed as "musts" and "must nots" to ensure consistent application and make sure there is no chance for misunderstanding. The rules are intended for the people who organize work, the people who carry it out, and the people who inspect it. They are based on systematic processes for identifying, assessing, and managing risks. They are one component of an appropriate identification and sanction policy.

The Golden Rules will be integrated into the management and operations before and during project execution. This integration will ensure each employee working onsite will be provided an orientation explaining the Golden Rules and which apply to the work conducted. A copy of the Total Golden Rules brochure is provided in **Appendix B** and Total's Golden Rules are listed below in order:

Rule 1 - High Risk Situations

You Must Not:

- Smoke outside designated areas.
- Work or drive under the influence of alcohol.
- Work or drive under the influence of drugs.

You Must:

- Assess all risks prior to the start of non- routine or complex operations in downgraded situations.
- Report all downgraded situations to management, monitor them, take appropriate measures to mitigate the risks and formally notify the personnel concerned.
- Follow start-up and shutdown procedures and check progress.

Rule 2 - Traffic

You Must Not:

- Exceed the speed limit and authorized driving time.

- Use a mobile phone while driving, even with a hands-free kit.

You Must:

- Check condition and conformity of vehicles and machinery before use.
- Wear your seat belt.
- Use designated pedestrian paths/sidewalks and hold the handrail when taking the stairs.

Rule 3 - Body Mechanics and Tools

You Must Not:

- Use defective tools or tools not intended for the task or the area where the work is being performed.
- Use a tool, including those for pressure tests, under conditions that exceed the manufacturer's specified design limits.

You Must:

- Use the tools specified in the work permit or procedures and adapt your body mechanics to the tool rating and repetitive nature of the task.

Rule 4 - Protective Equipment

You Must Not:

- Cross a barrier or reposition protective equipment without authorization.

You Must:

- Wear the designated personal protective equipment (PPE) for the area and task and check its condition before use.
- Wear a life jacket whenever required.
- Report any damage or malfunctioning of safety barriers.

Rule 5 -Work Permits

You Must Not:

- Perform any work without an approved work permit.

You Must:

- Assess risks before starting work.
- Use any required additional permits.

- Re-issue a work permit if the conditions on the original permit change or the work procedure is modified.

Rule 6- Lifting Operations

You Must Not:

- Walk or stand under a suspended load.

You Must:

- Perform a risk assessment, implement the lift plan and clearly mark out the area.
- Ensure all lifting equipment and gear is fit for purpose, in good condition and regularly inspected.
- Check that the load is securely slung and bundled.
- Designate a signaler and control the moving load at all times.

Rule 7 - Work on Powered Systems

You Must Not:

- Begin any work until you have checked that all energy and fluid sources have been isolated, (unless you are specifically authorized to do so).

You Must:

- Assess risks before starting work.
- Use any required additional permits.
- Re-issue a work permit if the conditions on the original permit change or the work procedure is modified.

Rule 8 - Confined Spaces

You Must Not:

- Enter a confined space without checking isolations and all atmospheric hazards.

You Must:

- Cover suffocation, falls, explosion, crushing, drowning and other risks in the specific work permit.
- Ensure that you will be continuously monitored.
- Have and emergency response and rescue plan.

Rule 9 - Excavation Work

You Must Not:

- Place machinery or spoil piles within 1 meter of a trench being excavated.

You Must:

- Perform excavation work with a permit comprising a map of all buried hazards.
- Apply precautions for work in confined spaces, as necessary.
- Clearly mark all excavation areas and identify underground structures.

Rule 10 - Work at Height

You Must Not:

- Work under or near power lines without respecting the minimum safe clearance distance.
- Work on building or tank roofs without first checking their integrity and ensuring that the appropriate protective devices have been installed.
- Move a deployed mobile elevated work platform (MEWP), unless you are specifically authorized to do so.

You Must:

- Put away tools when working at height (above 2 meters).
- Use a safety harness that is safely anchored, outside fixed barriers or in an MEWP.
- Use scaffolding that is fit for purpose and has been inspected.

Rule 11 - Change Management

You Must Not:

- Make technical or organizational changes without getting prior authorization.

You Must:

- Have a risk assessment and apply mitigation measures.
- Give workers appropriate training and update all relevant documentation.

Rule 12 - Simultaneous Operations or Co-Activities

You Must Not:

- Perform simultaneous operations or co-activities without completing a preliminary field check.

You Must:

- Conduct a risk assessment with the personnel concerned.
- Increase supervision and appoint a duly authorized coordinator.

Contractors and subcontractors shall ensure that the relevant golden rule(s) are explicitly cross-referenced against the task/activity whenever they prepare and produce Job Safety Analyses (JSAs).

1.4.2 Federal

The following Federal regulations are applicable:

- 29 CFR 1910, OSHA Safety and Health Standard for General Industry
- 29 CFR 1904, OSHA Recording and Reporting Occupational Injuries and Illnesses
- 29 CFR 1926, OSHA Safety and Health Standards for the Construction Industry
- 29 CFR 1926.605, OSHA Motor Vehicles, Mechanized Equipment, and Marine Operations
- 40 CFR Section 35.6015(a) (21) Health and Safety Plan

1.5 PROGRAM ELEMENTS AND OBJECTIVES

The objective of the H&S Program is to reduce the number of accidents, injuries, exposures, and illnesses to an absolute minimum. Our goal is zero accidents, exposures, and injuries.

Specific elements that form the foundation of the H&S Program include the following:

Employee Health Surveillance. This includes the administration of baseline and annual/interim physical examinations for employees involved in hazardous waste work and project- and material-specific biological monitoring. The project aims to maintain a workplace free from the use of illegal drugs and alcohol.

H&S Education and Training Program. This is a continuous program designed to promote hazard recognition and accident/illness prevention as well as to familiarize each employee with pertinent government regulations. In addition, this program is designed to address potential specific hazards of tasks that employees may be assigned to perform.

Employee Exposure Assessment to Potential Chemical and Physical Hazards. This includes a review of tasks, both administrative and project-related; to ascertain hazard potentials to those individuals assigned to perform those tasks and to take appropriate actions designed to minimize those hazard potentials. This site-wide HASP describes hazard potentials, prescribes

specific procedures, and PPE designed to minimize these potentials, and determines types of specific monitoring that may be required to ascertain the effectiveness of these efforts in minimizing these hazards.

Integral aims to:

- Ensure that employees assigned to specific tasks are mentally and physically able to perform those tasks.
- Ensure that individuals required to wear PPE in the performance of specific tasks can wear such prescribed equipment and that they have been trained in the selection, use, and maintenance of such equipment.
- Provide a mechanism by which employees assigned to various tasks have been trained in the proper performance of these tasks.
- Provide a mechanism for monitoring specific hazard potentials and the effectiveness of procedures and PPE in minimizing those potentials.
- Perform regular and frequent proactive safety inspections to identify potential hazards before an accident or injury happens.
- Provide an integrated H&S Program for site contractors to provide employees comprehensive protection from site hazards.
- Incorporate the American National Standards Institute (ANSI)/American Industrial Hygiene Association's (AIHA) Z10, Occupational Health and Safety Management System's quality concept of "Plan-Do-Check-Act" into the site H&S management approach. Utilizing this concept will allow the project to maintain a continual improvement cycle within its H&S Program. These improvements are expected to be realized by the reduction of onsite hazards and risks in a systematic manner.

1.6 EMPLOYEE PARTICIPATION AND RECOGNITION

Worker participation is meaningfully engaging workers at all levels in establishing, implementing, evaluating, and improving safety and health in the workplace. This means workers understand they are a valuable partner in making their workplace safer and are encouraged and able to communicate with management about hazards on the job. Workers are the experts when it comes to the tasks they do and the tools and equipment they use, which makes them a key resource for knowledge and innovative ideas that can improve safety and health. Recognizing workers or teams for their contributions to workplace safety is an important element to creating a strong safety culture. Positive feedback is a crucial driver for motivating employees and contractors, both individually and collectively, to continuously improve HSE performance. Total's approach to HSE Recognition is included in **Appendix C.**

1.7 IMPLEMENTATION

Design of the H&S Program is the responsibility of Integral; however, all contractors and site workers are responsible for complying with the requirements of the overall site HASP and contractor's component-specific HASP, and are critically important to a successful implementation of the H&S Program. Employees shall follow the more stringent practices when multiple requirements apply.

1.8 STOP WORK AUTHORITY

Stop Work Authority (SWA) establishes the responsibility and authority of any individual to stop work when an unsafe condition or act could result in an undesirable event. In general terms, the SWA process involves a stop, notify, correct, and resume approach for the resolution. Total has an established Stop Work program and all site personnel will be trained in the use of the Stop Work Authority if they observe potentially unsafe conditions or activities. STOP cards will be issued to personnel after completion of Total's Stop Work Authority training. Alternatively, Total has developed a Golden Rules app, that includes an electronic version of the Stop Card, which all site personnel are encouraged to download and use. Total will provide a training video to the selected contractor for training of all site employees. Total's Stop Work guidance and manual is provided as **Appendix D.**

A Stop Work can come in many forms. It can be as simple as reminding a fellow employee that they are not wearing the proper PPE before proceeding into the work area, or they can be as significant as noticing a critical error in safety planning or procedure that could save a life. It is critical that all personnel who come in site recognize that they possess stop work authority. If there is a potential safety issue, no matter how minor, it is the responsibility of everyone to speak up immediately. Situations that may initiate the use of Stop Work include:

- Unsafe conditions
- An Incident occurs
- Significant near-miss
- Emergency situation
- Alarm sounds
- Change in conditions
- Change in scope of work
- Rapid change in weather
- Change in work plan
- Anytime anyone feels that personnel, the environment, or equipment is at risk.

In the case of stop works, the following procedures will be implemented on site:

- All stop works, regardless of severity will be reported to LSS in a timely manner so that they can be documented. If the stop work is of a severity that it requires that remaining activities within an active work area need to be suspended, all activities will be suspended in as timely a manner as appropriate to ensure that no additional hazards are created. The personnel calling for the stop work will notify their supervisor as soon as practical.
- Once the reason for the stop work has been appropriately communicated, all personnel will work together to find an acceptable solution to the issue at hand. Field changes will be made to the JSA, JSAP, or HASP as needed to ensure that the hazard is appropriately addressed and signed off by LSS. The change will be communicated to all on site personnel and agreed upon by all site parties. Work will not resume until the hazard(s) have been identified, changes made and documented, and all changes communicated to all field crews. The appropriate report (i.e. an anomaly report) will be filed by the HSO and provided to LSS. All on site contractors and subcontractors will follow RETIA USA's Near Miss and Incident Reporting protocols attached as **Appendix E**.

1.9 COVID-19 FIELD MANAGEMENT PLAN

The emergence of the SARS-CoV-2 virus in late 2019, and subsequent COVID-19 respiratory illness pandemic, requires separate consideration and advanced planning. It is important that the latest CDC guidance is adhered to at all times during the work. Safe work practices that will underpin activities and responsibilities in the field include at a minimum: screening employees at the start of the day for fever, maintaining physical distancing of 6 ft, wearing face masks where close contact is required, and employing robust hand hygiene. In each step of the sampling program, including mobilization, fieldwork, and demobilization, we must consider how best to ensure that field staff, including subcontractors, are physically distant from one another. With that in mind, project managers and field team leaders need to be prepared to develop new sampling protocols and altered logistics that may involve the following:

- Sequenced and staggered work practices
- Estimations of how far ahead certain steps in the sequenced process should be before the next one is initiated
- Additional logistics to secure laboratories and other subcontractors if there are capacity issues or delays due to COVID-19
- Additional logistics to obtain supplies and deliver samples to couriers or the laboratory

- Schedule delays due to sampling and logistics modifications that may increase budgets along with additional communications with the client to discuss these needs and expectations
- Increased communications with the field team to talk through and potentially modify sampling plans in real-time.

Additional details on Integral's COVID-19 plan are presented in **Appendix U**.

1.10 OBJECTIVES AND METHODS

The primary objective of the pre-design investigation is to fill data gaps in and adjacent to the Arkema Project Area. The objectives include the following:

- Assess current concentrations of DDx[2], polychlorinated dibenzo-*p*-dioxins/furans (PCDD/Fs), and polychlorinated biphenyls (PCBs) in surface and subsurface sediment in the Arkema Project Area and in the navigation channel adjacent to the Arkema Project Area.
- Measure total dissolved carbon and volatile organic compounds (VOCs) in porewater sediment in support of sediment cap design.
- Evaluate potential nonaqueous-phase liquids in subsurface sediments in the Arkema Project Area.
- Assess DDx, PCDD/Fs, and PCBs in riverbank soils adjacent to the Arkema Project Area.
- Evaluate geotechnical parameters in sediment throughout the Arkema Project Area and in riverbank soils adjacent to the Arkema Project Area.
- Assess sediment stability downstream of Dock 2.
- Assess any current groundwater discharge to the Willamette River adjacent to the Arkema groundwater barrier wall and pump-and-treat source control measure.

To meet these objectives, field activities may include the following:

- Surface sediment sampling using a PowerGrab sampler (or similar device), subsurface sediment sampling using a vibracore sampler (or similar device), sonic drill rig equipped with an Osterberg sampler, and mud-rotary drill rig equipped with split spoon and Shelby tube samplers. Sediment samples will be collected at 1-ft intervals to total depth (anticipated to be 15 ft below mudline for the vibracores and 25 ft below mudline for the sonic and mud rotary rigs), or refusal, whichever comes first.

[2] DDx is the total of 2,4'- and 4,4'- dichloro-diphenyl-dichloroethane, dichloro-diphenyl-dichloroethene, and dichloro-diphenyl-trichloroethane.

- Riverbank soil sampling using an excavator and hand auger.
- Porewater sampling using a Trident Probe™ (or similar device).
- Deployment of seepage meters by professional divers to assess groundwater discharge.
- Installation of riverbank piezometers, deployment of pressure transducers, and collection of groundwater samples to assess groundwater discharge.

This HASP does not include dive plans. Dive plans will be submitted to the U.S. Environmental Protection Agency (EPA) for review 4–6 weeks prior to initiating field work. Additional details on the field methods are presented in the field sampling plan (FSP), Appendix A to the Pre-design Investigation Work Plan.

2 ORGANIZATION AND PERSONNEL

2.1 HEALTH AND SAFETY ORGANIZATION

Responsibility for H&S is shared by all levels of the project. This overarching H&S Program has been developed for this specific project. To administer the H&S Program effectively, each entity shall be integrated into the overall H&S project framework.

2.2 HEALTH AND SAFETY ROLES AND RESPONSIBILITIES

Successful implementation of the H&S Program requires dedication and participation from all entities and employee levels of the project organization. A list of key contacts is provided in the "Key Project and Safety Information" section at the beginning of this HASP and in **Appendix F**.

All Integral personnel, subcontractors, or consultants and visitors on this site must comply with the requirements of this site-specific HASP. The specific responsibilities and authority of management, safety and health, and other personnel on this site are detailed below.

2.2.1 LSS (Agent for Owner, Arkema Inc.)

As noted in Section 1, Arkema Inc. is the owner of the property at 6400 NW Front Ave., and LSS, as agent for Arkema Inc., is responsible for overseeing safety and risk management activities at the Arkema site and Arkema Project Area. LSS's H&S responsibilities include:

- Recognizing the supply chain will take its lead from the Client in terms of the matters to prioritize, the spirit in which work is carried out, the ways parties interact, and people behave.
- Provide leadership, vision and direction on all matters relating health and safety, being clear on requirements and objectives from the outset as well as roles and responsibilities.
- Appoint competent Consultants and Contractors, who fully understand the health and safety risks that are likely to arise from the project. Routinely assess safety performance of all Contractors and Consultants and their personnel, replacing any non-performing companies.
- Share information about possible health and safety risks on the site.
- Carry out periodic inspections and audits (or appoint a third party to perform such duties) to confirm that HSE arrangements are adequate, effective, and reliable.
- Assisting project contractors in the coordination of planned activities.

- Visible and active commitment to HSE, integrating good health and safety management with decision making.
- Be a visible champion of Health & Safety, actively promoting the Golden Rules and strive to foster and develop a positive health and safety culture.

2.2.2 Health and Safety Officer/Site Supervisor

The SHSO/SS has full responsibility and authority to implement this HASP and to verify compliance. The SHSO/SS reports to the project manager and is onsite or readily accessible to site personnel during all work operations. The SHSO/SS is responsible for assessing site conditions and directing and controlling emergency response activities. The specific responsibilities of the SHSO/SS include:

- Managing the safety and health functions on this site.
- Serving as the onsite point of contact for safety and health concerns.
- Assessing site conditions for unsafe acts and conditions and ensuring corrective action.
- Ensuring that all Integral employees and subcontractors understand and follow the site-specific HASP.
- Ensuring that daily work schedules and tasks are reasonable for the required levels of effort and weather conditions.
- Confirming local emergency response phone numbers and locations.
- Conducting and documenting the initial and daily or periodic health and safety briefings.
- Evaluating and modifying the level of protective apparel and safety equipment, based on site conditions.
- Ensuring that the field team observes all necessary decontamination procedures.
- Executing the fieldwork in accordance with the work plan.
- Recommending changes to the work plan if necessary because of unexpected site conditions (e.g., inaccessible sample locations, poor sample recovery).
- Conducting inspections on a weekly basis to determine the effectiveness of the HASP. The weekly inspections will include an assessment of all activities at the site. If any deficiencies in the health and safety protocols are observed, the SHSO/SS will lead a health and safety meeting with the field crew to discuss how the deficiencies will be corrected. The inspection results, including any modifications to the HASP to address deficiencies, will be documented in the field logbook.

If the SHSO/SS determines that site conditions are unsafe, he or she has the authority to suspend field operations until the problem is corrected. The SHSO/SS can modify site-specific HASP procedures in the field. Any changes must be documented in the field logbook, and field staff must be immediately informed of the change. The project manager and Integral's CHSM must be notified by phone or email within 24 hours of any major changes to this HASP.

2.2.3 Project Manager

The project manager has overall responsibility to ensure that personnel working onsite are safe. The specific responsibilities of the project manager include:

- Ensuring that a site-specific HASP is developed prior to the fieldwork or site visit
- Reviewing and approving the HASP prior to the fieldwork or site visit
- Ensuring employee understanding of and compliance with the HASP.

2.2.4 Corporate Health and Safety Manager

The CHSM provides guidance to the project manager and SHSO/SS on HASP preparation and reviews and approves the site-specific HASP. The CHSM also serves as an arbitrator if there is a conflict between the project manager, SHSO/SS, and field personnel. In addition, the CHSM[3] conducts periodic unannounced audits of Integral field operations, to ensure compliance with the HASP.

2.2.5 Field Personnel

All Integral personnel and subcontractors on this site are responsible for reading and complying with this HASP, using the proper PPE, reporting unsafe acts and conditions, and following the work and safety and health instructions of the project manager and SHSO/SS. All Integral personnel, subcontractors, and consultants can and are encouraged to suspend field operations if they feel conditions have become unsafe.

2.2.6 Site Workers

Site workers are responsible for complying with this HASP, using the proper PPE, reporting unsafe acts and conditions, and following the work and safety and health instructions of the project manager and SHSO/SS. All site workers have the authority and are encouraged to suspend field operations and leave the environment if they feel conditions have become unsafe.

[3] The audit task may be delegated to an office health and safety representative by the CHSM.

2.2.7 Divers

The seepage meters will require the use of divers to deploy and retrieve the samplers. All diving activities will be performed by professional diving subcontractors with appropriate training, certification, and experience. The selected diving subcontractor is solely responsible for diver safety and associated dive planning and documentation. **This HASP does not cover dive activities.** All dives will be conducted in dry suits. A dive plan will be prepared by the diving subcontractor and submitted to EPA for review 4–6 weeks prior to initiating the fieldwork.

2.3 SITE DESCRIPTION

The Arkema facility is located in Portland, Oregon, on the northwest bank of the lower Willamette River between approximately river miles 6.90 and 7.6. River stage and currents at the Portland Harbor site are influenced by hydrologic conditions in both the Willamette and Columbia rivers, and are further affected by the operations of federal and non-federal dams along these two rivers. Tidal fluctuations of up to approximately 3 ft per day were observed at the Arkema site during the 2009 engineering evaluation and cost analysis sediment investigation. A period of relatively high Willamette River stage occurs from late May through June when the Willamette River discharge to the Columbia River is restricted by high flows in the Columbia River that are associated with the spring freshet, as a result of snowmelt in the much larger Columbia River watershed. Under certain river stage, flow, and flood tidal conditions, typically in the late summer and fall, the influence of the Columbia River causes periodic slack water and flow reversals in the lower portion of the Willamette River.

The upland portion of the site encompasses approximately 54 acres of land. The Arkema Project Area is located from the riverbank to the navigation channel between approximately river miles 6.90 and 7.6 and is approximately 25 acres in size. The scope of work covered by this HASP also includes the riverbank and the portion of the navigation channel adjacent to the Arkema Project Area. The facility is located within the heavy industrial sanctuary of northwest Portland. Specific information on the site is presented below:

- **Owner:** Arkema Inc.
- **Current site use:** Inactive industrial, environmental remediation and monitoring are ongoing
- **Hazardous waste site**[4]: Yes
- **Industrial waste site:** Yes
- **Topography:** Generally level with steep banks along river

[4] As defined in 29 CFR 1910.120

- **Site access:** Private, access gate off Front Avenue
- **Site activity:** Inactive, except for environmental remediation and monitoring
- **Nearest drinking water/sanitary facilities:** Office building at Front Avenue gate
- **Nearest telephone:** Cell phone coverage is available across the site.
- **Size of upland portion of site:** 54 acres
- **Potential pathways for hazardous substance dispersion:** Direct contact/absorption, inhalation, incidental ingestion.

A detailed site map is provided in **Appendix A** to this HASP.

3 CHEMICAL AND PHYSICAL HAZARD ANALYSIS

This section describes the chemical and physical hazards identified for the proposed activities within the Arkema Project Area.

3.1 CHEMICAL HAZARD ASSESSMENT

The following table lists the historical maximum constituent concentrations (aqueous and solid) for constituents at both the upland site and in-water Arkema Project Area. The table lists the properties of decontamination chemicals that may be used at the site (i.e., hexane). The table also lists the chemical properties and OSHA's permissible exposure level (PEL), short-term exposure level (STEL), and immediately dangerous to life and health (IDLH) level. Some chemicals in sediment may volatilize or become airborne dust and enter the field crew's breathing zone and be inhaled. Breathing zone air can be monitored to ensure that the chemicals do not exceed the PEL. If any of the chemicals exceed the PEL, immediate action is required (e.g., don respirators, leave site) as designated in Section 6.10.1. In addition, small quantities of acids will be used to preserve selected aqueous samples.

Chemicals of Concern

Chemical of Concern	In-Water Concentration (site maximum)	Medium	OSHA PEL	MCL (mg/L)	OSHA IDLH	Odor Threshold	IP(eV)	Carcinogen or Other Hazard
Chlorobenzene	64 mg/L 35 mg/kg	GW Sed	75 ppm	0.1	1,000 ppm		9.07	
Perchlorate	367 mg/L 274 mg/kg	GW Sed	--	--	--			
Total Chromium	0.122 mg/L 95.8 mg/kg	GW Sed	0.5 mg/m^3	0.1	250 mg/m^3			
Chloride	89,700 mg/L ND	GW Sed	--	250	--			
Sodium	58,650 mg/L 57,800 mg/kg	GW Sed	--	--	--			
Chloroform	770 mg/L 0.12 mg/kg	GW Sed	2 ppm	--	500 ppm		11.42	Ca
Tetrachloroethylene	1.4 mg/L 0.008 mg/kg	GW Sed	100 ppm	0.005	150 ppm	4.68–50 ppm	9.32	Ca
Lindane (gamma hexachlorocyclohexane)	0.36 mg/L 0.43 mg/kg	GW Sed	0.5 mg/m^3	0.0002	50 mg/m^3			
4-4'-DDD	0.71 mg/L 690 mg/kg	GW Sed	--	--	--			
4-4'-DDT	1.9 mg/L 4,500 mg/kg	GW Sed	0.5 mg/m^3	--	500 mg/m^3			Ca

Chemical of Concern	In-Water Concentration (site maximum)	Medium	OSHA PEL	MCL (mg/L)	OSHA IDLH	Odor Threshold	IP(eV)	Carcinogen or Other Hazard
Acetone	1.3 mg/L 0.14 mg/kg	GW Sed	250 ppm	--	2,500 ppm	13–100 ppm	9.69	
Trichloroethene	2.3 mg/L 0.0038 mg/kg	GW Sed	100 ppm	0.005	1,000 ppm	21.4–28 ppm	9.45	Ca
4,4'-DDE	0.013 mg/L 24 mg/kg	GW Sed	--	--	--			Ca
Total Xylenes	0.00228 mg/L 0.063 mg/kg	GW Sed	100 ppm	10	900 ppm		8.44–8.56 (based on isomers)	
1,2-Dicholorobenzene	0.110 mg/L 0.042 mg/kg	GW Sed	50 ppm C	--	200 ppm		9.06	
Methylene Chloride	520 mg/L 0.00088 mg/kg	GW Sed	25 ppm	--	2,300 ppm	25–250 ppm	11.32	Ca
1,4-Dichlorobenzene	0.15 mg/L 0.045 mg/kg	GW Sed	75 ppm	--	150 ppm		8.98	Ca
1,3-Dichlorobenzene	0.001 mg/L 0.031 mg/kg	GW Sed	--	--	--			
2-Butanone	0.26 mg/L 0.031 mg/kg	GW Sed	200 ppm	--	3,000 ppm		9.54	
beta-Endosulfan	0.00019 mg/L 0.235 mg/kg	GW Sed	--	--	--			

Chemical of Concern	In-Water Concentration (site maximum)	Medium	OSHA PEL	MCL (mg/L)	OSHA IDLH	Odor Threshold	IP(eV)	Carcinogen or Other Hazard
1,1,1-Trichlorethane	0.00012 mg/L ND	GW Sed	350 ppm	0.2	700 ppm	20–400 ppm	11.00	
1,1-Dichloroethane	0.32 mg/L 0.00036 mg/kg	GW Sed	100 ppm	--	3,000 ppm	200 ppm	11.06	
Benzene	1.6 mg/L 0.72 mg/kg	GW Sed	1 ppm (5 ppm STEL)	0.005	500 ppm	4.68–12 ppm	9.24	Ca
Chloromethane	0.032 mg/L 0.00086 mg/kg	GW Sed	100 ppm	--	2,000 ppm		11.28	Ca
Chloroethane	0.14 mg/L 0.0009 mg/kg	GW Sed	1,000 ppm	--	3,800 ppm		10.97	
Toluene	0.38 mg/L 0.021 mg/kg	GW Sed	200 ppm	1	500 ppm	0.17–2.9 ppm	8.82	
n-Hexane	NA	Decon solvent	500 ppm	--	1,100 ppm	130 ppm	10.18	F
Sudan IV (hydrophobic dye)	NA	Powder	--	--	--	--	--	Irritant and possible mutagen

Notes:

--	none established	MCL	maximum contaminant level
Ca	carcinogen	NA	not applicable
Cor	corrosive	ND	not detected above detection limits or not analyzed
Decon	decontamination	PEL	permissible exposure level
F	flammable	ppm	parts per million
GW	groundwater	Sed	sediment
IDLH	immediately dangerous to life and health	STEL	short-term exposure level
IP(eV)	ionization potential (electron volts)		

The table below summarizes the chemical characteristics and potential chemical exposure routes for the project.

Chemical Characteristics and Exposure Routes

	Likely	Possible	Unlikely
Potential Chemical Exposure Routes			
Inhalation		X	
Ingestion		X	
Skin absorption		X	
Skin contact		X	
Eye contact		X	
Chemical Characteristics			
Corrosive			X
Flammable	X (hexane)		X (project area chemicals)
Ignitable			X
Reactive			X
Volatile	X		
Radioactive			X
Explosive			X
Biological agent			X
Particulates or fibers			X

If Likely, Follow These Safety Protocols

Chlorobenzene is volatile. All sampling activities will be conducted in well-ventilated areas, and air monitoring for organic vapors will be conducted periodically with an organic vapor monitor (OVM) (see "Air Monitoring" section). Hexane is volatile and flammable. Wear appropriate PPE when handling or using acetone and always use it in a well-ventilated area, preferably outside while standing upwind of the operation. Keep away from ignition sources.

3.2 PHYSICAL HAZARD EVALUATION

The following table presents physical hazards that are expected to be present during field activities.

Potential Physical Hazards during Field Activities

Possible Hazard	Proposed Safety Procedure
Heavy equipment (e.g. excavator, boat, drill rig)	Stay back from operating equipment; wear safety vest and hard hat; coordinate and maintain eye contact with equipment operator at all times.
Material handling	Lift properly; seek assistance if necessary; do not overfill coolers or boxes. Seek assistance if drums must be moved.
Adverse weather	Check weather forecast prior to commencing work; seek shelter during electrical storms; do not work in adverse weather conditions without proper training and equipment.
Uneven terrain/tripping	Use caution; wear properly fitting shoes or boots; keep work area orderly.
Noise	Wear hearing protection when working around heavy equipment and other noise sources.
Excavations	Do not enter excavations greater than 3 ft in depth without evaluation by a qualified person and implementation of applicable trenching and excavation safeguards as required by law.
Heat stress	Follow heat stress information (**Appendix S**). *Note:* potential for heat stress will depend on season and location of the site.
Cold/hypothermia	Keep warm and dry; bring changes of clothes; do not work in extreme conditions without proper equipment and training. Follow cold stress information (**Appendix S**). *Note:* potential for cold/hypothermia will depend on the season and the location of the site.
Falling objects	Wear hard hat at all times esp. near overhead hazards (e.g., winch).
Water hazards	Wear a U.S. Coast Guard (USCG)–approved personal flotation device (PFD) at all times whenever working within a boat or working over water greater than 6 in. deep. Inspect PFDs prior to use; do not use defective PFDs. Keep sampling equipment on boats organized at all times. Boats are required to be equipped with a fire extinguisher, warning horn, and a throwable life ring. Each field member must be briefed on the storage location of these safety items on the first day of the field event. Additional requirements are presented in **Appendix S** (safety guideline SG-16).
Vessel operations	To avoid injuries from heavy equipment, wear the required steel-toe boots when on the work deck or loading/unloading heavy equipment from the vessel. Wear the required hard hat when on the work deck because of the proximity of overhead gear. When sample handling equipment, containers, deck lines, hydraulic cables, and water hoses are not in immediate use, keep them clear of walkways and work areas until needed. Each time sampling operations at a given location have been completed, wash excess sediment on the deck onto the sampling location or, if specified in the FSP (depending on the anticipated level of contamination), containerize in U.S. Department of Transportation (DOT)–approved 55-gallon drums.

Possible Hazard	Proposed Safety Procedure
River Traffic	If required, the USCG will be notified of the schedule and scope of the overwater sampling work. If the USCG deems a notice to other mariners to be necessary, then information will be provided to the USCG to make barge and other river traffic aware of the sampling activities.
Drill rigs	Avoid all pinch points; do not operate or stand near the rig during electrical storms; stay a safe distance (25 ft) from power lines; level the drill rig.

The table below is a summary of potential physical hazards posed by proposed project activities.

Physical Hazards Posed by Proposed Project Activities

Activity	Potential Hazard
Surface and Subsurface Sediment Sampling	Uneven terrain/tripping, heavy equipment, noise, heat stress, cold/hypothermia, material handling, falling objects, adverse weather, vessel operations, and drill rigs.
Riverbank Soil Sampling	Uneven terrain/tripping, heavy equipment, excavations, heat stress, cold/hypothermia, material handling, adverse weather, drowning, noise.
Porewater Sampling	Uneven terrain/tripping, heat stress, cold/hypothermia, material handling, falling objects, drowning, adverse weather.
Groundwater Discharge Study	Uneven terrain/tripping, heavy equipment, noise, heat stress, cold/hypothermia, material handling, falling objects, adverse weather, drowning, drill rigs.
IDW Management	Uneven terrain/tripping, material handling, adverse weather, cold/hypothermia, heat stress, noise, drowning.

4 HEALTH AND SAFETY EDUCATION AND TRAINING

4.1 GENERAL

Ensuring that employees have the appropriate skills, attitude, and knowledge to perform tasks assigned to them safely is a key accident prevention tool. The main goals of the H&S training program are:

- Educate employees on the safety culture, expectations, and resources established in this HASP
- Train employees to be able to identify hazards correctly
- Give employees the technical understanding and skills to work in a safe manner
- Promote safety awareness so that employees develop a safe work attitude
- Meet regulatory requirements
- Reiterate and emphasize the Total Golden Rules

4.2 RESPONSIBILITIES

Managers and Supervisors of all Contractors – Ensure employees are adequately trained to perform assigned job responsibilities safely.

SHSOs for all Contractors – Prepare and coordinate delivery of project-specific information and training for employees on an as-needed basis. Also, assist managers in the tracking of training requirements needed for various types of work.

Employees of all Contractors – Attend and participate in the required training programs and maintain their training credentials to perform their jobs safely and meet H&S training regulatory requirements.

4.3 ON-SITE WORKER TRAINING PLAN

The following sections outline the training requirements for all project employees and is designed to prevent occupational injuries and illness at the site. The site training program is in place to provide employees with the knowledge and resources that result in exceptional employee safety in the workplace.

4.3.1 Hazard/Task-Specific Training

Certain hazards or tasks have specific training requirements and the designation of a competent person that must be met to ensure employee H&S and are required by OSHA standards or Total. The following are examples of such hazards or activities that require special training:

- General Safety
- Health & Environments
- PPE
- Material Handling
- OSHA Silica Rule
- Confined Spaces in Construction
- Welding & Cutting
- Electrical
- Scaffolding
- Fall Protection
- Cranes
- Motor Vehicles
- Excavating
- Concrete & Masonry Const.
- Steel Erection
- Tunnels
- Demolition
- Blasting
- Power Transmissions
- Working at height including stairways and Ladders
- Potential exposure to chemical hazards onsite
- Changing work conditions that may indicate a new hazard for employees
- Deck barge safety (https://www.osha.gov/Publications/3358deck-barge-safety.pdf).

Managers and supervisors must ensure that their employees have adequate training to perform all assigned tasks and job responsibilities safely. Managers and supervisors shall consult their contractor's SHSO to decide for employee H&S training for specific tasks and projects.

Hazard/task-specific training shall be provided by each contractor's SHSO (or their designee) or managers/supervisors via onsite courses or arrangements can be made for training through qualified vendors. Employees shall contact their SHSO to decide for a hazard or task-specific training session. Execution requires the contractor to designate a competent to design, inspect or supervise the activity.

4.3.2 First Aid and CPR Training

Each contractor's SHSO shall provide training to their site employees in the availability and locations of first aid kits and materials. There should be at least one first aid and cardiopulmonary resuscitation (CPR) trained employee onsite at all times. Employees should also be familiar with CPR and trained in the use of Automated External Defibrillators (AEDs). Each contractor shall provide on-site first aid kits and materials to its employees in accordance with 29 CFR 1926.50.

4.3.3 Project-Specific Orientation and Tailgate Talks

Employees are greatly influenced by initial impressions. Initial instructions and personal contacts contribute significantly to employee attitudes. Consequently, all new site employees shall receive a site H&S orientation, delivered by their contractor's SHSO or manager/supervisor.

The H&S orientation shall occur during the employee's initial visit to the site. The orientation shall cover the following topics:

- Project's H&S philosophy and principals
- H&S objectives
- Total's Twelve Golden Rules
- Total's STOP WORK Authority
- Key personnel – roles and responsibilities
- Employee H&S performance
- Site-specific H&S information including:
  - Contaminants of concern
  - Exposure mitigation and control measures (e.g., engineering controls, PPE)
  - Emergency notification and evacuation procedures
  - Emergency Response Plans
  - First aid assistance

- Availability of the SHSO
- Hazard identification and communication

Attendance and meeting content for each H&S orientation shall be documented in the contractor's training records and kept onsite.

Site safety meetings must be held before beginning new tasks or when new staff enter the site. The meetings should be held once a week (at a minimum) and daily for complex or high-hazard projects. Tailgate safety meetings must occur every morning during review of the day's work plan, covering specific hazards that may be encountered. Additional meetings must be held at any time health and safety concerns are raised by any site personnel. Attendance and topics covered are to be documented in the field logbook or Field Safety Tailgate Briefing Form (**Appendix T**).

4.3.4 Training for Hazardous Waste Operations

Personnel who perform project hazardous waste work as defined by 29 CFR 1910.120, the OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) Standard, shall participate in hazardous waste H&S training, which includes:

- Forty hours of initial H&S training
- Eight hours of annual refresher training
- Eight additional hours of training for hazardous waste supervisors and managers
- Continuing H&S training.

Contractors who do not have HAZWOPER training, must receive a site H&S orientation, and may only perform work in designated areas. The orientation will identify areas that are off-limits to contractors who do not have HAZWOPER training.

Integral and subcontractor personnel are required to complete the following training prior to working at the site.

Personnel Training Requirements

Task	No Training	24-hour	40-hour[a]	Supervisor[b]	First Aid / CPR[c]	Medical Monitoring
Field Scientists			X	X	X	X
Integral Subcontractors[d]						
Boat operators and crew[e]			X			X
Divers[f]			X			X

Notes:

[a] Must have current OSHA 8-hour refresher if it has been more than a year since the OSHA 40-hour training.

[b] At least one person onsite must have OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) supervisor training if this is a hazardous waste site.

[c] Each onsite Integral employee must be first-aid/CPR trained. If only one Integral staff member is onsite, at least one other worker onsite from another company must also be first-aid/CPR trained, otherwise a second Integral staff member must be made available.

[d] Integral subcontractors and consultants may have requirements that are more stringent than those listed above. These are minimum training and monitoring requirements required to work on this site.

[e] Integral subcontractors and consultants may have requirements that are more stringent than those listed above. These are minimum training and monitoring requirements required to work on this site. The Captain is required to have a current USCG Merchant Mariner Credential.

[f] Divers will also meet all certification and training requirements presented in their dive plan.

4.3.4.1 Initial 40-Hour Hazardous Waste H&S Training

Initial 40-hour hazardous waste H&S training shall be provided via vendors who meet the OSHA HAZWOPER qualifications. Minimum training content must include the basic information relevant to hazardous waste operations required by 29 CFR 1910.120. Training shall be completed by employees prior to engaging in onsite OSHA defined hazardous waste work.

4.3.4.2 8-Hour Hazardous Waste Refresher Training

Personnel actively involved in project hazardous waste activities shall participate in 8-hour hazardous waste refresher training. To remain eligible for field hazardous waste work, employees must attend an 8-hour refresher training class within 13 months (12 months plus 1-month grace period) of the last day of their initial 40-hour training or their last 8-hour refresher training. If the 8-hour refresher training is not completed within the 13-month period, the employee is not eligible to participate in field hazardous waste operations until the 8-hour refresher training is completed and the employee has met all other field H&S requirements (i.e., medical surveillance and fit testing, if necessary).

The 8-hour refresher training requirement may be completed by any of the following:

- Attend an 8-hour refresher class led by a contractor instructor

- Attend an 8-hour refresher class provided by an approved vendor
- Complete a computer-based approved 8-hour refresher curriculum.

4.3.4.3 8-Hour Hazardous Waste Supervisory Training

Personnel who act in a management or supervisory capacity on project hazardous waste activities shall receive an additional 8 hours of training on supervisory and management H&S Program issues in accordance with 29 CFR 1910.120 (e)(4). Topics presented may include:

- H&S requirements for hazardous waste operations
- Project/site HASPs
- Accident/incident reporting and investigation
- Spill prevention and containment
- H&S roles and responsibilities
- Hazard recognition
- Medical surveillance
- Health hazard monitoring
- Transportation of hazardous materials
- Management of investigation derived waste.

Employees who are approved to take the hazardous waste supervisory course must complete the 40-Hour Hazardous Waste H&S course and complete 3 days of on-the-job training on field hazardous waste projects working with a qualified manager. If the training is provided by a vendor, qualifications should be reviewed to determine the training's suitability.

4.3.4.4 Department of Transportation Compliance Training

In accordance with 49 CFR Part 172 (Subpart H), project employees that ship hazardous materials will be certified for DOT "hazmat" training as required. This will include project employees with responsibility for compliance with the U. S. DOT hazardous materials regulations. DOT training will also be required for those who sign shipping papers and/or hazardous waste manifests, prepare and offer materials for transport, or oversee the activities of other hazmat employees. The requirement also encompasses site personnel responsible for hazardous material packaging and container labeling.

4.3.4.5 Continuing H&S Training

Employees may require ongoing training as operations evolve, work environments change, and new hazards are introduced. For example, chemicals or processes that were not anticipated may become part of a standard site work practice. When such events occur, the contractor's SHSO shall implement continuing employee training as is warranted to protect personnel from the identified hazards. It is recommended that one Golden Rule is reviewed and highlighted every month, with monthly safety talks referring to the chosen rule.

4.3.4.6 Competence of SHSOs

SHSOs must have completed (at a minimum) the OSHA 30-hour Construction outreach training program and have at least five (5) years of practical construction site safety experience or three (3) years of construction site experience if the SHSO has one or more of the following formal certifications: Occupational Health and Safety Technologist (OHST), Construction Health and Safety Technician (CHST) or Certified Safety Professional (CSP). Ideally SHSO's shall have First Aid and CPR training.

4.3.4.7 Competence of Marine Personnel

The Captain of the vessel is required to have a current USCG Merchant Mariner Credential.

4.4 MEDICAL SURVEILLANCE AND EVALUATIONS

Each contractor is responsible for developing and implementing a medical surveillance program for their site employees engaged in field work with hazardous substances in accordance with 29 CFR 1910.120. Copies of the physician's written opinion for each employee assigned to work at the project site indicating the employee's fitness for duty to work on a hazardous waste site as defined by 29 CFR 1910.120(f)(7)(i)(A) will be made available for review upon request. Employees performing asbestos removal onsite will comply with the medical surveillance requirements set for in 29 CFR 1926.1101(m).

OSHA requires medical monitoring for a) personnel who are potentially exposed to chemical hazards in concentrations exceeding the PEL for more than 30 days per year, and b) personnel who must use respiratory protection for more than 30 days per year. Integral requires medical monitoring for all employees potentially exposed to chemical hazards.

Will personnel working at this site be enrolled in a medical monitoring program?	Yes	X	No	

4.5 COMPLIANCE MONITORING

The contractor shall monitor their employee compliance with the requirements of this HASP through regular and frequent H&S inspections as discussed in Section 5.6. Subcontractors shall also monitor their employees for compliance with the requirements of their respective component-specific HASP.

4.6 SUBCONTRACTORS

All contractors and subcontractors will adhere to LSS's requirements for new site personnel orientation and site specific "on-boarding" procedures.

Subcontractors are responsible for providing H&S training for their employees. Examples include 40-hour hazardous waste training, supervisor training, 8-hour refresher training and certain continuing training. Verification of any required training shall be submitted by the subcontractor prior to being given a notice to proceed.

In some circumstances, subcontractors may participate in site training. Site H&S orientations will include subcontractors when subcontractor personnel are required to know and understand project hazards and procedures. Any training required to address additional activities, which may expose subcontractor employees to additional hazards, is the responsibility of the subcontractor.

All subcontractors with an annual spend over $40,000 need to be set up and approved in ISNetworld, per RETIA's procedures.

5 HAZARD COMMUNICATION

5.1 PURPOSE AND SCOPE

This H&S Program has been prepared to meet the requirements of the OSHA Standard 1910.1200, Hazard Communication. It includes guidelines on the identification of hazardous chemicals, the preparation and proper use of labels, administration of material safety data sheets (MSDS) or safety data sheets (SDS), and employee training on chemical hazards. Each contractor shall comply with this section's requirements.

5.2 RESPONSIBILITIES

Managers and Supervisors for all Contractors – Managers and supervisors are responsible for ensuring that employees working under their direction receive adequate information on the chemicals and hazardous materials they may use and be exposed to during their project employment.

SHSOs for all Contractors – Maintain chemical inventory and MSDSs for chemicals used by their contractor on the project. They also coordinate MSDS requests from employees and seek guidance from H&S professionals when needed.

Employees for all Contractors – Active participation in the hazard communication training program. Employees are also responsible for asking for information on the chemicals and hazardous materials they may need to use.

5.3 CHEMICAL INVENTORY

Each contractor shall submit a list of chemicals they expect bring on site prior to mobilization and maintain a chemical/hazardous material inventory for chemicals and hazardous materials used at the site. The inventory shall be updated each time a new chemical or hazardous material is brought on site.

5.4 CONTAINER LABELING

Whenever possible, order chemicals and materials in container sizes that are convenient for immediate use and allow use of the manufacturer's label as the primary means of identifying the material and precautions recommended. Labels must remain legible and should not be marked or taped over. If the original label becomes illegible for any reason, the container must be relabeled, or the container and its contents must be properly disposed of.

If materials must be transferred to a container other than the original, the receiving container must be labeled to identify the contents. No unmarked containers of any size should be left unattended.

5.5 MATERIAL SAFETY DATA SHEETS/SAFETY DATA SHEETS

An MSDS/SDS is a summary of safety, health, and environmental information associated with a specific chemical or product. Each manufacturer or distributor is required to provide an MSDS/SDS for materials they manufacture or distribute.

For any material employees use or are potentially exposed to, employees have the right to request a copy of an MSDS/SDS from their contractor's manager/supervisor or SHSO. Each employee who may be exposed to hazardous chemicals when working must be provided information and be trained prior to initial assignment to work with a hazardous chemical, and whenever the hazard changes. Employees should contact their contractor's SHSO with any questions regarding the hazards, storage, disposal, or shipping of chemicals or potentially hazardous materials. Additionally, MSDS/SDSs should be translated to foreign language for non-English speaking employees to understand the hazards of the chemicals they are working with. Copies of the SDSs for project-related chemicals are in **Appendix R**.

5.6 HAZARD COMMUNICATION TRAINING

Each new employee shall have a basic introduction on hazard communication provided during the new employee orientation. The introduction includes:

- An overview of the OSHA hazard communication standard
- Instructions on how to access MSDS/SDSs
- An explanation of how to read chemical labels and MSDS/SDSs

Hazard-specific training shall be provided by each contractor to their employees who may use or be exposed to chemicals or hazardous materials prior to such use or exposure. Training may be conducted during the course of specialized training such as 40-hour OSHA hazardous waste site H&S training and fieldwork pre-job briefings. This training includes:

- A review of chemicals and materials present or anticipated to be present
- Methods and techniques to detect the presence or release of a material in the work area
- Discussion on how to minimize or prevent exposure
- An explanation of the proper use of PPE

6 PLANNING AND HAZARD CONTROL

6.1 APPLICATION AND USE OF HASP

Employees are expected to work in conformance with this site-wide HASP. Each contractor's managers/supervisors and SHSOs are expected to monitor employee performance with respect to H&S activities and to the extent possible, verify that:

- Project team members are aware of and understand the contents of this HASP
- PPE is used as described in this HASP
- Any procedures called for or described in this HASP are followed
- If the component-specific activities involve subcontractors, that subcontractors also verify that their personnel follow the procedures described in this HASP

6.1.1 Acknowledgment and Acceptance of Health and Safety Plan

All site personnel must understand the requirements of this HASP and their component-specific HASP and agree to their provisions. Each contractor is responsible for distributing this HASP and their component-specific HASP to personnel as they are assigned to the project. Subcontractor personnel must also acknowledge and accept the provisions of the site HASP. A Site Health and Safety Plan Acknowledgement form is provided at the front of this document.

6.2 CONTRACTOR PRE-START CHECKLIST

Prior to commencing any work, the Contractor shall complete the Contractor Pre-Start Safety Checklist form and provide to the SHSO for review and verification.

The aim of the checklist is making Contractors fully accountable for their employees and subcontractors complying with the Training, Certification, and PPE requirements at this site. This will ensure RETIA USA's requirements and expectations are understood in advance of work commencing and avoid delays and possible repercussions for workers arriving at the site unprepared or ill-informed on the site requirements.

The checklist shall be sent to all contractors and subcontractors prior to arriving at the site to perform work. The contractor shall complete the checklist, sign, and pass to the SHSO for verification. Once a Contractor has completed this checklist, they will not need to complete it again for subsequent site visits.

The Contractor Pre-Start Safety Checklist form is included in **Appendix I**.

6.3 CRITICAL ANALYSIS OF TASKS

Critical Analysis of Tasks (CATs) is a risk assessment of work activities which includes the identification and analyses of potential human factors that may lead to accidents/hazards for work-specific tasks. This evaluation should be conducted by the work-specific contractors (i.e., RE, CI, O&M) with input from workers/other management involved for all safety-critical site work.

Criticality is defined as the likelihood that a task will go wrong and the consequences of that task going wrong. Determination of the likelihood of a task going wrong should be based on the complexity of the task, probability of failure, and frequency that the task is performed. The CAT process should be completed prior to conducting work tasks and in conjunction with other hazard assessments. The process of identifying CATs should include:

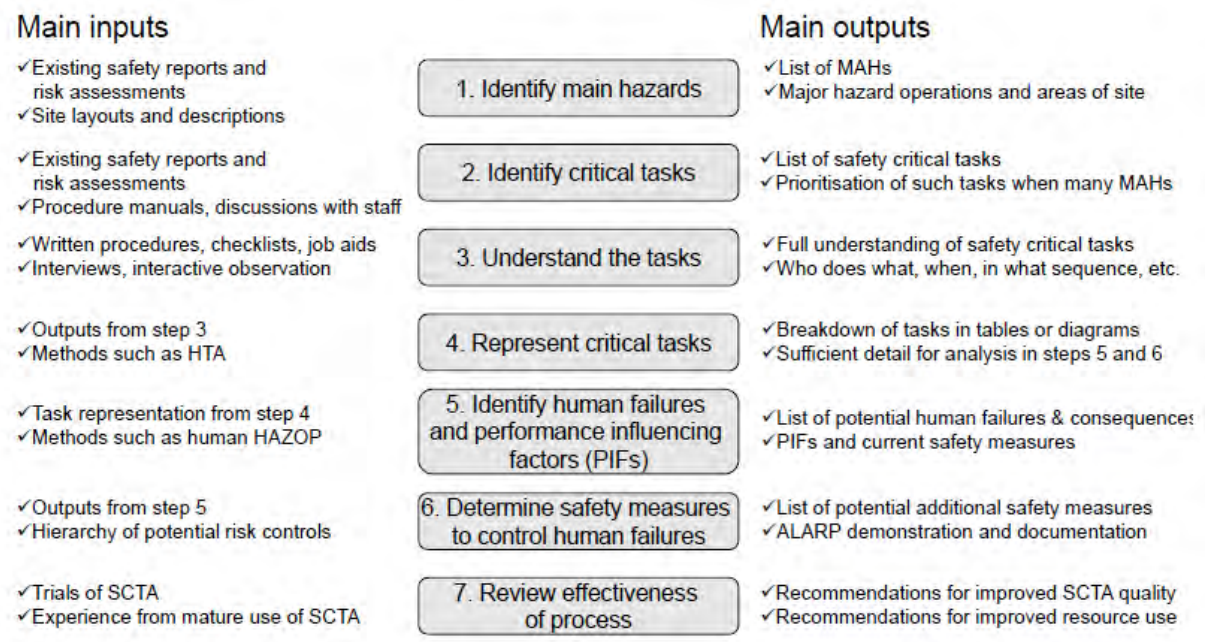
- The determination of which tasks are safety critical,
- The understanding of which human action(s) or interaction(s) have the potential to make failure more likely or serious, and
- The identification and management of safety-critical tasks to reduce the likelihood or consequences of failure.

A CAT assessment shall typically be required prior to undertaking any complex or high-hazard activities, such as, but not limited to, excavation, demolition, confined space entry, working at height, asbestos abatement, high-pressure washing, simultaneous operations, or any activity that LSS deems a CAT is warranted. Fundamentally the CAT assessment is about identifying sensible measures to control the risks in the workplace.

The process of evaluating CATs includes:

- Identification of site-specific work hazards,
- Identify safety-critical tasks,
- Develop a comprehensive description of each task,
- Characterize the safety-critical tasks so that they can by systematically analyzed,
- Identify human failures and performance-influencing factors,
- Determine safety measures to control risk of human failures,
- Review the effectiveness of the process

The visual representation for the CAT process is provided in **Figure 6-1**.



Note: From "Guidance on Human Factors Safety Critical Task Analysis", Energy Institute, London, March 2011.

Figure 6-1. Critical Analysis of Tasks Process

The information from the CATs Analysis is used:

- To generate the JSA
- Share and understand the significant hazards associated with the task
- Monitor the Job to identify any new hazards that may be introduced during or because of the activity the crew is conducting

The CAT's procedure, together with a completed CAT matrix, is included in **Appendix J**.

6.4 JOB HAZARD ANALYSIS

6.4.1 Description of Job Hazard Analysis

A JHA is a valuable tool used to assess risk to personal safety, property, and equipment. It provides a systematic method of evaluating processes or tasks for hazards and ensuring that employees are adequately trained to safely perform job tasks. It is Integral's goal to perform a JHA for all field tasks, whether infrequent or routine. If a high-risk procedure is about to be undertaken, a JHA must be performed as part of planning for the job. JHAs also must be

updated ("dirtied up") in the field if there is a change in conditions, such as a modification to a task or a new piece of equipment used at the site. **Appendix K** contains JHAs for each definable feature of work at the site.

Each contractor's SHSO will provide instructions and training to site employees regarding the proper completion and utilization of Job Hazard Analyses (JHAs).

The detailed hazard analyses conducted for each task and operation shall provide the basis for developing written standard operating procedures (SOPs) to protect employees from safety and health hazards. Written SOPs provide a mechanism for informing employees of procedures that ensure their safety and for enabling management to enforce hazard control procedures. Written SOPs are comprehensive, site-specific that set out a task in detail, identify the hazards and specify the controls necessary to complete the tasks.

6.4.2 How to Complete the JHA Form

The following are some basic guidelines to follow when completing a JHA form:

- Include the basic project identification at the top.
- Describe the basic activity that will be analyzed. Provide sufficient detail so that someone familiar with the activity will understand what is planned.
- Identify all hazards associated with the activity. The section below provides a list of possible hazards that may be encountered.
- Describe precautions to be taken for each hazard identified. Try to use engineering methods and/or administrative and work practices to plan a way to avoid the hazard before prescribing the use of PPE. In many cases, it is advisable to include the use of PPE as well in case engineering or other controls fail.
- Identify any specialized training or equipment needed to perform the activity safely.
- The complete JHA should be reviewed by the component-specific contractor's SHSO.

6.4.3 List of Possible Hazards

A list of possible hazards to consider is provided below. It is intended as a reminder of possible hazards that may be encountered and is not intended to be a complete list of all possible hazards.

Partial list of hazards to consider for JHAs:

Equipment/mechanical

- Entanglement
- Friction/abrasion
- Cutting
- Shearing
- Stabbing/puncturing
- Impact
- Crushing
- Drawing-in
- Air or high-pressure fluid injection
- Ejection of parts
- Pressure/vacuum
- Display screen equipment
- Hand tools.

Transport

- Site vehicles
- Mechanical handling
- Road conditions
- People/vehicle interface
- Fences
- Marine vessels

Access

- Slips, trips, and falls
- Falling or moving objects
- Obstruction or projection
- Working over water
- Working at height
- Confined spaces
- Excavations

Handling/lifting

- Manual handling
- Mechanical handling

Electricity

- Fixed installation
- Portable and tools equipment

Chemicals

- Dust/fume/gas
- Toxic
- Irritant
- Sensitizing
- Corrosive
- Carcinogenic
- Nuisance

Fire and Explosion

- Flammable materials/gases/ liquids
- Explosion
- Means of escape/alarms/detection.

Particles and dust

- Inhalation/ingestion
- Silica dust
- Abrasion of skin or eye

Radiation

- Ionizing
- Non-ionizing

Biological

- Insects, spiders, and ticks
- Snakes
- Bacterial
- Rodents and wild or stray animals
- Fungal
- Viral

Environmental

- Noise
- Vibration
- Ventilation
- Temperature (air and water)

- Light
- Humidity
- Overcrowding
- Ventilation

The individual

- Individual not suited to work
- Long hours
- High work rate
- Violence to staff
- Unsafe behavior of individual
- Stress
- Pregnant/nursing women
- Inexperience

Other factors

- Poor maintenance
- Lack of supervision
- Lack of training
- Lack of information
- Inadequate instruction
- Unsafe systems

6.4.4 Job Hazard Analysis Summary

The following bullets provide a summary of each JHA presented in **Appendix K**. Additional details on task-specific safety procedures are presented in Section 9.1.

- Surface and subsurface sediment sampling: The Hazard Priority Number (HPN) is 6, based on existing controls presented in this HASP. This activity is considered moderate risk because the HPN is between 6 and 8.
- Porewater sampling (Trident probe and seepage meter): The HPN is 6, based on the controls presented in this HASP. This activity is considered moderate risk because the HPN is between 6 and 8.
- Riverbank soil sampling (test pits): The HPN is 4.5, based on existing controls presented in this HASP. This activity is considered low risk because the HPN is below 5.
- Riverbank soil sampling (hand auger boreholes): The HPN is 2, based on existing controls presented in this HASP. This activity is considered low risk because the HPN is below 5.
- Groundwater discharge study (piezometer installation): The HPN is 4.5, based on existing controls presented in this HASP. This activity is considered low risk because the HPN is below 5.
- Groundwater discharge study (groundwater monitoring): The HPN is 2, based on existing controls presented in this HASP. This activity is considered low risk because the HPN is below 5.
- Investigation-derived waste management: The HPN is 1, based on existing controls presented in this HASP. This activity is considered low risk because the HPN is below 5.

6.5 HIERARCHY OF CONTROLS

Controlling exposures to occupational hazards is the fundamental method of protecting workers. Traditionally, a hierarchy of controls has been used as a means of determining how to implement feasible and effective controls. As far as practicable, the contractor shall mitigate hazards at the site through the following preferred order of controls:

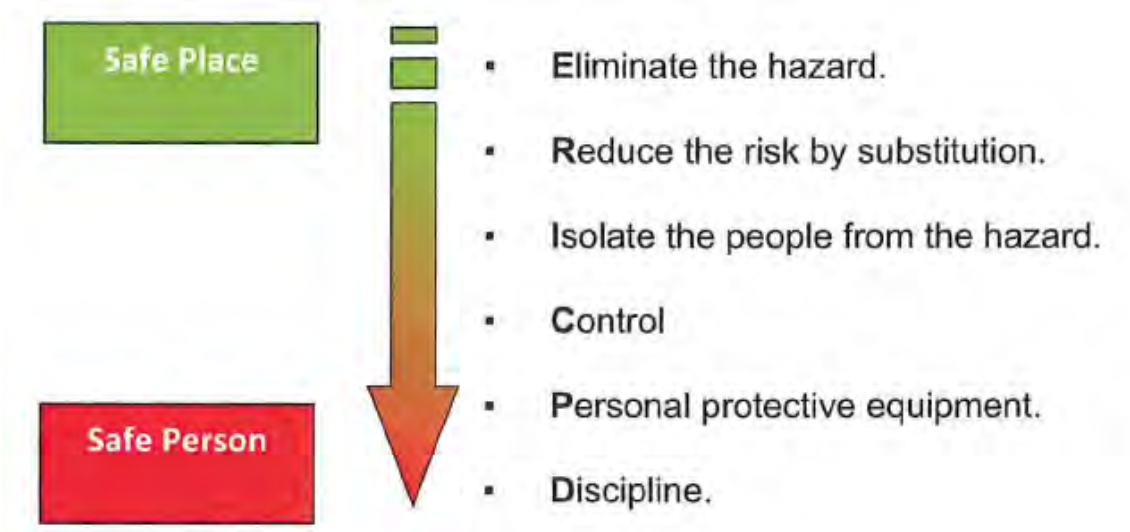
A. **Elimination/Substitution.** Eliminate the task or the hazard (e.g. buying in pre-cut components rather than cutting on site). Substitution of less hazardous materials, processes, operations, or equipment or development of alternative methods that eliminate or reduce hazards.

B. **Engineering Controls.** A primary method of hazard control, engineering controls are to be considered before implementing administrative controls or PPE. Examples of engineering controls include: isolation, enclosure, ventilation, and source modifications.

C. **Administrative Controls.** A secondary method to mitigate exposure to hazards, which may supplement engineering controls. Examples of administrative controls include: formal training: staff rotation, environmental sampling, biological sampling, postings, labeling, formal work practices, stop work authority, housekeeping, maintenance/repairs, and medical surveillance.

D. **Personal Protective Equipment.** Only to be considered when substitution, engineering, and administrative controls are not feasible, or on an interim basis until other controls are implemented. Examples of PPE include: eye protection, hearing protection, hardhats, safety shoes, gloves, protective clothing, safety harnesses, and respirators.

Eliminating the hazard is the most effective method of preventing accidents and ill-health. Personal Protective Equipment should not be relied upon as a primary control since it fails to danger (i.e. puts the wearer at risk in the event of failure of equipment) and requires careful fitting and use by the operator. Collective measures always have priority over individual measures, as summarized below:



6.6 COMPETENT PERSONS

The contractor shall each assign competent persons for each definable feature of work they perform. A competent person is defined by OSHA as "one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them."

Competent person designations are not professional certifications but rather are based on the professional judgment of each contractor. Contractors shall designate competent persons for each DFOW that have demonstrated expertise in their respective field and can meet the definition above.

6.7 SUBCONTRACTOR SELECTION

Consistent with LSS's Health & Safety Screening Procedure for Small Contractors, Consultants and Small Subcontractors, subcontractors selected to perform work for the Arkema Project Area will be qualified and have established performance programs that meet client and industry safety standards. Subcontractors selected to perform work for LSS will have been pre-qualified for previous work by or will be pre-qualified using a third-party review and verification process (e.g. ISNetworld). Potential subcontractors will be required to complete a pre-qualification questionnaire and will be subject to a review of the following:

- Evaluation of pre-qualification questionnaire or similar,

- Evaluation of subcontractor's health and safety program,
- Incident/accident records and statistics,
- Any audit results,
- Applicable training, licenses, or certifications,
- Insurance, and
- Workers compensation and experience multiplier.

Every effort should be made to select those subcontractors with above average H&S performance in their field. LSS reserves the right to disapprove any "lower tier" subcontractor they feel is not qualified.

6.8 ROUTINE INSPECTIONS

Jobsite safety inspections will be performed daily. The contractor's SHSO shall conduct inspections randomly without notice. The inspections will be documented appropriately, with identified H&S issues and deficiencies, subsequent actions, timetables, and responsibilities for correcting the deficiencies included. Deficiencies, depending on severity, may require immediate remediation. The contractor's SHSO shall discuss persistent issues identified through trend analysis and their implemented control measures during tailgate safety meetings, H&S committee meetings, and safety training as necessary.

Each contractor's SHSO shall also monitor employee compliance with the requirements of this HASP through daily H&S inspections. Inspections shall be documented; including any identified unsafe conditions or issues and the details regarding their assigned correction.

6.9 CONTROL OF EXPOSURE TO HAZARDOUS SUBSTANCES

Initial and continued monitoring for compliance and protection of workers based on a hierarchy of standards for exposure to hazardous substances and conditions will be implemented during all work tasks that may expose employees to hazardous substances. This hierarchy for contaminants includes:

1. OSHA permissible exposure limits (PELs),
2. National Institute of Occupational Safety and Health (NIOSH) recommended exposure limits (PELs),
3. American Conference of Governmental Industrial Hygienists threshold limit values (TLVs), and
4. Other scientific information such as contained in MSDSs.

6.10 ATMOSPHERIC AND AIR MONITORING

Employers are responsible for the protection of their employees from hazardous substances and therefore required to perform air monitoring for compliance with applicable OSHA standards. Air monitoring may be performed by a third party professional.

Contractor's performing personal and area monitoring must specify collection and analysis protocols in their component-specific H&S Plan.

6.10.1 Air Monitoring

Air monitoring is to be conducted when entering previously uncharacterized sites, when working in the vicinity of uncontained chemicals or spills, when opening containers and well casings, and prior to opening confined spaces. (*Note:* Integral personnel are not trained or authorized to enter confined spaces under any circumstances.) Air monitoring must be conducted to identify potentially hazardous environments and determine reference or background concentrations. Air monitoring can sometimes be used to augment judgment in defining exclusion zones.

Air monitoring may be discontinued at sites where there have been multiple sampling events in the same area/media during similar activities with no action-level exceedances. In such instances, the air monitoring results must be well documented, and there must be approval from the CHSM prior to discontinuing it. Air monitoring must be reinstated for fieldwork in different areas of the site or when sampling new media.

Periodic air monitoring will be performed with an OVM during sediment and riverbank soil sampling activities. The constituents of concern at the uplands site are primarily DDx, chlorobenzene, chromium, and perchlorate. Of these constituents, only chlorobenzene is volatile. There is virtually no chance for DDx, chromium, or perchlorate to become airborne during surface water and sediment sampling. The creation of airborne dust containing these constituents is unlikely because the sediments will be wet. Field personnel will place all excess sediment in DOT-approved 55-gallon drums before the sediment has a chance to dry out and become an airborne dust hazard.

6.10.1.1 Introduction

Personal air monitoring involves collecting samples within the breathing zone of the field personnel to better understand exposures, ensure appropriate levels of PPE, and document compliance with applicable regulations. Such samples may be full shift, for comparison to PELs or other applicable occupational exposure limits, or short term, for comparison to STELs. Some chemicals in soil or aqueous media may volatilize or become aerosolized and be inhaled by field personnel.

Breathing zone air can be monitored to ensure that the chemicals do not exceed a regulatory or project-specific action level (generally 50 percent of the PEL). Integral commonly uses photoionization detectors (PIDs) and dust meters (e.g., the MIE Inc. MiniRam) for monitoring volatile organic compounds (VOCs) and particle constituents, respectively. In practice, the air directly in the field personnel's breathing zone is monitored with the PID or dust meter for 10 to 15 seconds. The highest reading is recorded in the project logbook and checked against the site-specific action level in the table below. If any of the constituents exceed the action level presented in Section 6.10.1.4, immediate action is required (e.g., don respirators, leave site), as designated.[5]

The following sections provide general guidance on the selection and calibration of PIDs and dust meters, which are typically rented for Integral field projects.

6.10.1.2 Photoionization Detectors

It is critical to order a PID with a detector lamp with the appropriate ionization energy to detect constituents of interest at the site. The ionization energy of the lamp must be greater than the ionization potential of the constituents of interest (ionization potentials are listed in the NIOSH pocket guide to chemicals and are presented in Section 3.1). The unit should arrive at least a day prior to the start of fieldwork so field personnel can familiarize themselves with it and confirm that it was not damaged during shipping. Field personnel must also read the operation manual prior to using the detector in the field. It is important to note that moisture may damage the detector lamp and/or provide erroneous readings, so a moisture filter must be used on the probe. Also, the PID will only accurately quantitate the material used in the calibration process. A response factor is used to measure the sensitivity of the PID to a particular chemical present at the site. Response factors are normally presented in the operation manual for the PID.

The PID must be calibrated daily in accordance with the manufacturer's specifications, which are provided in the operation manual. The calibration typically requires the use of a span gas (generally 100 parts per million isobutylene) and zero gas (generally fresh air). It is important that all of the required calibration equipment/supplies are provided with the PID (e.g., span gas cylinder, regulator, tubing, and Tedlar™ bag). Calibration data should be recorded in the field logbook.

6.10.1.3 Action Levels

The following action levels have been established to determine appropriate actions to be taken during Arkema Project Area investigation activities:

[5] Note that neither the PID nor the MiniRam can identify chemicals. The PID detects total ionizable VOCs and the MiniRam detects total particles of sufficient diameter to be detected.

Monitoring Instrument	Calibration Frequency	Parameters of Interest	Monitoring Frequency
OVM	Daily	VOCs	30 minutes

The following action levels have been established to determine the appropriate level of personal protection to be used during Arkema Project Area investigation activities:

Instrument	Reading	Action[a]	Comments
OVM	Sustained 2 ppm over background for over 1 minute	Retreat to upwind direction and assess situation. Pull Drager tube for benzene. If less than 1 ppm, continue working.	If readings do not decrease, leave site and reassess situation. Might be able to employ engineering controls (e.g., fans, etc.) to reduce volatiles in breathing zone.

Notes:

[a] Examples: "upgrade to Level C" or "leave site."

Air monitoring must be conducted at least every 30 minutes, and more frequently if odors are observed by the field crew. Maintain, calibrate, and field check all air monitoring equipment in accordance with the manufacturer's recommendations.

6.10.2 Weather Conditions and Mobilization of Instrumentation

Meteorological (MET) data will be collected to provide information on daily site conditions. The following parameters will be collected:

- Wind direction
- Wind speed
- Temperature
- Barometric pressure
- Relative humidity
- Precipitation.

During periods of inclement weather (rain, snow, sleet, and heavy fog), air monitoring will not be conducted. The ability to collect accurate air monitoring data is significantly inhibited by moisture. However, the emissions of VOCs and dust are also significantly inhibited, and

exceedance of the site action limits at the perimeter of the site is highly unlikely during high moisture conditions.

During all other shut down periods because of inclement weather, all air monitoring instruments will be retrieved from the field.

6.10.3 Calibration and Maintenance

All air monitoring equipment will be maintained and calibrated per the manufacturer's recommendations. Calibration will be done daily prior to placing the instruments in the field, and under the approximate environmental conditions the instrument will be used. PIDs also will be bump tested at the end of the day to determine if they are functioning properly and accurate measurements were obtained. All calibration activities will be documented on an equipment calibration log. All equipment and equipment reference manuals and calibration logs are maintained at the Site in the project files.

If an instrument is found to be inoperative or suspected of giving erroneous readings, the SHSO will be responsible for having the instrument removed from service and obtaining a replacement unit. The specific operation for which this equipment is essential will cease until an appropriate replacement unit is obtained. The SHSO will be responsible for ensuring a replacement unit is obtained and/or repairs are initiated on the defective equipment.

6.10.4 Schedule

Air monitoring instruments will be pre-calibrated and mobilized into the designated locations when activities are scheduled for the days that require air monitoring. No work will begin until all air monitoring instruments are mobilized and operational.

The SHSO and/or an air monitoring technician will be responsible for performing field checks of all air monitoring instruments. Wind direction will be determined in the morning before placing the instruments in the field and checked at mid-day to determine if prevailing wind direction has changed. Exclusion zone air monitoring instruments will be checked periodically to evaluate if project action levels have been exceeded during work activities. All field checks will be recorded on an air monitoring field check form. Exceedances in project action levels will be communicated to contractors immediately. Corrective actions implemented will be noted the in the project file.

Corrective actions may include but are not limited to upgrading respiratory protection, utilizing engineering controls or shutting down operations.

6.10.5 Recordkeeping

The SHSO and/or air monitoring technician will be responsible for establishing and maintaining records of all required monitoring recorded in the site logbook as described below:

- Date, time, location of air monitoring
- Description of the analytical methods, equipment used, calibration data
- Type of PPE worn by personnel working in the designated areas
- Engineering controls used to reduce exposure
- Work operations taking place during monitoring
- Meteorological data pertinent to air monitoring.

6.11 UTILITIES

All underground lines and utilities (which include, but are not limited to, water, sewer, natural gas, fuel, electrical distribution, communications, lines, vaults, sumps) and other engineered structures (such as foundations, pilings, etc.) shall be identified prior to the start of work in any utility that could feasibly result in contact with or damage to the utility or structure. A copy of RETIA USA's Utility or Structure Clearance and Isolation Procedure is provided in **Appendix L**.

Field personnel will be particularly aware of overhead lines in the work area. All equipment capable of having parts of its structure elevated near energized overhead lines shall be operated so that a minimum clearance of 20 feet {29 CFR 1910.133 © (3) (iii)} is maintained. Operating or erecting any machinery within 20 feet of high-voltage lines is a prohibited activity as defined by OSHA.

6.12 TRAFFIC CONTROL

The performing contactor shall ensure that their site traffic is managed in accordance with Part 6 of the Federal Highway Administration's Manual of Uniform Traffic Control Devices (MUTCD) as well as any applicable local regulations. The MUTCD provides traffic management details such as proposed controls, signage, routing, and integration of traffic movement.

A site-wide Traffic Control Plan (TCP) will be developed and maintained as part of the Project Execution Plan.

If required, the USCG will be notified of the schedule and scope of the overwater sampling work. If the USCG deems a notice to other mariners to be necessary, then information will be provided to the USCG to make barge and other river traffic aware of the sampling activities.

6.12.1 Suitable and Compliant Hauling Equipment

The performing contractor shall employ the use of hauling equipment that is determined to be safe and compliant with applicable transportation regulations for hazardous waste in United States.

Truck drivers shall be required to remain in their cabs during soil/sediment transport. Contractors shall perform weekly inspections evaluating the cleanliness of cab interiors in their trucks used to haul contaminated soil at the site.

6.13 PERSONAL PROTECTIVE EQUIPMENT

The activities performed by site employees will frequently require the use of clothing and equipment that shields and/or isolates employees from chemical and physical hazards that may be encountered.

To prescribe PPE requirements effectively, the nature and extent of potential chemical and physical hazards associated with various activities (e.g. JHAs) shall need to be assessed by the performing contractor. Prior to mobilization, each contractor shall perform a detailed review of the project site. This shall include a review of the site history, types and quantities of materials handled at the site, types of operations performed at the project site, and types of activities to be performed during the project.

From this review, PPE shall be selected by contractor based on the reasonable anticipation of exposure to the chemical and physical hazard exposure potential.

6.13.1 Use of Personal Protective Equipment

Contractor employees shall be responsible for using PPE identified in this HASP or any contractor component-specific HASP, as directed by SHSOs or managers, and where recognizable hazards are identified. Employees are also responsible for inspecting PPE assigned to them and having worn out or defective equipment replaced.

Use of PPE is required by OSHA regulations contained in 29 CFR 1910 and 29 CFR 1926, and is reinforced by U.S. Environmental Protection Agency (EPA) regulations. These regulations include all individuals who may perform work at hazardous, or potentially hazardous, waste sites, when applicable. Types of protection, relevant OSHA regulation, and the source of the regulation appear in **Table 6-1**.

PPE in use shall be inspected daily and maintained in serviceable condition by contractor employees. Items of personal issue shall be cleaned and sanitized as appropriate prior to being reissued to another employee. Defective or damaged PPE shall be taken out of service immediately and, if required, properly disposed.

Table 6-1. OSHA Standards for the Use of Personal Protective Equipment

Type of Protection	Regulation	Source
General	29 CFR 1910.132 29 CFR 1910.1000-1045	41 CFR Part 50-204.7 General Requirements for Personal Protective Equipment OSHA Rulemaking
Eye and Face	29 CFR 1910.133(a)	ANSI Z87.1-[1] Eye and Face Protection
Noise Exposure	29 CFR 1910.95	41 CFR 50-204.10 and OSHA Rulemaking
Respiratory	29 CFR 1910.134	ANSI Z88.2-[1] Standard Practice for Respiratory Protection
Head	29 CFR 1910.135	ANSI Z41.1-[1] Safety Requirements for Industrial Head Protection
Foot	29 CFR 1910.136	ANSI Z41.1-[1] Men's Safety Toe Footwear
Electrical Protective Devices	29 CFR1910.335(a)(2)	National Fire Protection Association (NFPA) 70E: Standard for Electrical Safety in the Workplace
High-Visibility Safety Apparel	29 CFR 1926.651(d)	ANSI / International Safety Equipment Association (ISEA) 107 National Standard for High-Visibility Safety Apparel

Note:
[1] American National Standards Institute, 1430 Broadway, New York, New York 10018

6.14 BASIC PERSONAL PROTECTIVE EQUIPMENT

6.14.1 Eye Protection

Eye protection shall be worn by site personnel during all field activities, and whenever there is a potential hazard of foreign substances or harmful energy affecting the eye.

Safety glasses with side shields meeting the requirements of ANSI Z87.1 are adequate for most activities. Contractors shall analyze planned activities to determine whether additional eye protection is necessary, and state eye protection requirements in their component-specific HASP.

For potential splash hazards of liquids, a face shield or splash hood may be used in conjunction with regular safety glasses. In some exposures, goggles may provide the best form of eye protection. If lasers are used, specialized eye protection using specific lenses for the wavelength and energy emitted by a specific laser may be required.

Contractors are required to provide both shaded and clear safety glasses during sunny or rain days. SHSOs shall ensure employees notify safety supervisors for replacement of damaged and scratched safety glasses and the required care and maintenance.

Personnel that required prescription glasses shall wear prescription safety glasses that meet the requirements of ANSI Z87.1 or over-the-glasses style safety glasses that meet the ANSI Z87.1 standard.

Contact Lenses – Based on current information related to the use of contact lenses in the industrial work environment, contact lenses may be used in most situations. Eye protection such as safety glasses, face shields, or goggles appropriate for the hazards present should be used as well. If a specific situation or condition arises where the use of contact lenses presents an additional hazard, the hazard should be identified in the contractor's component-specific HASP or JHA and the use of contact lenses may be prohibited on an activity specific basis.

6.14.2 Hard Hats

Hard hats meeting the requirements of ANSI Z89.1 shall be worn by contractor employees:

- During all field activities
- Working near exposed electrical conductors
- Whenever there are potential hazards associated with falling or moving objects
- Whenever there are overhead objects such as piping, structural elements, or other stationary elements that create a bump hazard.

Hard hats shall be worn with the brim facing forwards unless there is a specific safety related reason to turn the hat backwards. In such instances the webbing in the hat shall be repositioned in the hat so that the back of the webbing is at the back of the head. The wearing of chin strap on all hard hats is a mandatory requirement.

The protective properties of the helmet will be degraded by exposure to many common work environments, such as temperature extremes, chemical exposure, sunlight and normal daily wear and tear. The shell, suspension and headband of the hard hat should be visually inspected daily. Look for cracks, dents, or wear that might reduce the protection of the hard hat. Check the suspension tabs (connects the suspension to the shell) for cracks and the straps for fraying or tearing. In line with recommended best practice, hard hats shall be replaced at least every 5

years (from the date of manufacture stamped on the hat), regardless of the hats outward appearance. Where user environments are known to include higher exposure to temperature extremes, sunlight or chemicals, hard hats/caps should be replaced automatically after two years of use. If a cap has been struck by a forcible blow of any magnitude, both the hard hat shell and suspension should be replaced immediately, even if no damage is visible. The following is a simple field test that can be performed by an employee or supervisor to determine possible degradation of polyethylene shells:

Compress the shell inward from the sides about 1" (2.5 cm) with both hands and then release the pressure without dropping the shell. The shell should quickly return to its original shape, exhibiting elasticity. Compare the elasticity of the sample with that of a new shell. If the sample does not exhibit elasticity similar to that of a new shell, or if it cracks due to brittleness, it should be replaced immediately."

6.14.3 Foot Protection

Personnel shall wear impact-resistant toe (e.g. steel toe, composite toe) protective footwear during all field activities, and while performing work activities where there is a danger of foot injuries due to falling or rolling objects, objects piercing the sole, and where employees' feet are exposed to electrical hazards. Safety footwear shall meet the requirements of ASTM standards F2412-05 (Standard Test Methods for Foot Protection) and F2413-05 (Standard Specification for Performance Requirements for Foot Protection) and cover the ankle. Any footwear worn for field work must have a good sturdy tread appropriate for outdoor use and a defined heel.

Chemical Protective Footwear – Chemical protective footwear (or boot covers that cover the foot and approved footwear) shall be worn by contractor employees in the exclusion zone and when there is the potential for footwear to come into direct contact or be splashed with hazardous materials or waste.

6.14.4 Hand Protection

Consistent with the RETIA USA Gloves policy, hand safety is critical to the Health and Safety program at the Arkema site with the purpose of eliminating hand injuries and creating an incident-free workplace; therefore, protective gloves shall be worn by all employees entering the exclusion zone of the site regardless of the work being conducted. All site workers should have a heightened awareness of the dangers to hands and steps to prevent hand injuries including good job planning, hazard recognition and judgement. By recognizing hand hazards, following established safety guidelines, and using protective guards, shields, gloves and other personal protective devices as needed, hand injuries can be prevented. A copy of Total's glove comparison chart can be found in **Appendix M.**

As a minimum, all staff and visitors shall wear a general duty work glove at all times while one, that will meet the following cut and abrasion performance standards:

a. ANSI / ISEA 105 - 2016 level A3 and/or CE -388 - 2016 level C Cut protection; and

b. ANSI Abrasion level 3.

Contractors are required to evaluate possible engineering and work practice controls to eliminate hand hazards and use PPE to provide additional protection against hazards that cannot be eliminated through other means. The general process to be used includes:

1. Identify task hazards,
2. Select and provide appropriate hand protection,
3. Train employees on the use of appropriate hand protection, and
4. Ensure hand hazards and injury preventative measures are identified in JSAs.

When selecting gloves, consider job hazard and operation requirements related to:

- Hazardous chemicals/substances to be contacted
- Nature of contact (i.e. total immersion, splash, etc.)
- Duration of contact
- Area of protection (hand only, forearm, arm)
- Equipment/tools used (rotating, sharp edges, etc.)
- Grip (dry, wet, oily)
- Thermal Protection
- Abrasion/cut/puncture resistance
- Tear/tensile strength
- Ergonomics (size, heat stress, dexterity)
- Decontamination/disposal.

Various types of gloves are available for protection against cuts, scrapes, bruises, etc. that may occur during the physical handling of material, equipment tools etc. Cotton, leather, Kevlar®, steel mesh, or other appropriate gloves shall be made available to employees by the contractor depending on the work activity and potential hazards. Specific glove requirements for tasks to be performed on site must be stated in the JSA. To be affective, selection and use of the correct gloves for the job is crucial. When several hazards are encountered that one glove will not provide adequate protection against, gloves will be layered accordingly. For example, when

handling contaminated debris, inner nitrile gloves may be worn to protect against chemical hazards with outer leather gloves to protect against cuts and abrasions.

Protective gloves must be inspected before each use to ensure that they are not torn, punctured or made ineffective. Gloves that are discolored or stiff may also indicate deficiencies caused by excessive use or degradation from chemical exposure. Any gloves with impaired protective ability must be discarded and replaced. If leather gloves are worn when handling hazardous materials, properly discard after use.

Contractor employees performing activities in the exclusion zone where there is a potential for direct contact with hazardous or toxic materials, shall wear chemical protective gloves. The selection of glove should be based on the activity and the material of potential contact. A wide variety of gloves are available, and consideration shall be given by the contractors to dexterity, durability, and material compatibility. Reuse of chemical-resistant gloves must be evaluated carefully, taking into consideration the absorptive qualities of the gloves. A decision to reuse chemically-exposed gloves must take into consideration the toxicity of the chemicals involved and factors such as duration of exposure, storage and temperature. Cleaning must be done in accordance with manufacturer's recommendations.

Gloves that are appropriate for specific task hazards and in good condition prevent some injuries; however, awareness and hazard recognition used in conjunction with gloves is required to alleviate all injuries. Gloves, and all PPE, are required as a final barrier between potential injury and the worker.

6.14.5 High-Visibility Clothing

High-visibility vests or jackets shall be worn by contractor employees always when outside of a vehicle or building on site, including the use of ANSI Class II high visibility clothing whenever personnel work in or around vehicular traffic. High-visibility clothing shall meet the level of visibility required for the work conditions in ANSI / ISEA 107 (1999). See related Section 9.17, Traffic and Work Zone Safety.

Employees performing asbestos work that are not exposed to equipment/vehicle movement are not required to wear high-visibility clothing. Once employees exit these areas, high visibility clothing is required.

6.14.6 Chemical Protective Clothing

Contractor personnel shall wear chemical protective clothing in circumstances where there is the potential for materials to come into contact with the employee's skin or non-chemical resistant clothing.

Skin protection shall be considered of paramount importance by contractors, and contractors shall be responsible for ensuring that their employees remain free of visible debris and contaminants on their persons. Contractors shall require that any of their employees observed with visible mud, dirt, debris, or the like are directed to immediately return to the decontamination facility and undergo decontamination and change out of their ensembles for clean PPE, or decontaminate the appropriate material if possible in the contaminant reduction zone (CRZ).

Selection consideration shall be given to such factors as size, durability, chemical compatibility, and heat stress potential. Project managers are particularly reminded to consider the correct size of protective garment for very large and small workers.

Chemical protective suits by nature invoke heat stress among wearers, and contractors shall maintain strict work/rest regimens and adhere to the heat stress guidelines described in Section 10.

6.14.7 Respirators

Respirator use will not be necessary for the pre-design investigation fieldwork.

6.14.8 Hearing Protection

Employees shall use hearing protection when noise levels exceed the allowable limit. The performing contractor shall be responsible for monitoring to determine if allowable limits are exceeded. Allowable limits can be found in Tables 11-1 and 11-2 in Section 11. A Hearing Conservation Program (described in Section 11) shall be implemented by contractors if the allowable limits are exceeded.

6.14.9 Personal Flotation Devices and Rescue

The contractors shall each analyze their planned activities to adequately provide personal floatation devices (PFDs) for their employees working in over or around water. The contractors shall also make PFDs available to their employees engaged in activities with the potential for water contact to allow for changing work environments and uninterrupted work activities. Ring buoys with at least 90 feet of line shall be provided and readily available for emergency rescue operations. Distance between ring buoys shall not exceed 200 feet. At least one lifesaving skiff shall be immediately available at locations where employees are working over or adjacent to water. More details on PFD use and requirements can be found in Section 9.13.

6.14.10 Specialized Protective Equipment

Specialized protective equipment shall be made available and implemented by the contractor depending on the anticipated activities and may include, but is not limited to:

- Fall protection harnesses and lanyards
- Chaps and/or shin guards for work in rough brush or using a chain saw
- Face shields
- Spark resistant tools
- Cooling vests
- Personal exposure monitors (i.e. H2S or another contaminant).

6.14.11 Personal Work Clothing

Employees are expected to supply personal clothing appropriate for their work assignments, including long pants, a shirt with 4-inch minimum length sleeves, and basic outerwear appropriate for normal protection against weather conditions.

6.14.12 Safety Equipment

The following safety equipment must be onsite during the proposed field activities.

Air Monitoring: Check the items required for this project.

[X]	Photoionization detector/Organic Vapor Meter (OVM)	[ ]	Landfill Gas Meter
[ ]	Lower explosive limit/O_2 meter	[ ]	Dust meter
[ ]	H_2S meter	[ ]	Radiation meter
[X]	Detector pump and tubes (e.g., benzene)	[ ]	Other: _____ _____

First-Aid Kit: Mandatory—include absorbent compresses, adhesive bandages, adhesive tape, antiseptic, burn treatment, medical exam gloves, sterile pads, cardiopulmonary resuscitation (CPR) shield, triangle bandages, scissors (e.g., for cutting off the PPE from an injured person). Check additional items required for this site.

X	Emergency blankets	X	Sunscreen
X	Insect repellent		Other: _____

Other: Check the items required for this project.

X	Eyewash		Fit-test supplies
X	Drinking water	X	Fire extinguisher (on drill rigs and sampling vessels)
	Stopwatch for monitoring heart rate for heat stress monitoring[6]		Windsock
	Thermoscan® thermometer for heat stress monitoring	X	Cell or satellite phone
	Survival kit[7]	X	Global positioning system
X	PFDs		Other: _____
	Cool vests		

6.14.13 Personal Flotation Devices and Rescue

The contractors shall each analyze their planned activities to adequately provide PFDs for their employees working in, over, or around water. The contractors shall also make PFDs available to their employees engaged in activities with the potential for water contact to allow for changing work environments and uninterrupted work activities. Ring buoys with at least 90 ft of line shall be provided and readily available for emergency rescue operations. Distance between ring buoys shall not exceed 200 ft. At least one lifesaving skiff shall be immediately available at locations where employees are working over or adjacent to water.

[6] Heart rate monitoring requires special training.
[7] Consult the CHSM for guidance for site-specific survival kits.

6.15 LEVELS OF PROTECTION

Each type of protective equipment has been designed specifically to protect against a reasonably anticipated chemical and physical hazard. To standardize PPE ensembles, "levels of protection" have been defined to address those chemical and physical hazards that may be present at hazardous waste sites. The levels of protection for the project are defined accordingly:

Level D — Long pants and shirt or work coveralls, American National Standards Institute Class II high-visibility vests or jackets, hard hat, latex or nitrile gloves under work gloves, eye protection, and rubber steel-toed boots (or leather steel-toed boots with Tyvek boot covers) are required at all times. Hearing protection and safety goggles are required as needed.

Level MD — Same as Level D with the addition of chemical protective coveralls (coated Tyvek) or rain slicks. Hypothermia protective clothing will be donned in accordance with the USCG Boat Crew Manual (Commandant Instruction M16794.51):

- When water temperatures are greater than 60°F (air temperature is not a factor), Type I, II, or III PFDs (includes the float coat) will be donned
- When water temperature is 50 to 59°F (air temperature is not a factor), anti-exposure coveralls will be donned.
- When water and air temperatures are both below 50°F, dry suits with proper undergarments (includes polypropylene underwear, cold weather boots, and thermal barrier) will be donned. The MSD-900 and the USCG-approved Boat Crew Dry Suit are both acceptable to be worn.

Based on the hazards identified in Section 3, the following table identifies the PPE required for field activities at this site.

Required Personal Protective Equipment

	Level of Protection[a]	
Site Activity	Initial	Contingency[b]
Surface and subsurface sediment sampling	MD	Leave Site
Riverbank soil sampling	MD	Leave Site
Porewater sampling	MD	Leave Site

	Level of Protection[a]	
Site Activity	Initial	Contingency[b]
Groundwater discharge study	MD	Leave Site
Sample handling (onshore)	D	Leave Site
IDW management	MD	Leave Site

Notes:

[a] See protection-level definitions, above.

[b] Based on unexpected change in site conditions.

7 RESPIRATORY PROTECTION

7.1 PURPOSE AND SCOPE

The following procedures shall be implemented whenever an on-site situation arises that requires the use of respirators by site personnel. They are intended to protect the health of project employees and comply with 29 CFR 1910.134, OSHA's Respiratory Protection standard. The use of personal respiratory protection shall be considered in the following situations:

- Whenever airborne exposures to hazardous chemicals may pose a hazard to site employees, may exceed established exposure limits, and may not be adequately controlled by other means
- When the implementation of an engineering or administrative control creates a greater hazard, e.g., would expose employees for longer than the task itself or expose employees to greater safety hazards
- Whenever respiratory protection may be needed on a precautionary basis until air monitoring data or other objective data is available to assess exposures
- Whenever an employee desires to use a respirator on a voluntary basis and the use of respiratory protection does not create a significantly greater hazard.

Activities and hazards that require the use of respiratory protection and the specific type and level of respiratory protection required shall be identified in each contractor's component-specific HASP and JHA.

7.2 RESPONSIBILITIES

Managers and Supervisors of all Contractors – Contractor managers and supervisors shall only assign personnel to activities, where it is anticipated that respirators will be worn, if they are medically qualified, fit tested and trained to use respirators, or will schedule personnel to complete a medical evaluation, fit tests, and training before respirators are used. Contractor managers and supervisors are responsible for having these guidelines implemented on activities they manage where project personnel use or are expected to use respirators.

SHSO of all Contractors – The SHSOs shall ensure that their contractor's employees that are assigned an activity involving the use of respiratory protection devices have been adequately trained, medically cleared to use such devices, and have been fit tested for the respirator that they have been assigned to use.

Medical Consultants of all Contractors – The contractor's medical consultant shall evaluate medical questionnaires, perform medical evaluations, and issue medical releases regarding employee medical qualification to use respiratory protection.

Employees of all Contractors – Project employees are responsible for using respiratory protection in accordance with these guidelines, the manufacturer's instructions, and training.

Subcontractors of all Contractors – Subcontractors where the use of respiratory protection is anticipated shall provide:

- Evidence of a written respiratory protection program that meets the requirements of the OSHA respiratory protection standard (29 CFR 1910.134)
- Documentation to confirm employee respirator training, fit tests, and medical evaluations prior to the use of respiratory protection under contract.

7.3 PROCEDURE

7.3.1 Hazard Evaluation and Selection of Respirators

Contractors are expected to execute an H&S planning process described in Section 6. As a part of this process, hazards that require the use of respiratory protection and the specific type and level of respiratory protection required shall be identified in each contractor's component-specific HASP and JHA. During the planning process, consideration should be given to the hazardous materials present, the media they are in, the activities that present exposure, and the potential for exposures to exceed threshold limit values (TLVs), permissible exposure limits (PELs), or other established limits. This would include factors such as toxicity, physical state of the contaminant, volatility, concentration, work activities being performed, and proximity to activities that have the potential to generate airborne respiratory hazards.

Information contained in **Table 7-1**, "Protection Factors" and **Table 7-2**, "Respiratory Protection Devices" shall also be used during the equipment selection process. The determination to use respiratory protection and the type of respiratory protection needed shall be reviewed by the appropriate contractor's H&S management.

Table 7-1. Respiratory Protection Factors*

Respirator	Protection Factor
I. Particulate Filter Respirators	
• Powered air-purifying respirator with high-efficiency particulate filter (full-face)	1,000
• High-efficiency particulate filter respirator with a full facemask	100
• High-efficiency particulate filter respirator with a half facemask	10

Respirator	Protection Factor
II. Chemical Cartridge and Gas Masks	
• Powered air-purifying respirator with chemical cartridge (full-face)	1,000
• Chemical cartridge respirator with a full facemask	100
• Half-mask chemical cartridge respirator	10
III. Combination Particulate and Gas/Vapor Air Purifying	
• Powered air-purifying respirator with chemical cartridge and high efficiency particulate filer (full-face)	1,000
• Chemical cartridge respirator with a full facemask, chemical cartridge, and filter	100
• Half-mask chemical cartridge respirator with a chemical cartridge and filter	10
IV. Supplied-air Respirators	
• Type C supplied-air respirator with a full-face piece operated in pressure-demand or other positive pressure mode, or with full facemask, helmet, or hood operated in continuous flow	1,000
• Type C supplied-air respirator without full facemask, helmet, or hood, operated in pressure-demand or other positive pressure or continuous flow mode	1,000
• Supplied-air respirator with full facemask helmet, or hood not operated in positive pressure or continuous mode	50
• Any other supplied-air respirator	10
V. Self-contained Breathing Apparatus (SCBA)	
• Combination respirator including a Type C supplied-air respirator with a full facemask operated in pressure-demand or other positive pressure or continuous flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode	10,000
• Self-contained breathing apparatus with a full facemask operated in pressure-demand or other positive mode	10,000
• Self-contained breathing apparatus with a full facemask operated in demand mode	50
• Self-contained breathing apparatus without a full facemask	10

* Adapted from ANSI Z88.2

Definition: Ratio of contaminant concentration outside respirator to inside.

Use: Allows calculation of maximum use concentration in which a particular type of respirator will provide adequate protection to wearer [i.e., (PEL) x (P.F.) = maximum use concentration].

Table 7-2. Respiratory Protection Devices

General Description	Limitations	Requirements
Air Purifying Respirators		
Full facemask respirator equipped with air purifying units to remove particulate matter from the ambient air prior to its inhalation. Some air	Do not protect against oxygen deficient (<19.5%) atmospheres or atmospheres that are immediately dangerous	When Level C respiratory protection devices are specified buy air monitoring results

General Description	Limitations	Requirements
purifying respirators are power-operated and provide respirable air to the facemask (or hood) under a slight positive pressure.	to life and health (IDLH). The method of purification is generally chemical or chemical group specific so they cannot be used in atmospheres that contain unknown concentrations of unknown materials. Also, cannot be used in atmospheres containing chemicals that present a health risk below their odor or taste thresholds. The useful life of this type of respirator is limited to the concentrations of contaminants, the breathing demand of the wearer, and the removal capacity of the purification medium.	
Atmosphere-Supplying Respirators		
A respirable atmosphere is supplied independent of the ambient air surrounding the wearer. These devices provide protection against oxygen deficiency and most toxic atmospheres.	Some limitations of atmosphere supplying respirators include time limitations of supplied air, bulkiness of equipment, and inherent safety hazards associated with working while dragging an airline or while wearing an air cylinder.	SCBAs will be pressure-demand types of devices, and where appropriate, equipped with an emergency escape bottle.

Voluntary Use of Respirators – Because the use of respirators adds additional risk factors to an operation, and requires compliance with specific regulations, any use of respiratory protection must be reviewed by the appropriate contractor's H&S management. The voluntary use of personal respirators is not permitted without review of H&S management. If the use of respirators is allowed, the procedures in this section must be followed.

Use of Dust Masks – Dust masks may be used to provide protection against nuisance levels of particulate contaminants when the concentration of contaminants does not exceed a PEL, TLV, or another designated action limit. The use of dust masks does not require a medical evaluation; however, employees must be informed of the proper use and limitations of dust masks. The selection of specific make and model of dust mask should be reviewed by the appropriate contractor's H&S management.

7.3.2 Procurement and Issue of Respirators

Employee respirators shall be supplied by each contractor. The equipment will only be issued to those employees who have received training on the use of respirators, are medically

qualified, and have a valid fit test. All respirators, cartridges, and associated equipment will be National Institute for Occupational Safety and Health (NIOSH) approved.

7.3.3 Training

All employees must receive training from their contractor on the proper selection, use, maintenance, and limitations of respirators prior to using respiratory protection. Training includes the following:

- Basic elements of the respiratory protection requirements described above and the OSHA respiratory protection standard
- When and where respirators are needed
- The capabilities and limitations of respirators
- The importance of proper use, maintenance, and fit
- Instruction on how to inspect the respirator
- Instruction with respect to donning and doffing respirators
- Instruction on how to perform positive and negative pressure fit checks
- Proper cleaning, maintenance, and storage procedures.

Employees who may use respirators several times over a period of years must have had initial respirator training or a respirator refresher training class within 13 months of use of a respirator.

The employee shall be provided an opportunity for the employee to practice inspection and donning and doffing respiratory protective equipment in a non-hazardous atmosphere prior to using the respirator in a potentially hazardous environment.

7.3.4 Medical Approval to Use Respiratory Protection

Employees must undergo a medical evaluation by a physician, or another licensed health care provider approved by the contractor's medical consultant prior to wearing a respirator. The medical approval is for a 12-month period. An additional medical evaluation should be performed if:

- An employee reports signs or symptoms related to their ability to use a respirator
- A physician, direct manager/supervisor, H&S staff, or SHSO recommends the employee be re-evaluated.

Those employees who actively participate in the hazardous waste medical surveillance program and have received a medical clearance to wear a respirator meet the requirements of the medical approval for respirator use.

The medical consultant shall provide the contractor and the employee with a written recommendation regarding the employee's capability to wear a respirator.

7.3.5 Respirator Fit Tests

Employees must pass a fit test that meets the requirements of 29 CFR 1910.134, OSHA's Respiratory Protection Standard, with the make, model, and size of respirator they will use prior to using the respirator in the field or a potentially hazardous environment. Respirator fit tests may be conducted by qualified vendors, or the appropriate contractor's H&S staff. Fit tests will not be conducted on employees with facial hair that interferes with the face-piece to face fit.

Prior to the fit test procedure, the employee will be first shown how to put on a respirator, how it should be positioned on the face, how to set strap tension, and how to determine an acceptable fit. Then he/she will select the respirator that provides the most acceptable fit from a variety of respirator models and sizes.

If the employee finds the fit of the respirator unacceptable, he/she will select a different respirator. Once a respirator has been selected, a fit test shall be conducted. Fit testing can either be qualitative (QLFT) or quantitative (QNFT) as permitted in the OSHA standard. Fit testing is to be performed in accordance with the mandatory procedures contained in Appendix A to 29 CFR 1910.134: Fit Testing Procedures.

7.3.6 Use of Air Purifying Respirators

Personnel issued respiratory protection should use respirators in accordance with the manufacturer's instructions and the following:

- Beards or other facial hair that prevents an adequate face seal are prohibited.
- Inspect the respirator for defects, wear, or other conditions that may inhibit the effectiveness of the respirator prior to each use. Inspect overall respirator function, tightness of connections, condition of straps, tubes, valves, cartridges, connections, etc.
- Perform a positive and negative pressure fit test of negative pressure, air purifying respirators prior to each use.
- Head coverings (e.g., Tyvek® hoods or hard hat liners), if used, must not interfere with the respirator to face sealing surface.

- Leave the work area at the first indication of facial irritation, discomfort, increased breathing resistance, contaminant breakthrough, or other indication the respirator is not functioning properly and immediately notify a project manager or SHSO.

7.3.7 Cartridge Change-out Schedules

Cartridges for Gases and Vapors – When air purifying respirators are used for protection, a cartridge change-out schedule should be specified in each contractor's component-specific HASP or JHA that specifies the use of air purifying respirators. The cartridge change-out schedule shall be developed and reviewed by the appropriate contractor's H&S management and may be determined using information from the following sources:

- The OSHA Respirator Change Schedule
- Cartridge service life spreadsheet calculators
- Information based on respirator manufacturer service life calculators, if applicable
- End of service life indicators on cartridges certified by NIOSH

At a minimum, cartridges should be changed at the start of each work shift or if an employee experiences contaminant breakthrough.

Cartridges for Particulate Contaminants – Respirator cartridges for particulate contaminants should not be used more than one work shift. Cartridges may need to be changed more or less frequently if users experience changes in breathing resistance.

7.3.8 Supplied Air and Self-Contained Breathing Apparatus

Breathing air for supplied-air respirators (SARs) and SCBAs must meet or exceed the requirements for Grade D breathing air (ANSI G-7.1-1989) including:

- Oxygen content volume to volume (v/v) of 19.5 to 23.5 percent
- Hydrocarbon content of less than 5 mg/m^3
- Carbon monoxide content of 10 parts per million (ppm) or less
- Carbon dioxide content of 1,000 ppm or less
- No noticeable odor
- Moisture content in cylinder shall not exceed a dew point of –50 degrees Fahrenheit (°F) at 1 atmosphere pressure.

7.3.9 Inspection and Maintenance Procedures for Self-Contained Breathing Apparatus

- Check the cylinder label for a current hydrostatic test date
- Inspect the cylinder for large dents or gouges
- Inspect the cylinder gauge for damage
- Complete a routine inspection
- Fill out the appropriate records with results and recommendations

Routine Inspection: Perform immediately before donning and after cleaning.

- Before proceeding, check that the:
  - O-ring is present on the conical high-pressure fitting
  - Bypass valve is closed
  - Mainline valve is closed
  - Regulator outlet is not covered or obstructed
- Backpack and harness assembly:
  - Visually inspect straps for wear, damage, and completeness
  - Check the wear and function of the belt
  - Check the back plate and the cylinder holder for damage
  - Check that the cylinder is firmly attached to the back plate
  - Cylinder and high-pressure hose assembly:
  - Attach the high-pressure hose connector to the cylinder fitting
  - Check that the belt and the high-pressure hose are not tangled
  - Open the cylinder valve and listen or feel for any leakage around the packing and the hose connection
  - Check the high-pressure hose for damage or leaks
- Regulator Function:
  - Cover the regulator outlet with the palm of your hand
  - Open the round golden mainline valve
  - Note the stoppage of air flow after the positive pressure has built up

  - Compare the pressure reading on the cylinder and regulator gauges; they should be the same
  - Close the mainline valve
  - Remove hand from the regulator outlet
  - Open the magenta bypass valve slowly; note its function
  - Close the bypass valve

- Warning Alarm and Regulator Integrity:
  - Cover the regulator outlet again with the heel of your hand
  - Open the mainline valve
  - While covering the regulator outlet, close the cylinder valve
  - Move your hand from the outlet so the air drains out slowly
  - Observe the regulator gauge reading at which the low-pressure alarm sounds; it should start sounding at 550 to 650 pounds per square inch (psi)
  - Remove your hand from the regulator outlet
  - Close the mainline valve
  - Blow air into the regulator for 5 to 10 seconds
  - Draw air from the outlet for 5 to 10 seconds

If a positive pressure or vacuum cannot be maintained, there is a leak. DO NOT USE THE SCBA!

- Face piece and corrugated breathing hose:
  - Inspect the head harness and the face-piece for damage, serrations, and deteriorated rubber
  - Inspect the lens for damage and proper seal in the face-piece; inspect the exhalation valve for damage and dirt build up
  - With the breathing hose separated from the face-piece, inspect the hose connector for damage and presence of a wagon wheel washer
  - Stretch the breathing hose and carefully inspect it for holes and deterioration
  - Attach the breathing hose to the face-piece
  - Perform a negative pressure test with the face-piece donned

- Storage:
  - Refill the cylinder to 2,216 psi
  - Close the cylinder valve
  - Tightly connect the high-pressure hose to the cylinder
  - Bleed the pressure from the high-pressure hose by opening mainline valve
  - Close the mainline valve
  - Close the bypass valve
  - Fully extend all the straps
  - Store the face-piece in a clean plastic bag for protection

7.3.10 Work Practices for Conditions Immediately Dangerous to Life and Health

Except under emergency conditions, all work under IDLH conditions must be preplanned in advance. The preplanning of such work shall involve the appropriate contractor's H&S management. Operations that involve the use of SARs or SCBAs by project employees must be directly supervised by the appropriate contractor's hazardous waste supervisor.

- In those instances, where employees must work under IDLH conditions, the following work practices must be followed:
- LSS and the PMC will be notified at least 3 days in advance of any planned work to be conducted under IDLH conditions.
- If such work is required under emergency conditions, LSS shall be notified as soon as possible.
- At least one employee or more, if necessary, shall be located outside the IDLH atmosphere. The number of outside employees shall be determined by the appropriate contractor's H&S management based on the number of employees working in the IDLH atmosphere, the complexity of the task, and complexity of a potential rescue. A written rescue plan is required.
- The outside employee(s) shall remain in visual, voice, radio, or signal line communication with the employee(s) working within the IDLH condition.
- The outside employee(s) shall be equipped with pressure demand SCBAs and appropriate rescue and retrieval equipment to aid employees working in the IDLH atmosphere.

7.3.11 Procedures for Care and Maintenance of Air Purifying Respirators

Cleaning Procedure for Respirators used Daily or More Than Once per Week

At the end of each day, respirators used daily or respirators expected to be used within the next 30 days shall be cleaned and stored as follows:

- Respirator cartridges shall be removed and discarded in labeled bags or containers for final disposal in accordance with project's waste management procedures.
- Respirators shall be rinsed thoroughly with potable water to remove visible dirt, dust, sweat, saliva, etc.
- Wipe respirator down thoroughly with disposable disinfectant towelette.
- Dry off respirator and place in plastic bag for storage.
- Store in a clean, dry location.

Cleaning Procedure for Respirators for Long-Term Storage or Intermittent Use

It is not anticipated that respirators will be stored long term or intermittently used. Should this be required the contractor will include this procedure in their competent specific H&S plan.

8 SAFETY MANAGEMENT PROGRAM

8.1 REGULAR HEALTH AND SAFETY REPORTING

The contractors shall provide project management with a monthly H&S report detailing the following:

- Status of the project's H&S Program
- Summary of total man hours and safety statistics, including any lost-time injuries, recordable, first aids, accidents, near misses and anomalies
- Significant identified hazards or anomalies
- Hazard corrections implemented
- Concerns or issues regarding the H&S Program
- H&S trends

8.1.1 Trend Analysis

The contractors will review its collected H&S inspection data to identify any H&S performance trends. This will serve to identify areas for improvement and better direct resources and training. Each contractor will provide its trend analysis in its monthly H&S report and during the H&S meetings.

8.2 MONTHLY HEALTH AND SAFETY MEETINGS

The site H&S committee discussed in Section 2.2 shall meet monthly. The meetings shall be a means for contractors to discuss H&S issues or concerns, and for the PMC to report on the status of overall site H&S performance.

9 WORK PRACTICES AND GUIDELINES

9.1 DEFINABLE FEATURES OF WORK

The following sections contain brief descriptions of the work to be completed and safety procedures that are specific to each task. Additional details are presented in the pre-design investigation work plan and field sampling plan.

9.1.1 Surface and Subsurface Sediment Sampling

The following sections present the description of work and safety procedures. The proposed sediment sample locations are presented in Figures 3-1, 3-2a,b, and 3-6 of the work plan.

9.1.1.1 Description of Work

The following sections present a description of work for surface and subsurface sediment sampling. The water depth will range from less than 5 ft in the nearshore areas between the docks to approximately 40 ft in the navigation channel.

Surface Sediment Sampling

If needed for Phase 2, surface sediment (0–1 ft below mudline [bml]) samples for chemistry analyses will be collected using a vessel-deployed hydraulically-powered 0.1 m^2 grab sampler or equivalent sediment sampler. The maximum penetration of this grab sampler is 1 ft. A total of three subsamples will be collected within an approximate 5-ft radius from each station and homogenized into a composite sample. The number and locations of samples will be determined based on the results of the Phase 1 sampling.

Subsurface Sediment Sampling

Vibracore: A vessel-deployed vibracorer equipped with 15-ft core tubes will be used to collect subsurface sediment cores. Prior to core advancement and sample collection, all coring and non-disposable sampling equipment will be decontaminated. The vibracorer uses a hydraulic system that vibrates and drives a 4-in.-outside-diameter aluminum core tube into the sediment. A continuous sediment sample is retained within the aluminum core tube with the aid of a core cutter/catcher attached to the bottom of each tube. The core tube will be driven to the target depth of 15 ft bml or refusal, whichever comes first, and retrieved. Before removing the aluminum core tube from the vibracorer, the core cutter/catcher will be visually inspected to ensure that proper penetration was attained and that there was no obvious loss of sediment from the tube.

Mud-Rotary Boreholes: The mud-rotary drill rig will be mounted on a barge. The barge will be anchored in place using two spuds. The conductor casing will be pushed approximately 2 ft into the sediment and will be securely attached to the barge deck using a clamping mechanism so it does not drop when drilling commences. Mud-rotary boreholes are advanced by grinding the subsurface material (in this case sediments) using a drill bit attached to a rapidly rotating drill string of hollow steel rods. During borehole advancement, drilling mud is forced downward through the hollow drill string to keep the hole open and prevent caving and heaving. Steel conductor casing will be employed at all mud-rotary borehole locations. To contain the sediment cuttings as they surface during drilling activities, the top of the conductor casing will protrude through a 4- by 8-ft sheet of ¾-in. plywood that has a 2- by 6-in. frame attached. The sediment cuttings will be shoveled into properly labeled, DOT-approved, 55-gallon steel drums. Care will be taken to minimize any spilling of the sediment.

Sonic Boreholes: If needed for Phase 2, sediment samples will be collected using a sonic drill rig. The sonic drill rig will be mounted on a barge. The barge will be anchored in place using two spuds. Sediment samples will be collected in 2.5-ft drives with Osterberg piston-type sampler (or equivalent technology). The Osterberg sampler will be equipped with a 2.5-ft-long by 3-in.-diameter Shelby Tube, which will allow for the collection of relatively undisturbed samples that will be useful for assessing potential NAPL/sheens. Once the casing is advanced to the approximate top of the sample interval, the Osterberg sampler will be advanced ahead of the end of the casing to collect a representative sediment sample. When the sampler is retrieved, the casing will be advanced to the bottom of the previously sampled interval while potable water is pumped at high pressure through the casing to keep sediment from entering the casing.

9.1.1.2 Safety Procedures

A hard hat with chin strap, safety glasses, steel-toed boots, high visibility vest, personal flotation device (PFD), and nitrile gloves are required at all times without exception. Use hearing protection as needed. Don hypothermia protective clothing in accordance with the USCG Boat Crew Manual (Commandant Instruction M16794.51):

- When water temperatures are greater than 60°F (air temperature is not a factor), Type I, II, or III PFDs (includes the float coat) will be donned.
- When water temperature is 50 to 59°F (air temperature is not a factor), anti-exposure coveralls will be donned.
- When water and air temperatures are both below 50°F, dry suits with proper undergarments (includes polypropylene underwear, cold weather boots, and thermal barrier) will be donned. The MSD-900 and the USCG-approved Boat Crew Dry Suit are both acceptable to be worn.

Exercise caution when working on a boat deck. Always be aware of your surroundings and river wave action that can rock the sampling vessel without notice. Keep sampling equipment on boats organized at all times. Sediment will be removed from the boat deck between sample locations to avoid slippery conditions and slip/trip/fall hazards. Skiffs are required to be equipped with a throwable life ring, fire extinguisher, and warning horn; and each field member will be briefed on the storage location for this equipment.

Sediment sampling at selected locations will be conducted with a sonic or mud-rotary drill rig. Avoid all pinch points on the drill rigs. Do not operate or stand near the rig during electrical storms and stay a safe distance (25 ft) from power lines, if present near the shoreline. Make sure the drill rig is leveled properly prior to drilling. The federal safety regulations include OSHA's machine guarding standards (29 CFR 1910 Subpart O) for the mud rotary drilling will be followed. All Integral personnel will make eye contact with the drillers before approaching the drill rig.

Avoid getting sediment and decontamination chemicals on your clothes or skin. Exercise care when lifting, assembling, and decontaminating the samplers. Always stay clear of the winch line and be aware of its location.

The field screening of sediment cores for the nonaqueous-phase liquids evaluation will include the use of Sudan IV hydrophobic dye powder, which is an irritant and possible mutagen. The powder will only be handled in areas shielded from wind. In addition, field personnel will don nitrile gloves and safety goggles at all times when handling the powder.

9.1.2 Riverbank Soil Sampling

The following sections present the description of work and safety procedures. The proposed riverbank sample locations are presented in Figures 3-1, 3-2a,b, and 3-6 of the work plan.

9.1.2.1 Description of Work

Soil boreholes will be advanced using a 3.25-in.-diameter hand auger at 39 locations along the Arkema Project Area riverbank. Soil samples will be collected at 1-ft intervals to a target depth of 4 ft below ground surface (bgs).

Shallow test pit explorations will be excavated using a track-mounted backhoe or excavator at six locations in the riverbank area to a depth of approximately 6 ft bgs. The upper 1–2 ft of soil from the test pit area (approximately 6 ft wide by 8 ft long) will be removed and placed to one side of the excavation. The excavation will be continued using the excavator, placing the soils on the opposite side of the excavation until the appropriate depth and width are obtained. Soil samples greater than 3 ft bgs will be collected using the backhoe or excavator bucket.

9.1.2.2 Safety Procedures

A hard hat, safety glasses, steel-toed boots, high visibility vest, and nitrile gloves are required for riverbank soil sampling at all times without exception. Use hearing protection as needed and don a PFD when working near the shoreline. Avoid getting soil and decontamination chemicals on your skin.

A backhoe will be used to excavate test pits on the riverbank to collect soil samples for geotechnical analyses. The backhoe will either be traversed to the riverbank on Lot 1 where the bank is gentle or transported to the riverbank using a barge, depending on the river stage and access issues. Stay back from operating equipment and maintain eye contact with equipment operator. Do not enter excavations greater than 3 ft in depth without evaluation by a qualified person and implementation of applicable trenching and excavation safeguards as required by law.

A hand auger will be used to collect chemistry soil samples on the banks. The hand auger soil sampling will be done on the steep riverbank with a substantial amount of debris and tripping hazards. Always watch for tripping hazards and voids in the riverbank fill material and use the buddy system at all times.

9.1.3 Porewater Sampling

The following sections present the description of work and safety procedures. The proposed porewater sample locations are presented in Figures 3-4 and 3-5 of the work plan. The water depth will range from less than 5 ft in the nearshore areas between the docks to approximately 40 ft in the navigation channel.

9.1.3.1 Description of Work

Seepage meters will be deployed at eight locations. The unit is deployed by divers and rests on the sediment surface. The UltraSeep system will be programmed to collect continuous flow data and multiple samples from each of these stations over the course of 24 hours. At the end of the deployment period, divers will retrieve the UltraSeep system and associated samples.

The Trident Probe™ (or equivalent system) will be deployed from a small, well-anchored vessel using an aluminum push rod, along with a submersible air-hammer to assist in driving the probe into the sediment. The Trident Probe™ will be used to collect sediment porewater samples from three locations to measure dissolved organic carbon and VOCs in support of sediment cap design. The samples will be collected at depths of approximately 1, 2, and 3 ft bml to assess any vertical gradients in dissolved organic carbon and VOCs.

9.1.3.2 Safety Procedures

A hard hat with chin strap, safety glasses, steel-toed boots, high visibility vest, PFD, and nitrile gloves are required at all times without exception. Use hearing protection as needed. Don hypothermia protective clothing in accordance with the USCG Boat Crew Manual (Commandant Instruction M16794.51):

- When water temperatures are greater than 60°F (air temperature is not a factor), Type I, II, or III PFDs (includes the float coat) will be donned.
- When water temperature is 50 to 59°F (air temperature is not a factor), anti-exposure coveralls will be donned.
- When water and air temperatures are both below 50°F, dry suits with proper undergarments (includes polypropylene underwear, cold weather boots, and thermal barrier) will be donned. The MSD-900 and the USCG-approved Boat Crew Dry Suit are both acceptable to be worn.

Exercise caution when working on a boat deck. Always be aware of your surroundings and river wave action that can rock the sampling vessel without notice. Keep sampling equipment on boats organized at all times. Boats are required to be equipped with a throwable life ring, fire extinguisher, and warning horn; and each field member will be briefed on the storage location for this equipment.

Avoid getting porewater and decontamination chemicals on your clothes or skin. Exercise care when lifting, assembling, and decontaminating the sampling equipment. Always stay clear of the winch line and be aware of its location.

9.1.4 Groundwater Discharge Study

The following sections present the description of work and safety procedures. The proposed groundwater discharge sample locations are presented in Figure 3-4 of the work plan.

9.1.4.1 Description of Work

Four piezometers will be installed along the toe of the riverbank slope to a target depth of 15 ft bgs using a track-mounted sonic drill rig. The boreholes will be 6-in. in diameter and will be sampled continuously from ground surface to the bottom of the borehole. The piezometers will be constructed of 2-in.-diameter Schedule 40 PVC with 10 ft of 0.010-inch slot screen. No. 10/20 silica sand filter pack (or equivalent filter pack) material will be added to the sonic casing as the casing is removed, keeping several feet of silica sand within the auger or casing to continually fill the void created by the augers or casing as they are retracted. The sand will be poured in slowly to avoid bridging. The filter pack will extend approximately 2 ft above the top of the screen. The piezometer will be pumped and/or surged repeatedly to promote settling of the

filter pack. Additional silica sand will be added if significant settling has occurred. A bentonite pellet seal will be placed from the top of the filter pack to the ground surface as the augers are retracted. The bentonite pellets will be added slowly to avoid bridging. An 8-in.-diameter above-ground well monument will be installed.

Pressure transducers will be installed in the piezometers along the toe of the riverbank slope. Pressure transducers are already deployed in the monitoring wells on the river side of the groundwater barrier wall and in the stilling well on Dock 1 as part of the monitoring associated with the groundwater extraction and treatment system. Groundwater samples will be collected from each of two well clusters at the top of the riverbank. Groundwater sampling will be conducted using low-flow sampling techniques. A peristaltic pump or equivalent will be used to purge and sample the wells. Sample parameters will be allowed to stabilize prior to sampling.

9.1.4.2 Safety Procedures

A hard hat, safety glasses, steel-toed boots, high visibility vest, and nitrile gloves are required at all times without exception. Use hearing protection as needed. Avoid getting groundwater, soil cuttings, and decontamination chemicals on your clothes or skin.

Piezometers will be installed on the riverbank near the groundwater barrier wall using a sonic drill rig. The sonic drill rig will either be traversed to the riverbank on Lot 1 where the bank is gentle or transported to the riverbank using a barge, depending on the river stage and access issues. Avoid all pinch points on the drill rig. Do not operate or stand near the rig during electrical storms and stay a safe distance (25 ft) from power lines, if present near the shoreline. Make sure the drill rig is leveled properly prior to drilling. The federal safety regulations include OSHA's machine guarding standards (29 CFR 1910 Subpart O) for the mud rotary drilling will be followed. All Integral personnel will make eye contact with the drillers before approaching the drill rig.

Previously deployed pressure transducers will be monitored in monitoring wells on the river side of the groundwater barrier wall and in the stilling well on Dock 2. Always wear a USCG-approved PFD when doing any work on the dock or near the shoreline. Groundwater samples will be collected from the monitoring wells and newly installed riverbank piezometers. Always get help lifting buckets of purge water and avoid splashing when transferring the purge water from buckets to 55-gallon drums.

The seepage meters will be deployed by professional divers. A dive plan will be submitted for EPA review 4–6 weeks prior to initiating fieldwork. Integral personnel will not participate in diving activities. Be sure to keep proper footing on boat and beach surfaces, if observing seepage meter deployment or retrieval.

9.1.5 IDW Management

Always wear a USCG-approved PFD when doing any work on the sampling vessel or dock. A hard hat, safety glasses, steel-toed boots, high visibility vest, and nitrile gloves are required at all times without exception. Use hearing protection as needed.

Use caution when lifting and carrying heavy objects. Be mindful of footing when working on the vessel and walking on the beach. Watch for drift wood and other tripping hazards on the beach and riverbank areas.

Sediment cuttings from drilling activities will be placed in properly labeled, 5-gallon buckets on the vessel deck. The 5-gallon buckets will be carried off of the vessel onto the upland portion of the site, transferred to DOT-approved 55-gallon drums, and staged for offsite disposal in accordance with state and federal regulations.

Liquid wastes (i.e., decontamination waters) will be potentially contaminated with chemicals. The presence of any constituents in the wastewaters is expected to be diluted; therefore, the wastewaters are not expected to be classified as hazardous waste. Decontamination waters will be temporarily containerized in 5-gallon buckets aboard the vessel. The 5-gallon buckets will be moved from the vessel to the upland portion of the site, transferred to DOT-approved 55-gallon drums, and staged for offsite disposal in accordance with state and federal regulations.

9.2 COORDINATION OF ACTIVITIES BETWEEN CONTRACTORS

The contractor will coordinate with LSS and Integral to ensure that their schedule of planned activities has been coordinated. If necessary, a simultaneous operations (SIMOPS) hazard assessment will be performed. All SIMOPS hazard assessments will be reviewed and controls in place prior to operation, which may have impact on adjacent or near site employees' equipment or the public. This will prevent interruptions or delays in work progress and serve to better protect site employees and the public.

9.3 HOUSEKEEPING

These guidelines are for the establishment and administration of a clean and orderly work environment at field project sites. A continuous housekeeping program strongly tends to prevent accidents. A clean and orderly work environment can be achieved and maintained through ongoing housekeeping efforts undertaken by personnel at all levels. Contractors shall initiate participation in housekeeping activities and good work habits, not only at the end of a work assignment but throughout the evolution of the project.

Contractors shall follow the work practices outlined within their housekeeping program.

- Contractors shall plan the location of equipment and storage facilities to allow the easy flow of personnel, equipment, materials, fire hazards, and to prevent the obstruction of evacuation, firefighting, or rescue activities.
- Materials shall be stored in a manner that facilitates access of material handling equipment and personnel handling limitations. Lack of sufficient workspace and storage capacity leads to the potential for accidents and decreases efficiency.
- Avoid storage of flammable liquids, such as paints and thinners, unless they are required for specific project needs. If needed, such storage shall be within a metal storage cabinet that has been labeled and approved for the storage of flammable liquids.
- Continuously maintain work areas in a neat and orderly manner.
- Containers shall be provided for the collection of waste, trash, and other non-hazardous refuse. Investigation-derived waste and other waste materials that are potentially hazardous shall be stored and labeled in accordance with OSHA and local regulatory requirements.
- Deploy leads, hoses, and extension cords so they do not present tripping hazards and are not subject to contact with moisture or physical stress. Where possible, they should be hung overhead with non-conductive material and kept away from walkways, doors, stairs, and ladders.
- Protect protruding rebar and anchor bolts and conspicuously mark them.
- Clean small spills that create slip hazards and/or flammability hazards immediately and do not leave them unattended.
- Keep walkways, aisles, stairways, and passageways in a clear and unobstructed condition.
- Prohibit eating and drinking in work areas where there is potential exposure to toxic or hazardous materials. Smoking is limited to designated smoking areas where there is no such exposure.

9.4 MANUAL MATERIAL HANDLING

Contractor employees shall follow the work practices outlined below when lifting and carrying heavy objects.

- Test any load you are required to lift and compare its weight, volume, and shape to lifting abilities. Employees shall not attempt to lift beyond their capacity. Use mechanical means when possible for heavy or repeated lifting.

- Obtain assistance in lifting heavy objects. Back belts or back braces may be used if desired; however, many ergonomists do not believe that these devices create a benefit or provide protection.
- When two or more persons are involved in a manual lift, one designated person shall provide direction of the lift.
- When two or more persons are carrying an object, each employee, if possible, should face the direction in which the object is being carried.
- When two or more persons carry a heavy object that is to be lowered or dropped, there shall be a prearranged signal for releasing the load.
- The right way to lift is easiest and safest. Crouch or squat with the feet close to the object to be lifted, secure good footing, take a firm grip, bend the knees, keep the back vertical, and lift by bending at the knees and using the leg and thigh muscles. Exercise caution when lifting or pulling in an awkward position.
- Employees shall avoid twisting or excessive bending when lifting or setting down loads.
- When moving a load horizontally, employees shall push the load rather than pull.
- For tasks that require repetitive lifting, the load shall be positioned to limit bending and twisting. The use of lift tables, pallets, and mechanical devices shall be considered.
- When gripping, grasping, or lifting an object such as a pipe or board, the whole hand and all the fingers shall be used. Gripping, grasping, and lifting with just the thumb and index finger shall be avoided.

9.5 ELECTRICAL SAFETY

Electrical work related to the pre-design investigation will be limited to the generators on the sampling vessels. The following work practices can eliminate or minimize the potential for electrical shock, fires, and burns when working on or around electrical equipment. Contractors shall comply with the following:

- Treat all electrical circuits as live until their condition has been verified. Treat even low voltages as dangerous.
- Inspect all electrical equipment and tools before each use. Inspect insulation, fixtures, switches, plugs, fuses, etc. Remove from service any faulty equipment and notify the source of the equipment.
- Do not work with electrical equipment with wet hands or standing in wet areas.
- Only a qualified electrician shall wire or install electrical systems.

- Ground fault circuit interrupters (GFCIs) shall be provided for all areas where electrical equipment or portable electric tools may be used. If a GFCI outlet is not available, a portable GFCI outlet adapter or extension cord shall be used.
- Do NOT use a finger or any conductive object to point to circuits, panels, fixtures, etc.
- Do not install fuses or circuit breakers larger than the circuit rating.
- Conduct a tool count before beginning work and after work is completed.
- Use lockout/tag out procedures whenever working on electrical equipment.
- Use only approved and properly rated lighting devices and tools in vessels, boilers, and confined spaces.
- Use the following precautions when using electrical cords:
- Visually inspect electrical cords before each use for fraying, cuts, or other damage.
- Do not use extension cords for permanent installations.
- Keep extension cords properly covered or raised overhead to prevent tripping hazards and damage from traffic.
- Extension cords or cables shall not be secured with staples, hung from nails, or suspended by bare wire.
- Only use electrical cords that are equipped with a grounding pole on the plug (three pole plugs). Never remove a grounding pole from a cord.
- All electrical equipment, including motors, generators, wiring, and controls, shall be installed so that exposed live parts are properly guarded or insulated to provide adequate protection to operating personnel. Avoid open panels, circuit boxes, and exposed wiring.
- Portable electrically driven tools shall be grounded with a three-wire circuit. Explosion-safe (explosion-proof or intrinsically safe) tools shall be required in hazardous areas.

In wet locations:

- Plugs and receptacles shall be kept out of water unless they are an approved submersible type.
- Where a receptacle is used in a wet location, it shall be contained in a weatherproof enclosure, the integrity of which is not affected when an attachment plug is inserted.
- All temporary lighting strings in outdoor or wet locations (such as tunnels, culverts, valve pits, floating plants, etc.) shall consist of lamp sockets and connection plugs permanently molded to the hard service cord insulation.

If a rescue from electrical equipment is required, use the following precautions:

- Disconnect the circuit before attempting the rescue.
- Make sure you are standing on a dry surface.
- Use a dry belt, rope, coat, or other non-conductive material to loop over the victim and drag them away from the contact.
- Assess the condition of the victim; do not approach if they are still in contact with the circuit.
- Apply first aid and/or CPR (if you are qualified) and get medical help.

9.6 LOCKOUT/TAG OUT

Lockout/Tag Out work related to the pre-design investigation will be limited to the generators on the sampling vessels. Any locks or tags placed on equipment must be coordinated with the owner/ operator of the equipment.

These guidelines cover inspecting, servicing, and maintaining equipment where unexpected energization or startup of the equipment has the potential to harm employees. These guidelines are intended to prevent accidents and injuries caused by the accidental release of energy. Project contractors performing lockout/tag out of equipment shall comply with the procedures outlined in this section and be documented using a Lockout/ Tag out permit. Contractors shall describe their Lockout/Tag out permit process in their component specific.

9.6.1 Definitions

Lockout – The process of preventing the release of material or energy (mechanical, kinetic, potential, electrical, or chemical) from a power source using physical means, such as a lock to maintain an energy isolation device in the safe position, and prevent the inadvertent energization of machinery, equipment, or a system. Lockout usually involves installing a lock at a power (or flow) source so that equipment supplied by that source cannot be operated. The lockout locks shall be provided only for lockout purposes and shall not be used to lock toolboxes, storage sheds, or other devices.

Tag out – Accomplished by placing a tag on the power source. The tag acts as a warning not to restore energy. It is not a physical restraint. Tags must clearly state "Do Not Operate" or the like. Identifying information must be applied by hand.

Authorized Employees – Those who physically lock or tag out equipment for servicing or maintenance. Note that these individuals are not necessarily the people who normally operate the equipment. In some cases, the authorized employee may be a representative of a client or third-party operator.

Affected Employees – Those whose job requires them to operate equipment subject to lockout or tag out, or those employees who work in areas where lockout or tag out is used.

9.6.2 What Must Be Locked or Tagged Out?

Employees shall implement these guidelines when they are potentially exposed to hazards such as unguarded moving parts, live electrical systems, or flow of material from open pipes, valves, or other systems. This program applies to non-routine activities. This includes inspections, repair and replacement work, renovation work, and modifications or other adjustments to equipment that may affect employees. For routine activities, mechanical guarding and electrical insulation are the preferred protection.

Some types of energy that lockout/tag out must be used to control include:

- Electrical
- Mechanical
- Pneumatic
- Fluids and Gases
- Hydraulic
- Thermal Gravity

9.6.3 Lockout/Tag out Procedure

When employees perform a service that requires lockout or tag out, they shall coordinate all activities with the operator of the equipment or facility. The following actions should be performed to execute a lockout or tag out:

- Shut down the equipment
- Isolate equipment
- Apply lockout devices or warning tags
- Release stored energy to achieve a "zero energy state"

Shut the Equipment **Down and Isolate It** – First, locate all energy sources that power the piece of equipment you will work on. Always look for hidden energy sources. Many machines have more than one power source, so you must study the machines and power sources involved.

Notify any affected employees before you start a lockout procedure, then shut off each power and material feed to the equipment.

Every power source has its own procedure for shutoff. Shutoff may be accomplished by pulling a plug, opening a disconnect switch, removing a fuse, closing a valve, bleeding the line, or placing a block in the equipment. Generally, follow this sequence of events:

- Shut down the machine by following the normal method for shutdown
- Turn off the energy at the main power source

- Turn the machine switch back on to confirm that the power source has been deactivated
- Attempt to restart the machine to guarantee that the power is shut off, then return the switch to the off position

Apply Lockout Devices – Make sure the power cannot be supplied unless you know about it. If several people will work on a piece of equipment, each must apply his/her own lock. Use a multiple lockout device that can accommodate several locks at once. All personal locks shall be accompanied by a tag that identifies the employee(s), is signed and dated by the employee(s), and specifies the work activity being performed. This prevents any accidental startups while another employee may still be working on the machinery.

When all energy sources are locked, inform others of the lockout situation. One way to do this is by applying a tag to the power source. Note: Never use another employee's lock and never lend your lock to another employee.

Safe Release of Stored Energy – Equipment must be at "zero energy state" before servicing or maintenance work can begin. To achieve a zero-energy state, release energy by draining valves, releasing springs, bleeding air or hydraulic pressure, or supporting elevated weights. When you are finished, test the machine to ensure that all energy was disconnected or released.

Putting the Power Back On – After servicing is finished, make sure all tools and personnel are removed from the area and replace all machine guards. Only then can you remove your tag and lock and reconnect all sources of energy. You may then restart the equipment in accordance with normal startup procedures.

9.6.4 Training and Inspections

Training – All affected contractor employees must be trained in the purpose and use of lockout and tag out before the effort begins. All authorized employees shall be trained in recognition of hazardous energy sources, hazardous energy sources in use, and how to follow the lockout/tag out procedure. The appropriate contractor shall conduct retraining when an audit shows deficiencies with the procedures or at the request of a manager.

Inspections – When these procedures are applied to a single site for more than a month, an inspection must be done by an authorized employee. This inspection should include questions to determine if employees understand the purpose of lockout/tag out, if proper locks and tags are being used, and if established procedures are being followed.

9.6.5 Special Conditions

Other Contractors – Contractors and facility operators shall inform each other of their lockout/tag out procedures in enough detail for their employees to recognize the function of

locks or tags that they may observe during their work. Work shall not proceed until the need, function, and ownership of all locks or tags are clarified. Under no circumstance shall employees or subcontractors remove locks or tags of others.

Shift and Personnel Changes – The employees ending their shift shall remove their locks before leaving. However, they may only remove their lock if it is safe to operate the equipment or another lock is put in place that is under the control of someone on the next shift. When a piece of equipment will remain unsafe until the employee next returns, that lock may remain in place.

Power Sources that cannot be Locked Out – When a power source cannot be physically locked out, a tag out may be used without locks.

Plug-Supplied Equipment – Any employee who works on an appliance or device that obtains its power through a flexible cord shall apply a plug lockout device to its attachment plug or keep the plug in his or her control throughout that effort.

9.7 COMPRESSED GAS CYLINDERS

This section is not applicable to the current fieldwork. Compressed gas cylinders will be addressed in the contractor's dive plan.

9.7.1 Identification and Labeling

This section is not applicable to the current fieldwork.

9.7.2 Engineering Controls / Design Considerations

This section is not applicable to the current fieldwork.

9.7.3 Using Cylinders

This section is not applicable to the current fieldwork.

9.7.4 Storing Cylinders

This section is not applicable to the current fieldwork.

9.7.5 Transporting Cylinders

This section is not applicable to the current fieldwork.

9.7.6 Piping Incompatibilities and Restrictions

This section is not applicable to the current fieldwork.

9.7.7 Emergency Procedures

This section is not applicable to the current fieldwork.

9.7.8 Training

This section is not applicable to the current fieldwork.

9.8 WORKING AT HEIGHT & FALL PROTECTION

Working at height is unlikely for the pre-design investigation, but guidelines are included in the unlikely event they are needed. Contractor employees may be exposed to falls during their work at the site. To prevent injuries from falls, contractors shall comply with the following work practices concerning fall protection.

A fall exposure is considered to exist when an employee is within 6 lateral feet of a change in elevation of 6 vertical feet or more. Typical exposures can include:

- Working at height on process equipment or structures
- Excavations
- Leading edge of a surface (floor)
- Floor openings

All employees shall use fall protection 100 percent of the time when exposed to a fall more than 6 feet or when required by rules such as those of a client or the owner or operator of a facility. Fall protection may consist of any of the following:

- Guardrails
- Safety nets
- Positioning systems
- Warning systems
- Personal fall arrest systems.

Employees shall not use fall arrest equipment until they have been properly trained. Contractor SHSOs and site managers shall ensure fall protection is available and used as required for all

employees for whom they are responsible and that employees receive adequate training in the use of the equipment.

The following work practices and guidelines shall be considered for protection against falls:

- Before working or walking on a surface, consider the strength and structural integrity of the surface. Can it support employees and any needed equipment or material safely? Employees shall work on those surfaces only when the surfaces have the requisite strength and structural integrity.
- When not protected by any other means of fall protection, such as safety nets or scaffold with proper guardrails, employees shall use full body harnesses, lanyards with double-locking snap hooks, and an adequate anchorage (fall arrest equipment). To achieve 100 percent fall protection, employees may need to use a two-lanyard system and/or vertical or horizontal lifelines, retractable lifelines, or other approved positioning devices.
- Employees shall rig fall arrest equipment so that it minimizes the potential for a fall arrest event or any potential free-fall, lateral swing, or contact with any lower object. Under no circumstances shall fall arrest equipment be rigged so that an employee can free-fall more than 6 feet.
- Anchorage points for fall arrest equipment shall be capable of supporting 5,000 pounds per employee attached. Anchorage points for fall arrest equipment shall be located above the employee's body harness attachment point where practical.
- When vertical lifelines are used, a separate lifeline shall protect each employee. The lifeline shall be properly weighted at the bottom and terminated to preclude a device such as a rope grab from falling off the line.
- Horizontal lifelines shall be limited to two persons at one time between supports and maintain a safety factor (strength/requirement) of at least 2.
- Before each use, employees shall visually inspect all fall arrest equipment for cuts, cracks, tears, or abrasions; undue stretching; overall deterioration; mildew; operational defects; heat damage; or acid or other corrosion. Equipment showing any defect shall be withdrawn from service. All fall arrest equipment subjected to impacts caused by a free-fall or by testing shall be removed from service. Personnel shall use full body harnesses for personal fall protection.
- Fall arrest equipment shall be stored in a cool dry place not subjected to direct sunlight.
- Fall arrest equipment shall not be used for any other purpose, such as towropes or hoist lines.
- Proper guardrails shall be installed on open sides of all walkways and runways where the fall distance exceeds 4 feet. Proper guardrails shall be installed on open sided floors where the fall distance exceeds 6 feet. All floor openings or floor holes shall be protected

by guardrails or hole covers. If hole covers are used, they shall be strong enough to support the maximum intended load, secured against displacement, and properly labeled.

- When guardrails are used for fall protection, they shall consist of a top rail, intermediate rail, and toe board. The top rail shall have a vertical height of 42 inches; the mid-rail shall be at 21 inches, and the toe board 4 inches. When wood railings are used, the post shall be of at least 2-inch by 4-inch stock spaced not to exceed 8 feet, the top rail shall be of at least 2-inch by 4-inch stock, and the intermediate rail shall be of at least 1-inch by 6-inch stock. If pipe is used, it shall be at least 1½-inch nominal diameter. If structural steel is used, it shall be of 2-inch by 2-inch by 3/8-inch angles or equivalent. If wire rope is used for railings, it shall have a diameter of at least 2 inches and shall be stretched taut to allow no more than a 3-inch deflection.
- When operating a scissor-lift work platform, the lift shall have guardrails on all open sides, with the door access chains or rails in place.
- Employees operating aerial lifts shall wear a body harness and lanyard attached to the aerial lift. Employees shall not attach the lanyard to an independent structure.
- Employees riding in a crane-suspended work platform shall wear a body harness and lanyard attached to the grab rail of the platform.
- Employees working on or near wall forms or rebar shall wear a body harness lanyard and/or positioning device when exposed to a fall more than 6 feet.
- Positioning devices shall be rigged to prevent a free-fall greater than 24 inches.
- Stairs, ladders, or ramps shall be provided for all access ways where there is a change in elevation greater than 19 inches.
- Manila or synthetic rope shall not be used as guardrails.
- Employees shall not stand or sit on guardrails.
- Personal fall arrest systems shall not be attached to guardrail systems.
- Employees shall not use vehicles (e.g. pickups, flatbeds etc.) as walking/working surfaces for work at any height unless they have been specifically adopted for working at height and such use has been approved by LSS.
- If warning lines are used, they shall consist of rope, wire, or chain and be flagged at intervals of 6 feet or less with high-visibility material. The lowest point shall be no less than 34 inches from the surface and the highest point shall be no more than 39 inches. The warning line shall be placed at least 6 feet from the edge.
- Safety net systems shall be installed as close to the working surface as practical, but in no case, more than 25 feet below the working surface and shall extend outward at least 8 to 13 feet depending on the vertical fall distance. Safety nets shall be drop-tested after

initial installation and at 6-month intervals. The maximum size of net mesh shall not exceed 36 square inches nor be longer than 6 inches on any side. Mesh opening shall be secure to prevent enlargement.

- Body belts shall not be used for personal fall arrest. Full body harnesses are required.
- A written rescue plan will be developed for the safe recovery of an employee should a fall arrest system be required.

9.9 EXCAVATIONS

Test pits will be excavated along the riverbank as part of the pre-design investigation. Contractor employees who work in or around excavations are exposed to many hazards. Contractor employees shall learn to recognize these hazards and avoid situations that put themselves, other employees, or subcontractors at risk. Contractor employees shall comply with the following safe excavation work practices. A copy of RETIA USA's Excavation and Trenching Procedure is provided as **Appendix N**.

9.9.1 Pre–Excavation Activities

Before excavation, the location of any underground utilities such as gas, sewer, electricity, and telephone lines shall be determined and marked. On private property, the contractor may need to be asked to locate underground utilities. In some cases, it may be necessary to use non-intrusive subsurface investigation techniques to identify underground utilities and installations.

Excavations shall be conducted under the direction of a "competent person." OSHA defines "competent person" as an individual who, by way of training and/or experience, is knowledgeable of applicable standards, is capable of identifying workplace hazards relating to the specific operation, is designated by the employer, and has authority to take appropriate actions. For excavations, the competent person shall be on site and is responsible for ensuring the following:

- Performing documented inspections before the start of each shift and as needed throughout the shift to ensure a safe operation.
- Removing employees from the hazardous area when there is evidence of a possible cave-in.
- Identifying and correcting hazards associated with the excavation.
- The contractor responsible for the excavation shall provide the competent person.
- For many excavations, an excavation permit must be completed before excavating. The permit shall be generated by the contractor performing the work. If necessary, the

permit shall be completed by the competent person for that excavation. Contractors shall describe their process for issuing excavation permits in their component specific HASP.

- Surface encumbrances (buildings, utility poles, pavement, or other structures that may be undermined by the excavation) that have a potential to create a hazard to employees or become subject to physical damage must be removed, supported, or neutralized, as necessary, before the start of any excavation work.
- The competent person must evaluate soil conditions and determine the shoring or sloping requirements for the trench or excavation, based on the soil evaluation. If no attempt is made to determine soil type, excavations shall be sloped at an angle not steeper than 1.5 (horizontal) to 1 (vertical) (34 degrees), or a trench box or other protective system shall be used. For excavations, greater than 20 feet (6 meters) in depth, sloping and/or shoring systems must be designed by a professional engineer.

9.9.2 During Excavation

- The competent person must inspect the trench or excavation daily before performing any work within the trench or excavation deeper than 5 feet.
- For trenches, less than 5 feet deep, the competent person must inspect and evaluate the potential for a cave-in.
- All excavations that are 4 feet deep or deeper shall have a ladder for access into the excavation with no more than 25 feet of lateral travel in any direction.
- All excavations that are 5 feet deep or deeper and excavations shallower than 5 feet in unstable soil shall be sloped, braced, or shored to prevent cave-ins.
- No material, including trench spoil, may be stored within 2 feet of the edge of the excavation.
- All excavations shall be barricaded with the appropriate barrier tape and other protective devices to protect against falls or other inadvertent entry.
- If possible, excavations should not be left open. If an excavation must be kept open, proper covers, fencing, and security should be provided to prevent public access to the excavation during non-working hours.
- Tools, equipment, or heavy machinery shall not be placed near an excavation where they may affect the structural stability of the walls or fall into the excavation.
- When mobile equipment is operated adjacent to an excavation, or when such equipment is required to approach the edge of an excavation, and the operator does not have a clear and direct view of the edge of the excavation, a warning system such as barricades, use of a dedicated spotter, hand or mechanical signals, or stop logs shall be used. Where possible, the grade should slope away from the excavation.

- Place any environmentally impacted soils on plastic liners and cover the spoil piles to prevent further spreading of the contamination. The liners and covers shall be durable enough for the intended period of storage.
- For all excavations at this site, air monitoring should be conducted before entry and periodically during the work to ensure that a safe atmosphere is maintained during excavation work. Air monitoring shall be performed for explosive/flammable vapors, oxygen, and any hazardous gases that may be present such as hydrogen sulfide, carbon monoxide, or other hazardous gases that may be present because of activities conducted in the excavation or contaminants in the soil. Use forced ventilation if needed. Acceptable entry conditions are:
  - Oxygen 20.5 percent to 23.5
  - < 10 percent of the lower explosive limit
  - Hydrogen Sulfide < 10ppm
  - Carbon Monoxide < 25ppm
  - Total VOCs < 25ppm
  - Benzene < 1ppm

Note: If air monitoring results indicate levels outside of the conditions above, employees and subcontractors shall not enter the excavation and shall contact their SHSO for guidance.

- Heavy equipment, tools, or individuals shall not operate/work within 10 feet of any power line or exposed electrical distribution component unless it has been de-energized and visibly grounded or provided with an effective insulating barrier.
- Workers shall wear required PPE.
- The competent person must evaluate soil conditions and stability as new soil layers are uncovered.
- Do not stand under any live load, including an excavator bucket.
- Stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials.
- Do not stand in the swing radius of excavation equipment.

9.10 LADDERS

Ladders are unlikely to be needed for the pre-design investigation, but guidelines are included in the unlikely event they are needed. Per Total's guidelines, ladders are used to access elevated work areas only on an exceptional basis. Ladders should not be used as a work station or only exceptionally for simple tasks, when no other means can be implemented and only after a risk

assessment has been conducted and approved by LSS. The use of mobile Individual Platforms (MIP) or Lightweight Individual Movable Platform (LMIP) for works at low and medium heights is preferred. Mobile Individual Platforms are also known as work stand platforms, rolling ladders, safety cages etc. The following guidelines shall be followed by contractor employees when using ladders.

9.10.1 Portable Ladders

- Ladders shall be used to travel from one elevation to another. Except where it is not feasible, work shall not be performed from ladders. When it is necessary to perform work at high elevation, scaffolds or mobile lift equipment shall be used.
- If it is necessary to work from a ladder:
  - The ladder shall be secured to prevent it from slipping or falling.
  - When possible, employees working more than 6 feet above grade should wear a body harness and lanyard and tie off to a secure anchor, (not the ladder!) or have another employee hold the ladder.
- Before using any ladder, it shall be inspected. Look for:
  - Missing non-skid feet
  - Worn or frayed ropes
  - Cracks in sides or rungs
  - Missing rivets or other fasteners
  - Bent or missing spreaders
  - Bowed or distorted members
  - Loose rungs
  - Any condition that could cause a safety problem
- Ladders that have fallen or been misused shall be checked for excessive dents or damage.
- Ensure that tie-off rope is attached and in good condition.
- Ensure that the spreaders and locking mechanisms on stepladders are in good condition.
- Ensure that hinges move easily and are in good condition.
- Ladders should not be painted. Paint can hide damage and defects.

- Select the correct type of ladder for the job. Only fiberglass ladders shall be used at electricity-generating facilities. Only non-conductive ladders shall be used for work involving electricity or the use of electrically powered tools. Make sure the ladder is long enough to reach the desired point without compromising recommended safe-use procedures.
- Secure ladders by tying the top or bottom to a fixed structure that will support more than the anticipated total load. Maintain an adequate slope with the base at least one quarter of the length of the ladder away from the supporting structure.
- The ladder shall extend 3 feet above any landing you will access.
- Do not leave unattended step or straight ladders standing. They shall be closed, lowered to the ground, and placed where they do not present tripping hazards.

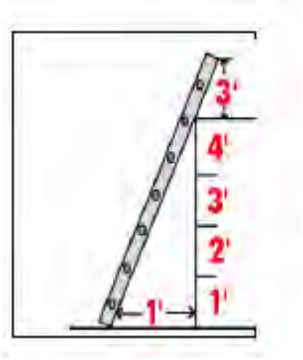


Figure 9-1 Portable Ladder Use

- Keep the area around the base and top of the ladder free of tripping hazards, and barricade the area if the base or top projects into a passageway.
- When either the length or the weight of a ladder makes it difficult to handle, two people shall raise and secure the ladder. One shall secure the feet while the other walks under the ladder from the opposite end until it is raised enough to place or move. Raise the extension, if needed. Reverse the process for lowering the ladder.
- Extension ladders must be equipped with necessary irons, locks, and hooks and assembled so the sliding (upper) section is on top of the base (lower) section. In addition, extension ladder sections shall overlap at least 3 feet. If the ladder extends more than 4 feet above the top tie-off, place a barrier or flag on the ladder to prevent personnel from climbing beyond a safe point.
- Ensure that shoes/boots are free of mud, oil, or grease before ascending or descending a ladder. Ladder rungs shall be cleaned immediately if they become soiled to reduce slipping hazards.
- Employees shall use a tool pouch or bucket-and-line to raise or lower materials, rather than carrying them while ascending or descending a ladder.
- Only one employee shall climb or descend a ladder at a time.
- When climbing, or descending a ladder, face the ladder and maintain three points of contact always (i.e., two feet and one hand, two hands and one foot).
- Straight ladders shall not be climbed beyond the third step from the top.

- Excavations and trenches more than 4 feet deep shall have a ladder (or ladders) that extend at least 3 feet above the ground surface placed so that personnel will not travel more than 25 feet horizontally to get to a ladder.
- When storing ladders, take the following precautions:
- Ladders stored horizontally should have support in enough places to prevent sagging and permanent set.
- Tie together or secure ladders that are stored vertically to keep them from falling into aisles or equipment.
  - Do not store wooden ladders near radiators, stoves, or other heat sources that could dry the wood and cause deterioration.
  - Do not store wooden ladders near steam lines or other places where they are kept wet or damp enough to rot wood.
  - Clean ladders after every use before returning them to storage. Remove all mud, oil, and grease.

9.10.2 Stepladders

- Stepladder legs shall be fully spread with the spreader bars locked in place.
- Stepladder should be placed on a level surface will all feet touching the ground surface.
- Stepladders shall not be used as straight ladders.
- The top two steps shall not be used.
- Do not leave tools or materials on the top shelf of a stepladder; remove them before descending a ladder and/or moving it.

9.10.3 Fixed Ladders

Fixed ladders more than 20 feet high must be caged unless other fall prevention safety devices are installed and used. Fixed ladders with cages exceeding 20 feet in height shall have landing platforms installed every 30 feet. Use of the body harness and lanyard described in Section 9.8 would meet this requirement.

Fixed ladders shall be securely attached to an immobile structure and attachments shall be inspected annually for signs of deterioration or detachment. Repairs must be made immediately. An example of a fixed ladder is depicted in **Figure 9-2**.

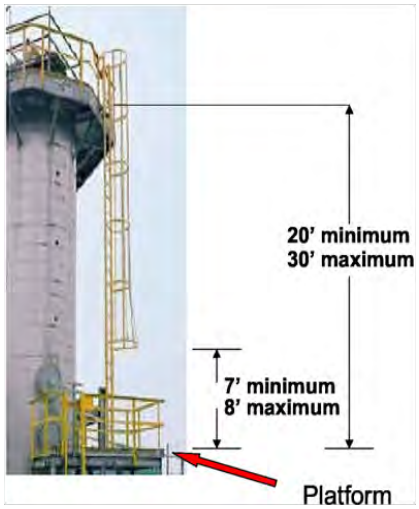


Figure 9-2. Fixed Ladders.

9.11 TOOLS AND POWER EQUIPMENT

9.11.1 Hand Tools

Contractor employees who have a need to use basic hand tools shall comply with the following work practices:

- All tools shall be of an approved type and maintained in good condition. Tools are subject to inspection at any time. Contractor managers and supervisors have the authority and responsibility to condemn unserviceable tools, regardless of ownership.
- Tag defective tools to prevent their use or removal from the job site.
- Use the proper tool for the job performed.
- Do not use hammers with metal handles, screwdrivers, knives with metal continuing through the handle, and metallic measuring tapes on or near energized electrical circuits or equipment.
- Do not throw tools from place to place or from person to person. Tools that must be raised or lowered from one elevation to another shall be placed in tool buckets or firmly attached to hand lines.
- Do not place tools unsecured on elevated places.
- Dress, repair, or replace all impact tools such as chisels, punches, drift pins, etc., that become mushroomed or cracked before further use.

- Use suitable holders or tongs, not the hands, to hold chisels, drills, punches, ground rods, or pipes that are struck by another employee.
- Do not use shims to make a wrench fit.
- Do not use wrenches with sprung or damaged jaws.
- Do not use pipes or other means to extend a wrench handle for added leverage unless the wrench was designed for such use.
- Use tools only for the purposes for which they have been designed.
- Store and handle tools with sharp edges so that they will not cause injury or damage. They shall not be carried in pockets.
- Use eye protection when using or working around impact type tools (e.g., hammer, chisel, ax, hatchet, etc.).
- Replace wooden handles that are loose, cracked, or splintered. The handle shall not be taped, glued, or lashed with wire.
- Keep all cutting tools such as saws, wood chisels, knives, or axes in suitable guards or in special compartments.
- When using such tools as screwdrivers and wrenches, avoid using your wrists in a bent, flexed, extended, or twisted position for long periods of time. Employees shall maintain their wrists in a neutral or straight position. Do not use screw drivers for prying.
- Do not leave tools lying around where they may cause a person to trip or stumble.
- When working on or above open grating, use a canvas or other suitable covering to cover the grating to prevent tools or parts from dropping to a lower level where others are present, or barricade or guard the danger area.
- Do not depend on the insulation on hand tools to protect users from shock.

9.11.2 Electric Tools

Contractor employees who have a need to use electric power tools shall comply with the following work practices:

- The non-current carrying metal parts of portable electric tools such as drills, saws, and grinders shall be effectively grounded when connected to a power source unless the tool is an approved double-insulated type or the tool is connected to the power supply by means of an isolating transformer or other isolated power supply, such as a 24-volt direct current (DC) system.

- All power tools shall be examined before use to ensure general serviceability and the presence of all applicable safety devices. The electric cord and components shall be given a thorough examination for cracks, exposed wires, or other defects.
- Power tools shall be used only within their capability and shall be operated in accordance with the manufacturers' instructions.
- The use of eye protection is required when using or working around power tools.
- Operators shall take care to use appropriate hand positions on cutting tools such as saws, drills, or grinders to avoid hand injury.
- All tools shall be kept in good repair and disconnected from the power source while repairs are being made.
- Electrical tools shall not be used where there is a hazard of flammable vapors, gases, or dusts until that hazard is firmly under control.
- GFCI shall be used with all electric power tools.
- All guards and safety interlocks with which the tools were purchased shall be in place and in working order.
- Any tool that is identified as defective shall be tagged "not for use," and set aside for repair and/or discarded.
- Do not wear loose or frayed clothing while operating power tools and equipment. Hair should not stick out from hard hats.
- Do not use electrical cords to transport, suspend, hoist, or lower tools.
- Do not allow power cords to lie in water.

Disconnect rotating tools from the power source before adjusting, servicing, or cleaning them. Follow the lockout procedure described in Section 9.6.

- Do not modify tools.

9.11.3 Pneumatic Tools

Contractor employees that use pneumatic power tools shall comply with the following work practices:

- Compressed air and compressed air tools shall be used with caution.
- Pneumatic tools shall never be pointed at another person.
- Pneumatic hose connections shall be secured by some positive means to prevent them from becoming accidentally disconnected. Chicago fittings have wire holes to allow such security.

- Pneumatic power tools shall be secured to the hose by some positive means to prevent the tool from becoming accidentally disconnected.
- Safety clips or retainers shall be securely installed and maintained on pneumatic impact tools to prevent attachments from being accidentally expelled.
- Compressed air shall not be used for cleaning purposes except when reduced to less than 30 psi and then only with effective chip guarding and PPE.
- Compressed air shall not be used to blow dust or dirt from clothing (or skin).
- The manufacturer's safe operating pressure for hoses, pipes, valves, filters, and other fittings shall not be exceeded.
- The use of hoses for hoisting or lowering tools shall not be permitted.
- All compressed air hoses exceeding 30 psi shall have a safety device at the source of supply or branch line to reduce pressure in case of hose failure or disengagement of a connection.
- Before adjusting or changing air tools, the air shall be shut off at the air supply valve ahead of the hose. The hose shall be bled at the tool before breaking the connection. Disconnection at the quick-change connectors is one way to meet this goal.
- Eye protection is required when using or working around pneumatic tools.
- Use hearing protection if noise exposure is a concern (i.e., if it is too loud to conduct a normal conversation).
- Pneumatic tools shall be operated only by persons trained in their use.
- A pneumatic tool used where it may contact exposed live electrical parts shall have a non-conductive hose and an accumulator to collect moisture.
- Employees shall not use any part of their bodies to locate or attempt to stop an air leak.
- All guards and safety interlocks must be in place and functional.

9.11.4 Engine-Powered Tools

This section is not applicable to the current fieldwork.

9.12 WORKING AROUND HEAVY EQUIPMENT

Contractor employees shall comply with the following work practices while working around heavy equipment:

- Assume the operator cannot see you. The operator's vision may be blocked by blind spots. He or she is frequently concentrating on their work and equipment and may not notice a site visitor.
- If you must approach the operator, be sure you have made radio and eye contact with the operator and they know you will be approaching them before approaching the equipment. Verbal contact, direct or by radio, is even better. Do not approach if the equipment is moving or in operation.
- Stay clear of pinch points and swing areas of equipment. These areas shall be taped or barricaded off; however, when equipment moves frequently, you cannot count on other organizations to mark these zones.
- Do not walk near a moving piece of equipment. It could turn or rotate any minute. Modern construction equipment moves fast and in any direction.
- On a noisy site, you may not notice the equipment's back-up alarm. Keep aware of what is happening around you.
- Never walk under a load on a crane or hoist. Indeed, avoid the area under the hook or bucket.
- Do not cut across the path of equipment backing up.
- Wear your hardhat and safety glasses. The safety glasses protect your eyes from dust and debris and the hardhat provides protection for your head and makes you more visible on the site.
- Maintain a clearance of at least 10 feet between any part of the machine or its load and any electrical line or apparatus carrying up to 50,000 volts. One foot of additional clearance is required for every additional 30,000 volts.

9.13 WORKING NEAR OR OVER WATER

When working on, over, or near water, basic water safety precautions must be taken. Such areas include banks and shores of lakes, streams and ponds, dock areas, working from vessels of any kind, aeration basins, sedimentation basins with standing water or any other areas where a danger of drowning may exist.

Contractors shall comply with the following procedures when working near or over water at the project site.

- Employees shall wear Coast Guard-approved PFDs (either vests or jackets) where a potential danger of drowning exists. PFDs are required when working from any type of boat or floating platform.

- The PFDs should be inspected before and at the end of each use for wear, torn stitching or straps, inoperable buckles, or other defects.
- Ring buoys with at least 90 feet of line shall be provided and readily available for emergency rescue operations. Distance between ring buoys shall not exceed 200 feet.
- At least one lifesaving skiff shall be immediately available at locations where employees are working over or adjacent to water, unless the width of the water body is small enough to allow any potential rescue to occur from the bank (as would be the case with most aeration basins and sedimentation basins).

In some circumstances, additional precautions may be required by OSHA regulations. If you are planning to conduct work where water hazards may be present, be sure to take all appropriate precautions. Contractors working over or near water shall review the full text of the OSHA Standard for Work Over or Near Water, and comply with all its applicable requirements.

The drowning risk assessment for the site is included in **Appendix O.**

9.13.1 U.S. Coast Guard Notification

The USCG will be notified of the schedule and scope of the in-water sampling work. If the USCG deems a notice to mariners to be necessary, the information will be provided by LSS to make barge and other river traffic aware of these activities. The contact information for the USCG is provided in Section 8.2.

9.13.2 General Overwater Safety Guidelines

The overwater safety program requires the following:

- Wear PFD at all times when working over water. Inspect the PFDs prior to use and do not use defective PFDs. PFDs will be selected such that the flotation device positions the face of an unconscious wearer out of the water at all times (note: certain OSHA flotation vests do not float a person in that position when unconscious).
- Hypothermia protective clothing will be donned in accordance with the USCG Boat Crew Manual (Commandant Instruction M16794.51):
  - When water temperatures are greater than 60°F (air temperature is not a factor), Type I, II, or III PFDs (includes the float coat) will be donned.
  - When water temperature is 50 to 59°F (air temperature is not a factor), anti-exposure coveralls will be donned.
  - When water and air temperatures are both below 50°F, dry suits with proper undergarments (includes polypropylene underwear, cold weather boots, and

thermal barrier) will be donned. The MSD-900 and the USCG-approved Boat Crew Dry Suit are both acceptable to be worn.

- The boat operator must have training in the safe operation of the boat.
- No smoking is allowed on boats or near refueling activities.
- Keep sampling equipment on boats organized at all times.
- Boats are required to be equipped with a throwable life ring, fire extinguisher, first aid kit, eyewash bottle and water (if acids are taken on the boat), drinking water (for long trips), alternate propulsion mechanism (e.g., paddles), rope, and warning horn, and each field member will be briefed on the storage location of this equipment.
- Use all equipment in accordance with the manufacturers' recommendations.

9.13.3 Sampling Vessel Operations

The physical hazards associated with the deployment and retrieval of sampling equipment result from the equipment's weight and the method of deployment. Only trained personnel will deploy and retrieve sampling gear. Under circumstances of potentially dangerous waves or winds, the vessel pilot and cruise leader will employ best professional judgment to ensure safe field operations.

To avoid injuries from heavy equipment, personnel will wear steel-toed boots, safety glasses, hard hats, and gloves at all times during mobilization, operation, and demobilization of vessels. Sample handling equipment, containers, deck lines, hydraulic cables, and water hoses not in immediate use will be kept clear of walkways and work areas until needed. Each time operations at a given location have been completed, excess sediment on the deck will be containerized in (DOT-approved 55-gallon drums to prevent personnel from slipping, to minimize personnel exposure to potentially contaminated sediment, and to limit cross-contamination between sample locations.

Life vests will be provided for and worn by all personnel working on the deck, or as directed by the site safety officer or vessel operator. The vessel is also equipped with throwable life rings, fire extinguishers, and warning horns, and each crewmember will be briefed on the storage location of this equipment.

9.13.4 Small Craft Operation

Safety procedures on small boats (i.e., length 20 ft or less) may necessitate an increased level of protection, depending on boat size and location in the river. Small boat procedures will include all the requirements listed above. In addition, all personnel onboard will be required to wear life vests at all times. Any Integral staff or subcontractors operating small watercraft in the

lower Willamette River during work in support of the removal action activities must have completed a USCG Auxiliary *Boating Safely* or equivalent course and have a demonstrated knowledge of the safe handling of these craft (Section 5.1).

9.14 FLAMMABLE AND COMBUSTIBLE LIQUIDS

Work with flammable or combustible liquids exposes the employees to fire, explosion, and toxicity hazards. Contractor employees shall comply with and implement the following controls.

9.14.1 Storage and Handling

- Only approved containers and portable tanks shall be used for the storage and handling of flammable and combustible liquids.
- Approved safety cans shall be used for the handling and use of flammable liquids in quantities greater than 1 gallon.
- For quantities of 1 gallon or less, only the original container or approved safety cans shall be used for storage, use, and handling of flammable/combustible liquids.
- If flammable or combustible liquids must be shipped, the individual offering the material for shipment must have completed approved hazardous material training.
- Flammable or combustible liquids shall not be stored near exits, stairways, or pathways that people normally use for safe passage.
- No more than 25 gallons of flammable/combustible liquids shall be stored in a room outside of a storage cabinet or tank approved for the purpose.
- Quantities of flammable and combustible liquids more than 25 gallons shall be stored in an acceptable or approved cabinet meeting the requirements of 29 CFR 1926.152(b)(2)(i).
- Cabinets shall be labeled in conspicuous lettering, "Flammable - Keep Fire Away."
- Not more than 60 gallons of flammable or 120 gallons of combustible liquids shall be stored in any one storage cabinet. Not more than three cabinets may be in a single storage area.

9.14.2 Outdoor Storage

- For storage of flammable and combustible liquids outdoors, containers (not more than 60 gallons each) shall not exceed 1,100 gallons in any one pile or area. Five feet of clearance shall separate piles or groups of containers. These containers shall remain at least 20 feet from any other building or structure.

- Within 200 feet of each pile of containers, there shall be a 12-foot wide access way to permit approach of fire control apparatus.
- The storage area shall be graded in a manner to divert possible spills away from buildings or other exposures, or shall be surrounded by a curb or earth dike at least 12 inches high. Provisions shall be made for the controlled draining of accumulations of groundwater or rainwater, or spills of flammable or combustible liquids when curbs or dikes are used.
- At least one portable fire extinguisher, having a rating of not less than 20 pounds, shall be located not less than 25 feet or more than 75 feet from any flammable or combustible liquid storage area located outdoors.
- Precautions shall be taken to prevent the ignition of flammable/combustible vapors. Sources of ignition include, but are not limited to: open flames; lightning; smoking; cutting and welding; hot surfaces; frictional heat; static, electrical, and mechanical sparks; spontaneous ignition, including heat-producing chemical reactions; and radiant heat.

9.14.3 Dispensing Flammable and Combustible Liquids

- Areas where flammable or combustible liquids are dispensed at one time, in quantities greater than 5 gallons from one tank or container to another tank or container, shall be separated from other operations by 25 feet or by construction having a fire resistance of at least 1 hour. Adequate natural or mechanical ventilation shall be provided to maintain the concentration of flammable/combustible vapor at or below 10 percent of the LEL.

- Static electricity is generated by the contact and separation of dissimilar material, such as when fluid flows through a pipe or from an orifice into a tank. If the accumulation of static charge is sufficient, a static spark may occur. Transfer of flammable/combustible liquids from one container to another shall be done only when containers are electrically bonded and grounded to prevent such accumulation of static charge (**Figure 9-3**).

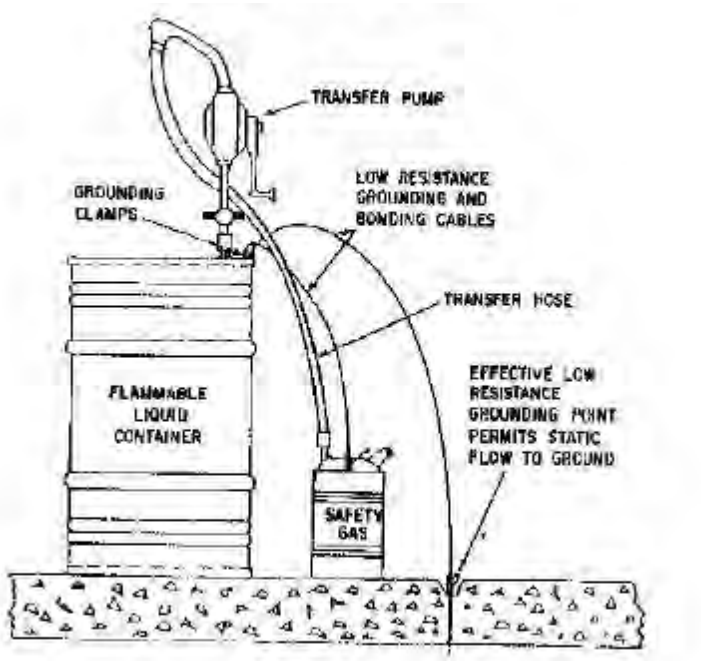


Figure 9-3. Typical Grounding System

- The management of flammable and combustible liquids is much more complicated than is indicated by the length of this section, which reviews only those issues appropriate to the incidental use of these materials.

Storage and handling of the mobile and combustible liquids shall comply with the requirements of National Fire Code No. 30.

9.15 HAZARDOUS WASTE SITE CONTROLS

Work sites designated as hazardous waste sites must control access to the work area to only authorized personnel and conform to general work practices expected at hazardous waste site operations as required by the OSHA Standard for Hazardous Waste Operations, 29 CFR 1910.120. Contractors shall comply with the following procedures regarding hazardous waste site controls.

9.15.1 Access Control

Controlled access to project work areas is required to protect personnel working on the site as well as to limit the potential for transporting contaminants offsite. Details of site-specific access control procedures shall be included in the SRAC site-specific HASP.

Contractors shall comply with the following practices regarding access control:

- Set up physical barriers and assign personnel to prevent non-authorized persons from entering the work site.
- Keep the number of personnel and equipment onsite to the minimum required to do the project effectively and safely.
- Establish work zones within the site.
- Establish controlled access points to be used by authorized personnel.
- Track the entry and exit of personnel through a check-in, checkout system.
- Establish a formal decontamination corridor from exclusion zones.

9.15.2 Work Zones

Contractors are required to establish work zones to prevent the spread of site contaminants to non-contaminated areas on or offsite. Movement between zones shall be restricted to those that need access to a specific area, and entry and exit between zones shall be through designated access control points. A description of the required three work-zone system is provided below.

Exclusion Zone – The exclusion zone shall include any area where contamination is known or suspected. Areas of air, water, soil, or sediment that are contaminated with hazardous materials shall be included in the exclusion zone. The zone shall be well known to site workers. The zone shall be defined with caution tape, signage, traffic cones, fencing, and barriers. The need will be location-specific and the specific method shall be identified in the contractor's component-specific HASP. Work practices that shall be followed in the exclusion zone include:

- Employees in the exclusion zone must wear the PPE designated in this site HASP, the contractor's component-specific HASP for tasks executed within the zone.
- No eating, drinking, chewing gum or tobacco, smoking, application of cosmetics, including application of lip balm, sunscreen, or insect repellant is allowed in the exclusion zone.
- Sitting or kneeling in areas of high concentrations of contaminants shall be avoided.
- If any PPE becomes defective or visibly contaminated, the employee shall leave the work area via the designated egress area, and decontaminate or replace the items as needed in the decontamination facility before returning to work in the exclusion zone. Contaminated PPE must be disposed of properly.
- Prescription drugs shall not be used within the exclusion zone unless approved by the contractor's medical consultant. The use of illegal drugs or consumption of alcohol is prohibited.

- When leaving the exclusion zone, employees shall exit via the designated access/ egress point(s) and follow decontamination procedures described in the contractor's component-specific HASP.

Contaminant Reduction Zone – A Contaminant Reduction Zone (CRZ) shall be established to provide a transition between the exclusion zone and the support zone. The CRZ shall be set up at the access control points of the exclusion zone and will vary in size depending on the complexity of activities that need to occur within the zone. The CRZ shall include the 3-stage decontamination facility and any equipment decontamination pads established for equipment exiting the exclusion zone. The specific requirements for personnel PPE while in the CRZ shall be outlined in the contractor's component-specific HASP. The CRZ shall be placed in an area that is not contaminated at the boundary of the exclusion zone.

Support Zone – The support zone shall be established near the entrance to the site and far enough from the exclusion zone and CRZ that specialized protective clothing or respirators are not used. The use of normal Level D field PPE such as hard hats, safety glasses, high visibility clothing, and safety work boots is expected except for areas such as office trailers, break and lunch areas, or other areas designated as having no known or anticipated hazards. Operational support activities and equipment storage and maintenance areas are in the support zone. No equipment or personnel shall go from the exclusion zone to the support zone without passing through the CRZ's decontamination facility and being decontaminated in accordance with the contractor's component-specific HASP.

9.15.3 Considerations when Establishing Work Zones

Work zones shall be large enough to perform tasks within the zone safely, with no exposure to hazards to personnel outside the zone, but they should also be small enough to be able to secure and control access. Some considerations in establishing work zones include:

- Physical and topographical features of the site
- Dimensions of the contaminated area
- Weather
- Physical, chemical, and toxicological characteristics of contaminants and chemicals used in the zone
- Potential for exposure to site contaminants
- Fire and explosion potential
- Planned operations and space needed to perform the work safely
- Surrounding areas
- Decontamination procedures

- History of job site.

9.15.4 Work Zones Established for the Arkema Project Area

Site control measures in the work zones are described below for each type of field activity at the Arkema Project Area.

9.15.4.1 Surface and Subsurface Sediment sampling

Exclusion zone: All subsurface sediment sampling will occur on the sampling vessel. During sampling on the sampling vessel, the exclusion zone includes the area of the vessel in which sediments collected from the river bottom are handled. This area will be considered the exclusion zone only when samples are being handled on the vessel.

CRZ: The CRZ during sediment handling is the entire vessel deck, except as noted in the preceding paragraph. Decontamination of both personnel and equipment will occur in this zone to prevent the transfer of chemicals of concern to the support zone.

Support zone: On the sampling vessel, the support zone will be located in the cabin of the vessel or on the vessel deck when contaminated sediments are not on deck.

Controls to be used to prevent entry by unauthorized persons: No unauthorized persons will be allowed on the sampling vessel.

9.15.4.2 Riverbank Soil Sampling

Exclusion zones:

- Test Pit Excavations—An approximately 20-ft radius around the backhoe will be marked with orange traffic safety cones or caution tape.
- Hand Auger Borings—An approximate 6-ft radius around the boring will be marked with orange traffic safety cones.

CRZ: After sampling is completed at a station, the exclusion zone will become the CRZ.

Support zone: All areas outside the exclusion and contaminant reduction zones will be considered the support zone.

Controls to be used to prevent entry by unauthorized persons: No unauthorized persons will be allowed into the exclusion/contaminant reduction zones.

9.15.4.3 Porewater Sampling

Exclusion zone: During sampling on the sampling vessel, the exclusion zone includes the area of the vessel where the porewater sampling occurs. This area will be considered the exclusion zone only when samples are being handled on the vessel.

CRZ: The CRZ during sediment handling is the entire vessel deck, except as noted in the preceding paragraph. Decontamination of both personnel and equipment will occur in this zone to prevent the transfer of chemicals of concern to the support zone.

Support zone: On the sampling vessel, the support zone will be located in the cabin of the vessel or on the vessel deck when contaminated sediments are not on deck.

Controls to be used to prevent entry by unauthorized persons: No unauthorized persons will be allowed on the sampling vessel.

9.15.4.4 Groundwater Discharge Study

Exclusion zones:

- Seepage meter deployment/retrieval and porewater sampling—During porewater sampling on the sampling vessel, the exclusion zone includes the area of the vessel where the porewater sampling occurs. This area will be considered the exclusion zone only when samples are being handled on the vessel.
- Piezometer Installation—An approximately 20-ft radius around the backhoe will be marked with orange traffic safety cones or caution tape.
- Groundwater monitoring and transducer deployment—An approximate 6-ft radius around the well or piezometer will be marked with orange traffic safety cones.

CRZ: After sampling is completed at a station, the exclusion zone will become the CRZ.

Support zone: All areas outside the exclusion zone and CRZ will be considered the support zone.

Controls to be used to prevent entry by unauthorized persons: No unauthorized persons will be allowed into the exclusion/contaminant reduction zones.

9.15.4.5 IDW Management

Exclusion zone: During sampling on the sampling vessel, the exclusion zone includes the area of the vessel in which sediments collected from the river bottom are handled. This area will be considered the exclusion zone only when samples are being handled on the vessel.

CRZ: The CRZ during sediment handling is the entire vessel deck, except as noted in the preceding paragraph.

Support zone: On the sampling vessel, the support zone will be located in the cabin of the vessel or on the vessel deck when contaminated sediments are not on deck. The beach area and upland portion of the site where drum storage occurs are also part of the support zone. The IDW will be managed on the vessel and will be transferred in 5-gallon plastic buckets (or similar containers) and carried to the upland portion of the site and placed into DOT-approved 55-gallon drums.

Controls to be used to prevent entry by unauthorized persons: No unauthorized persons will be allowed on the sampling vessel. Sampling staff will instruct people to stay outside the transfer areas on the beach and upland portion of the site.

9.15.5 General Hazardous Waste Site Work Practices

- **Buddy System** – Work shall be scheduled so that no person works unobserved within the exclusion zone at any time. Each worker within the exclusion zone shall maintain visual contact with at least one other worker on the site. All site personnel shall remain aware of each other and monitor each other's condition.
- **Eating, drinking, chewing gum or tobacco** are prohibited within the contaminant reduction and exclusion zones. (Single-portion drink containers and drinking of replacement fluids for heat stress control is permitted only in support areas.)
- **Smoking** is prohibited for Integral personnel and subcontractors in all areas of the site because of the potential for contaminating samples and for the health of the field team.
- All personnel leaving potentially contaminated areas must wash their hands, forearms, and faces in the CRZ prior to entering any clean areas or eating areas.
- Personnel leaving potentially contaminated areas must shower (including washing hair) and change into clean clothing as soon as possible after leaving the site. The work clothing should be washed separately from other laundry as soon as possible.
- Long hair must be secured away from the face so it does not interfere with any activities.
- Sitting or kneeling shall be avoided in areas of known or suspected areas of contamination.
- Defective PPE shall be repaired or replaced immediately.

9.16 DECONTAMINATION AT HAZARDOUS WASTE SITES

Proper decontamination helps protect employees and prevents the contamination of uncontaminated areas. Decontamination protects all site personnel by minimizing the transfer

of harmful materials into clean areas. It helps protect the community by preventing uncontrolled transportation of contaminants from the site.

9.16.1 Worker Hygiene and Prevention of Contamination

To prevent contamination, contractor employees shall:

- Follow procedures in the contractor's component-specific HASP for proper dressing before entry into the exclusion zone. Proper dressing will minimize the potential for contaminants to bypass the PPE and escape decontamination.
- Eliminate direct contact with contaminated materials, such as soil or sediment or asbestos containing material.
- Require that employees have no exposed bodily areas that may permit direct contact with contaminated material when entering exclusion zones. Workers shall regularly monitor themselves and others for rips, loose material, or exposed areas that permit contamination to contact personnel or non-chemical protective clothing. Personnel with exposed areas or faulty PPE shall immediately exit the exclusion zone and enter the decontamination facility to correct the problem.
- Excavate soils or sediment using mechanized means (e.g., backhoes), with techniques such as hand-digging to be employed by contractors only if no other means is feasible.
- Protect employees from any source of contaminants on the site with signage, fencing, and barriers as appropriate.
- Stress work practices that minimize contact with hazardous substances. Use remote sampling and handling techniques when appropriate.
- Limit the number of employees in the exclusion zone to the absolute minimum needed to perform the job safely.
- Supply all decontamination facilities, excluding those used for equipment decontamination, with potable water. The performing contractor shall also provide for monitoring of their potable water delivery systems on a basis adequate to maintain its potable state.
- Protect monitoring and sampling instruments by bagging. Make openings in the bags for sample ports and sensors that must contact site materials, or cover equipment and tools with a strippable coating that can be removed during decontamination.

The performing contractor shall provide 3-stage shower facilities, when applicable, that are easily accessible for employees leaving exclusion zones under their control. This shall entail the setup of multiple 3-stage decontamination facilities if there is ongoing construction work in multiple exclusion zones simultaneously that prevents quick facility access by employees.

Setup plans for 3-stage decontamination facilities, whether centralized or separate, shall be provided in each contractor's component-specific HASP.

Every employee leaving the exclusion zone shall undergo full decontamination in a three-stage decontamination facility.

Each contractor shall require that its employees remain free of visible contamination when in exclusion zones. If contractor employees become visible contaminated, they are responsible for immediately leaving the exclusion zone and entering the decontamination facility to decontaminate themselves or arrange for a change of PPE.

9.16.2 Decontamination Equipment Selection

In selecting decontamination equipment, contractors shall consider whether the equipment must be decontaminated for reuse or can be easily disposed.

Recommended equipment for decontamination includes:

- Storage tanks or appropriate treatment systems
- Three-stage decontamination facilities (potable water is required)
- Drains or pumps
- Long-handled brushes
- Pressurized sprayers for washing and rinsing
- Curtains, enclosures, or spray booths
- Long-handled rods and shovels
- Wash and rinse buckets
- Containers for the storage and disposal of contaminated material

9.16.3 Decontamination Design

Decontamination facilities shall be in the CRZ, i.e., the area between the exclusion zone (the contaminated area) and the support zone (the clean area), and described in the contractor's component-specific HASP.

Site-specific factors that affect the decontamination facility design must be considered. Typical factors include:

- The availability and delivery of potable water for decontamination.
- The chemical, physical, and toxicological properties of the wastes.

- The amount, location, and containment of contaminants.
- The potential for and location of exposure based on assigned worker duties, activities, and functions.
- The potential for wastes to permeate, degrade, or penetrate materials used for personal protective clothing and equipment, vehicles, tools, buildings, and structures.
- The proximity of incompatible wastes.
- The movement of personnel and/or equipment among different zones.
- The emergencies that may arise.
- The methods available for protecting workers during decontamination.
- Decontamination shall be an organized process by which levels of contamination are reduced.
- The decontamination process shall consist of a series of steps performed in a specific sequence. For example, outer, more heavily contaminated items are decontaminated first, followed by the decontamination and removal of inner, less contaminated items. The process shall be described in each contractor's component-specific HASP.
- Personnel who wish to enter clean areas of the decontamination facility, such as locker rooms, must be appropriately decontaminated first.

9.16.4 Personal Protective Equipment for Decontamination Facility Workers

Contractors shall describe the level of PPE required for any work performed in/on the decontamination facility in their component-specific HASP.

9.16.5 Decontamination Methods

- All personnel, clothing, equipment, and samples leaving the contaminated area of a site shall be decontaminated to remove any visible material that may have adhered to them.
- The selected decontamination method should be reviewed for any safety and health hazards. If the selected method poses a direct health hazard, measures shall be taken to protect both the decontamination personnel and the workers to be decontaminated.
- All proposed decontamination methods for personnel, sampling equipment, heavy equipment, and other materials shall be described by the contractor in their component-specific HASP.

9.16.6 Sampling and Monitoring Equipment Decontamination

Sampling equipment often becomes grossly contaminated. Sampling equipment such as trowels, split spoons, or other equipment that is used to collect samples must be cleaned and decontaminated between samples to prevent cross contamination. These items shall be cleaned and decontaminated in accordance with the contractor's sampling and analysis protocols. Dirt and wash solutions from sampling equipment decontamination shall be collected by the contractor and entered into the site waste disposal stream.

Once grossly contaminated, testing and monitoring instrumentation can be difficult to decontaminate without causing damage to the instrument. Care shall be taken in the field to prevent contamination of field instruments by avoiding direct contact between the instrument and contaminated soils, water, or surfaces. In some cases, it may be necessary to place instruments in plastic bags, leaving small openings for sampling ports, detectors, and exhaust ports. The plastic bags can then be removed as the instrument comes out of the exclusion zone. The outside of instruments shall be decontaminated as necessary.

9.16.7 Heavy Equipment Decontamination

Trucks, backhoes, and other heavy equipment can be difficult to decontaminate. The contractors shall establish decontamination pads in a CRZ immediately outside of exclusion zones to perform heavy equipment decontamination. All heavy equipment traffic used in exclusion zones shall be routed to decontamination pads upon exiting the exclusion zone. All spent decontamination water shall be captured by the contractor for disposal as outlined in Section 9.16.8, Decontamination Water, Disposable PPE, and Site Wastes.

Contractors shall employ wash methods with water under pressure and scrubbing of areas as necessary. Care shall be taken where equipment comes into direct contact with contaminated soils such as tires, buckets, or treads. In severe cases, tires may need to be replaced or parts disposed of. Equipment shall be visually inspected by the performing contractor to be sure it is free of any visible signs of contamination before leaving the CRZ.

Contractors shall not permit heavy equipment to leave the decontamination pad with remaining visible contamination.

Contractor will each describe the set up and placement of heavy equipment decontamination pads in their component-specific HASPs.

9.16.8 Decontamination Water, Disposable PPE, and Site Wastes

Post-decontamination water (i.e., grey water) shall be captured from equipment decontamination pads and personnel decontamination facilities. Captured grey water shall be

placed in drums, tanks, or containers clearly labeled as appropriate. Proposed methods for disposal of grey water shall be described in each contractor's component-specific HASP.

Potentially contaminated equipment, disposable PPE, respirator cartridges, disposable sampling equipment, brushes, buckets, and any other contaminated site wastes (apart from soil being treated) shall be secured by each contractor in approved containers and labeled. Disposal methods for these materials shall be in accordance with applicable local regulations and industry best practices and shall be described in each contractor's component-specific HASP.

Care shall be taken during work and decontamination activities to minimize waste materials generated.

9.17 TRAFFIC AND WORK ZONE SAFETY

Contractors shall comply with the following practices whenever employees or subcontractors work in areas exposed to vehicular traffic.

- A traffic control plan will be developed with concurrence between contractor's onsite prior to concurrent work starting.
- Where vehicular traffic hazards exist, a system of traffic and work zone controls shall be developed to mitigate the hazard. The system should meet the requirements of Part 6 of the MUTCD published by the Federal Highway Administration.
- In general, when the MUTCD allows the use of traffic safety direction devices, such as cones, the contractor shall supplement those direction devices with a physical barrier, such as a truck.
- All traffic control systems on public roads must be coordinated with local traffic control officials as required by applicable law.
- Periodically evaluate effectiveness of temporary traffic control setups by walking or riding the job area looking for evidence of poor controls and near misses such as swerving traffic, motorists braking quickly, skid marks, blind spots, etc.
- Give motorists plenty of advanced warning of upcoming work zones.
- All employees working within designated work zones outside of the exclusion zone or near vehicular traffic shall wear ANSI Class II high-visibility clothing such as orange, yellow, or yellow-green shirts, jackets, or vests. During wet or inclement weather, similarly colored rainwear shall be worn.
- Between the hours of sunset and sunrise, high-visibility clothing should incorporate reflective striping or fabric and be visible at 1,000 feet. This clothing shall meet ANSI standard #107 for High Visibility Safety Apparel.

- All employees working near traffic and vehicles must maintain situational awareness always. Stay mindful that warning signs and cones inform drivers to act but that some drivers may not pay attention and vehicles may still enter the work zone.
- The site speed limit shall be 10 mph.

9.17.1 Motor Vehicle Safety

- Personnel must be licensed, authorized, and qualified drivers to operate motor vehicles and powered industrial equipment onsite.
- Personnel shall comply with local traffic laws and site requirements, including the use of seat belts always, when operating motor vehicles onsite.
- Pick-up trucks and other motor vehicles subject to Oregon Department of Motor Vehicles requirements shall be current on State-required registration and inspection.
- Vehicles shall be inspected prior to each use, with defective equipment reported and vehicles taken out of service if necessary to maintain personnel safety.
- Seat belts shall be worn on all heavy equipment, including forklifts and vehicles. No riders other than the operator shall be allowed on any piece of mobile equipment. When pickup trucks are used to transport employees, benches with backrests shall be provided or the employees must sit down in the bed area, not on the side rails.
- Motor vehicle safety shall be discussed regularly during tailgate safety meetings.
- Motor vehicle ignitions shall be turned off when not in use.
- Motor vehicles and equipment that are not in use and are on a slope or incline (however slight) will be choked at all times. Static mobile equipment (e.g. trailers, compressors) will also be chocked at all times on site. Outside of these situations, it is recommended that vehicles and equipment are chocked when not in use.
- When not in use, or where the operator is more than 25 feet or not in view, operators of Heavy equipment shall ensure the attachment is lowered, the controls are in the neutral position, the brakes are set, all manufacturers provided and recommended safety measures are utilized and the ignition is turned off.
- Cell phone use while driving is not allowed, including the use of hands-free devices. If it is not feasible to wait until arrival at a destination, drivers are to pull off the road and park in a safe location to use the cell phone. Drivers should not pull to the side of the road to use a cell phone; this significantly increases the risk of a rear-end collision.
- Drivers are to practice defensive driving and drive in a courteous manner.
- Drivers are required to have a valid driver's license and liability insurance (per local state laws).

- Vehicles are to be driven at speeds within local speed limits.
- Personnel who are impaired by fatigue, illness, alcohol, or illegal or prescription drugs, or who are otherwise physically unfit, are not allowed to drive or work on Integral field sites.
- Personnel are to avoid engaging in other distractions (e.g., changing radio stations) while driving.
- Motor vehicle accidents are to be reported to the responsible law enforcement agency, the Integral contracts and risk manager, and the Integral CHSM on the same day of occurrence. Documentation of any damage should include photographs.
- Personnel who have experienced work-related vehicle accidents or citations may be required to complete a defensive driving program.
- All Integral-owned field vehicles are to be equipped with the following:
  - First-aid kit
  - Fire extinguisher
  - Flares
  - Spare tire and jack
  - Other equipment required for the project (e.g., tire chains, towing cable, tools, cellular phone or radio).

9.18 HEAVY EQUIPMENT

Contractor employees shall comply with the following rules during the use of powered industrial trucks, tractors, backhoes, loaders, forklifts, or any other heavy equipment:

- Only authorized persons shall be permitted in the cab or on the equipment. Only those designated persons who are trained and qualified shall operate a powered industrial truck. Training shall consist of both formal and practical training.
- No climbing on operating equipment unless expressly allowed in operators manual, and only then using designated ladders or working platforms.
- A mechanical check by a competent person shall be performed on any equipment brought onsite.
- Dump trucks shall unload perpendicular to the slope.
- Industrial trucks shall be examined daily before being placed in service. The vehicle shall not be placed in service if any condition is found that would adversely affect safety.
- No unauthorized person shall be permitted to ride on a truck.

- No person shall ride on any portion of the forklift.
- Industrial trucks shall not be altered unless approved by the truck manufacturer.
- Load limits, as specified by the manufacturer, shall not be exceeded under any circumstances.
- Operating and maintenance procedures, as specified by the manufacturer, shall be followed.
- Any power-operated industrial truck not in safe operating condition shall be removed from service. Authorized personnel shall make all repairs.
- No load shall be lifted until its weight has been determined.
- Only stable or safely arranged loads shall be handled. Caution shall be exercised when handling off-center loads that cannot be centered.
- Trucks shall not be driven up to anyone standing in front of any fixed object.
- No person shall be allowed to stand or pass under the elevated portion of any truck, whether loaded or empty.
- Stay clear of tip hazards, such as dump trucks with boxes raised.
- When a truck is left unattended, out of view or is located more than 25 feet away, the load engaging means shall be fully lowered, controls shall be neutralized, power shut off and brakes set. Wheels shall be blocked if on an incline.
- The truck operator shall be required to look in the direction of, and keep a clear view of, the path of travel.
- When ascending or descending grades more than 10 degrees, loaded trucks shall be driven slowly with the load upgrade.
- No truck shall be operated with a leak in the fuel system until the leak has been corrected.
- Truck operators shall exercise extreme caution when near energized lines or equipment. The operator shall maintain 10 feet of clearance from the energized source.
- Truck and forklift operators shall be mindful of overhead obstructions, especially within buildings.

9.19 WELDING AND CUTTING

Welding and cutting are unlikely to be needed for the pre-design investigation, but guidelines are included in the unlikely event they are needed.

For the protection of all persons involved with welding and cutting, contractors shall comply with the following practices:

- Before performing welding, cutting, grinding, or any other "hot work" in a hazardous area, contractor employees shall obtain a Hot Work Permit from their competent person. Hazardous areas are those areas where there is the presence or the potential of the presence of flammable or combustible materials, liquids, gases, vapors, mists, or dusts. Contractor shall describe their process for issuing Hot Work Permits in their component specific HASP.
- Only experienced and properly trained persons shall perform welding and cutting. Before welding or cutting is started, the area shall be inspected for potential fire hazards.
- When welding or cutting in elevated positions, precautions shall be taken to prevent spatter, sparks, or hot metal from falling onto people or flammable material below.
- Suitable fire extinguishing equipment shall be immediately available at all locations where welding and cutting equipment is used. Personnel assigned as fire watch shall be trained in fire extinguisher use.
- Welders or their assistants shall not carry matches or lighters when engaged in welding or cutting operations.
- If welding or cutting cannot be conducted safely, the operation shall not be performed.
- A fire watch shall be maintained wherever welding or cutting is performed in locations where combustible materials present a fire hazard. A fire check shall be made of the area 2 hours after completion of welding.
- Where combustible materials such as paper clippings, coal, or wood shavings are present, the floor shall be swept clean for a radius of 35 feet before welding. Combustible floors shall be kept wet or protected by fire-resistant shields. Where floors have been wetted down, personnel operating arc welding or cutting equipment shall be protected from possible shock.
- To protect the eyes, face, and body during welding and cutting, the operator shall wear an approved helmet or goggles, proper protective gloves, and clothing. Helpers or attendants shall wear proper eye protection. Other employees shall not observe welding operations unless they use approved eye protection. Only high quality, fire resistant PPE (including gloves with FR liners) that have been verified as suitable shall be used on site.
- The wearing of arm protectors for all hot works is strongly recommended (ANSI Z49, 4.3.5 states that caps and sleeves shall be worn during overhead operations or when necessary) to eliminate any gap between the glove cuff and sleeve and minimize the potential for trapping slag, sparks, and spatter.

- Proper eye protection shall be worn to guard against flying particles when the helmet or goggles are raised.
- Machinery, tanks, equipment, shafts, or pipes that could contain explosive or highly flammable materials shall be thoroughly cleaned and decontaminated prior to the application of heat.
- In dusty or gaseous spaces where there is a possibility of an explosion, welding or cutting equipment shall not be used until the space is adequately ventilated.
- Welders shall place welding cable, hoses, and other equipment so that it is clear of passageways, ladders, and stairways.
- Where the work permits, the welder should be enclosed in an individual booth or shall be enclosed with noncombustible screens. Workers or other persons adjacent to the welding areas shall be protected from rays by shields or shall be required to wear appropriate eye and face protection.
- After welding or cutting operations are completed, the welder shall mark the hot metal or provide other means of warning other workers.

Potentially hazardous materials are materials used in fluxes, coatings, and coverings, filler metals used in welding and cutting, or materials released to the atmosphere during welding or cutting operations. While welding, or cutting, adequate ventilation or approved respiratory protection equipment shall be used. Special precautions shall be taken when using materials that contain cadmium, fluorides, mercury, chlorinated hydrocarbons, stainless steel, zinc, galvanized materials, beryllium, and lead.

In addition to the above welding and cutting rules, special attention must be given to the equipment used.

9.19.1 Gas Welding and Cutting

- Only approved gas welding or cutting equipment shall be used.
- Approved backflow check valves shall be used on gas welding rigs in both gas and oxygen lines.
- Welding hose shall not be repaired with tape.
- Matches shall not be used to light a torch; a torch shall not be lighted on hot work. A friction lighter or another approved device shall be used.
- Oxygen, acetylene, or fuel gas cylinders shall not be taken into confined spaces.

9.19.2 Electric Welding

- Only approved electric welding equipment shall be used.
- The electric welding machine shall be properly grounded prior to use.
- Rules and instructions supplied by the manufacturer or affixed to the machine shall be followed.
- Welders shall not strike arc with an electrode whenever there are persons nearby who might be affected by the arc. When electrode holders are to be left unattended, the electrodes shall be removed and the holders shall be so placed or protected that they cannot make electrical contacts with employees or conducting objects.
- When the welder must leave his work, or stop work for any appreciable length of time, or when the welding machine is to be moved, the power supply switch to the equipment shall be opened.

9.20 DEMOLITION

This section is not applicable to the current fieldwork.

9.21 FIRE PROTECTION

Each contractor shall be responsible for complying with the fire protection requirements in 29 CFR 1910 Subpart L, including providing portable fire extinguishers that are distributed appropriately throughout work locations. Fire extinguishers should be of the appropriate class rating for the conditions of the work. Contractors shall ensure that employees are sufficiently trained in the use of such equipment.

9.22 SCAFFOLDS

This section is not applicable to the current fieldwork.

9.23 MECHANIZED PERSONNEL LIFTS

9.23.1 Pre-Operations

This section is not applicable to the current fieldwork.

9.23.2 Power Lines

This section is not applicable to the current fieldwork.

9.23.3 Wind and Temperature

This section is not applicable to the current fieldwork.

9.23.4 Signs and Warning Labels

This section is not applicable to the current fieldwork.

9.23.5 Driving and Crushing Hazards

This section is not applicable to the current fieldwork.

9.23.6 Operation

This section is not applicable to the current fieldwork.

9.23.7 Barricading, Crushing Hazard

This section is not applicable to the current fieldwork.

9.23.8 Transfer to a Structure, Falling Hazard

This section is not applicable to the current fieldwork.

9.23.9 Machine Capacity and Tip Hazards

This section is not applicable to the current fieldwork.

9.23.10 Improper Use

This section is not applicable to the current fieldwork.

9.23.11 Towing and Hauling

This section is not applicable to the current fieldwork.

9.24 RIGGING EQUIPMENT

Contractor employees shall comply with the following practices when rigging equipment:

- All rigging equipment shall be of sufficient strength, proper type, and safe for its intended use.
- Rigging equipment shall not be loaded more than its recommended safe working load.
- Prior to each use, a competent person shall inspect all slings, fasteners, and attachments for damage or defects. Damaged or defective equipment shall be immediately removed from service.
- Makeshift lifting devices formed from bolts, rods, or reinforcing steel shall not be used.
- Slings shall not be shortened with knots, bolts, or other makeshift devices.
- Slings used in a basket hitch shall have the load balanced to prevent slippage.
- Slings shall be securely attached to the load using hooks with retaining devices or using shackles or another positive latching device.
- Slings shall be padded or protected from the sharp edges of their loads.
- A sling shall not be pulled from under a load when the load is resting on the sling.
- Slings shall be long enough to provide the maximum practical angle between the sling leg and the horizontal plane of the load.
- Shackle pins shall never be replaced with bolts or other non-approved devices.
- Only hooks with approved retaining devices shall be used. Hooks shall never be rigged so that they are points loaded at the tip of the hook unless they are designed for that purpose. The load shall be securely seated in the saddle of the hook.
- When eyebolts are used, care shall be taken to ensure the bolt is not side loaded.
- Chain falls, come-alongs, and other such devices shall not be loaded beyond their rated capacities.
- Chain falls, come-alongs, and other such devices shall always be rigged for a straight pull.
- The chain or hoist cable for chain falls, come-alongs, or other such devices shall not be wrapped around a load and used in place of a sling unless specifically designed for that purpose.

9.25 CRANES, DERRICKS, AND HOISTING EQUIPMENT

Contractor employees shall comply with the following practices when using cranes, derricks, or hoisting equipment:

- Operator certifications and annual inspection certificates shall be reviewed when a crane comes to the jobsite. If the operator does not have a current certification, they shall not operate the crane. No crane shall be operated until the annual inspection certificate is reviewed.
- Only authorized persons shall be permitted in the cab or on the equipment.
- Only those designated persons who are trained and qualified shall operate the hoisting equipment.
- Cranes shall be inspected daily via use of a Daily Crane Inspection Report.
- No person shall be permitted to ride the hook, sling, or load of any hoisting equipment.
- Load limits as specified by the manufacturer shall not be exceeded under any circumstances.
- Operating and maintenance procedures as specified by the manufacturer shall be followed.
- Before a lift is attempted, the lifting mechanism shall be level and firmly supported with the hoist line centered over the center of gravity of the load to be lifted.
- No load shall be lifted until its weight has been determined.
- For the first lift of each day, the load shall be test lifted at least several inches and the brakes checked.
- With every load, the slings and bindings shall be checked and shall be readjusted as necessary to ensure safety and stability.
- Signals to the equipment operator shall be given by one person designated to perform the task. The operator shall, however, obey a "stop" signal (a clenched fist) given by anyone.
- No employee shall be under a suspended load or inside the angle of a hoist line. No employee shall stand or work near a cable, chain, or rope under tension unless the nature of his work requires it.
- Hoist lines, ropes, or wire cables shall not be guided by hand when standing within reach of the drum or sheave.
- Wire rope loops shall be made by proper splicing or mechanical clamping of the tail section. Wire rope clips shall not be used to form eyes in wire rope bridles or slings.

- Operators shall not leave their position at the controls of cranes, hoists, derricks, or other lifting devices while the load is suspended.
- Operators of cranes, derricks, hoists, and other hoisting equipment shall exercise extreme caution when near energized lines or equipment. The operator shall keep the equipment at least 10 feet away from all lines energized up to 50 kilovolts (kV) and 0.4 inch more for each 1 kV over 50 watts (W).
- Tag lines shall be used on all loads.
- All spreader bars shall be tagged with the rated capacity.

9.26 SHIPPING INFORMATION

Federal laws and international guidelines place restrictions on what materials may be shipped by passenger and cargo aircraft. In addition, 49 CFR regulates the labeling, manifesting, and shipping of all packages containing potentially hazardous materials. In the course of this field investigation, the following items will be shipped to and from the site:

Shipping Instructions

Item	Hazardous Constituent	Quantity	Packaging	How Shipped
Sediment Samples	Pesticides, VOCs, PCBs, SVOCs, PCDD/Fs, TPH	Approx. 1,000 sediment samples	Coolers	Lab courier, field vehicle, FedEx
Soil Samples	Pesticides, VOCs, PCBs, SVOCs, PCDD/Fs	Approx. 100 soil samples	Coolers	Lab courier, field vehicle, FedEx
Porewater Samples	Pesticides, PCBs, PCDD/Fs	Approx. 10 samples	Coolers	Lab courier, field vehicle, FedEx
Groundwater Samples	Pesticides, VOCs	Approx. 25 samples	Coolers	Lab courier, field vehicle, FedEx
Solvents (hexane)	Hexane	1 L	Cooler	Field vehicle
Calibration gas (100 ppm isobutylene)	Isobutylene	17 L	Box	Field vehicle
Hydrophobic dye (Sudan IV)	Sudan IV	50 grams	Jar	Field vehicle
Other:				

Notes:
ppm = parts per million
SVOC = semivolatile organic compound
TPH = total petroleum hydrocarbons

A 24-hour emergency response number (on any shipping documents such as a Uniform Hazardous Waste Manifest, Shipper's Declaration of Dangerous Goods, etc.) is required for shipments of all dangerous or hazardous goods. Integral does not have a 24-hour emergency contact number for dangerous or hazardous goods shipment. No dangerous or hazardous goods may be shipped by Integral until an account is set up with a 24-hour emergency response service such as ChemTel Inc. (1-888-255-3924; https://www.chemtelinc.com/). If any hazardous or dangerous goods need to be shipped for a project, they must be shipped directly to the site by the supplier. Any hazardous or dangerous goods that are not used in the course of the field effort must remain at the site.

The samples must be prepared and labeled for shipment in accordance with the sampling and analysis plan developed for the site.

Labels for air shipment of equipment with lithium batteries are required to note the presence of these batteries. Warning labels are available from the equipment rental agency and can be copied.

10 CLIMATE AND TEMPERATURE EXTREMES

10.1 REGIONAL WEATHER

The table below summaries monthly precipitation and temperatures for Portland, Oregon.

Table 10-1. Average Monthly Rainfall and Temperature

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Precip.	6.17”	4.83”	4.66”	3.35”	2.61”	1.66”	0.70”	0.92”	1.67”	3.36”	6.69”	6.76”
Temp. °F(Max)	46.6	50.6	55.9	61.1	67.1	73.0	79.2	79.7	75.0	63.2	52.1	46.1
Temp. °F(Min)	37.0	38.4	40.8	43.8	48.4	53.2	57.1	57.6	54.3	47.7	41.3	36.9

(Source: Portland KGW TV, Oregon (356749), 1973-2016, https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?or6749)

10.2 HEAT STRESS

Project employees may be exposed to hazards associated with hot work environments (see safety guideline in **Appendix S**). Factors that contribute to heat exposure include temperature, humidity, PPE, radiant heat, sunlight, access to drinking water, exposure duration, and work activity. Individuals vary widely in their susceptibility to heat stress. Factors that may influence individual susceptibility to heat stress include the following:

- Lack of physical fitness
- Lack of acclimatization
- Age
- Dehydration
- Obesity
- Alcohol and drug use
- Infection
- Sunburn
- Diarrhea
- Chronic disease

The following outlines contractor requirements and guidelines when their employees or subcontractors perform work:

- In ambient air temperatures, above 80°F
- That involves heavy physical labor in temperatures above 70°F
- In chemical-protective clothing above 70°F.

10.2.1 Hazards Associated with Heat Stress

Heat Stroke – Heat stroke is a serious medical emergency and can lead to death if left untreated. It is an acute and dangerous reaction caused by the failure of heat regulating mechanisms of the body. Persons who are elderly, obese, chronically ill, alcoholic, diabetic, or have circulatory system problems are at greater risk.

- Symptoms include:
  - Red, hot, dry skin
  - Nausea
  - Headache
  - Weakness
  - Dizziness
  - Elevated body temperature (BT)
  - Rapid respiration and pulse
  - Coma
  - Loss of consciousness
- Treatment for heat stroke:
  - Heat stroke is a serious medical emergency. Emergency medical services shall be contacted if heat stroke is suspected.
  - Move the victim to a cool place (shade, air-conditioned building, vehicle).
  - Remove heavy clothing.
  - Cool the victim with ice packs, wet towels, or cloth.
  - Keep head and shoulders elevated.
  - Keep victim's airway open, check breathing, and pulse.

Heat Exhaustion – A state of exhaustion or weakness caused by loss of fluids through perspiration and inadequate fluid replacement. Severe cases may result in loss of consciousness (fainting). This condition can progress to heat stroke if left untreated.

- Symptoms include:
  - Pale, clammy, moist skin; heavy sweating; and extreme weakness.
  - BT is normal, pulse is weak and rapid, and breathing is shallow.
  - The person may have a headache, nausea, or feel dizzy.

- Treatment for heat exhaustion:
  - Remove the victim to a cool location (shade, air-conditioned building, or vehicle).
  - Allow the victim to lie down and prop their legs up.
  - Cool the victim with wet towels, cloth, or cold packs.
  - If the victim in not nauseous, they should drink water slowly.
  - If the victim loses consciousness, transport to local medical facility.
  - Continue treatment until symptoms are gone. Consult with contractor medical consultant before returning to work.

Heat Cramps – Heat cramps are a condition that can progress to heat exhaustion or heat stroke.

- Symptoms include:
  - Severe cramping of the arms, legs, and abdomen
- Treatment includes:
  - Removing the victim to a cool location; loosen clothing
  - Having the victim slowly drink cool water
  - Resting the cramping muscles

Heat Rash – Heat rash is a mild red skin rash in areas where the body is in contact with clothing or protective gear. The area is likely to itch and can be a source of irritation. Treatment includes decreasing the amount of time in protective gear and applying talcum powder to absorb moisture. When possible, wear breathable clothing to prevent a buildup of moisture within the clothing.

10.2.2 Heat Stress Monitoring

Since the susceptibility to heat stress hazards can vary greatly from one individual to another, often the best way to monitor for heat stress is through observing employees and individual physiological monitoring. When working in conditions that have the potential to create heat stress, either heart rate (HR) or body temperature (BT) shall be monitored by the supervisor, Site Safety officer or self-monitored by the employee in accordance with frequencies that are at least as stringent as the suggested frequency given in **Table 10-1**. This includes any work by employees wearing chemical protective ensembles.

Table 10-1. Suggested Frequency of Physiological Monitoring for Fit and Acclimatized Workers

Adjusted Temperature[b]	Normal Work Ensemble[c]	Impermeable Ensemble
90°F (32.2°C) or above	After each 45 minutes of work	After each 15 minutes of work
87.5° to 90°F (30.8° to 32.2°C)	After each 60 minutes of work	After each 30 minutes of work
82.5° to 87.5° F (28.1° to 30.8°C)	After each 90 minutes of work	After each 60 minutes of work
77.5° to 82.5°F (25.3° to 28.1°C)	After each 120 minutes of work	After each 90 minutes of work
72.5° to 77.5° F (22.5° to 25.3°C)	After each 150 minutes of work	After each 120 minutes of work

[a] For work levels of 250 kilocalories/hour.

[b] Calculate the adjusted air temperature (Ta adj) by using this equation: Ta adj °F = Ta °F + (13 X % sunshine). Measure air temperature (Ta) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate percent sunshine by judging what percent time the sun is not covered by clouds that are thick enough to produce a shadow (100 percent sunshine - no cloud cover and a sharp, distinct shadow; 0 percent sunshine - no shadows).

[c] A normal work ensemble consists of cotton coveralls or other cotton clothing with long sleeves and pants.

Heart Rate – HR shall be measured by the radial pulse for 30 seconds as early as possible in the initial rest period. On an individual basis, if the HR exceeds 110 beats per minute (BPM), that individual shall not return to work until their HR drops below 110 BPM and they are fully recovered. If more than one worker has an HR that exceeds 110 BPM, a work rest regimen or other control measures shall be implemented to maintain HRs below 110 BPM.

Body Temperature – The BT shall be measured using a clinical oral thermometer or a clinical ear thermometer. On an individual basis, if the BT exceeds 99.6°F, that individual shall not return to work until their BT drops below 99.6°F and they are fully recovered. If more than one worker has a BT more than 99.6°F, a work rest regimen or other control measures shall be implemented to maintain BTs below 99.6°F.

Personnel shall monitor themselves and each other for the development of symptoms such as sudden fatigue, nausea, dizziness, irritability, malaise, flu-like symptoms, and lightheadedness.

Contractors shall supply a qualified third-party emergency medical technician to conduct evaluation of employees' HR, BT, and physical symptoms when 10 or more contractor employees are conducting activities with a heat stress potential.

10.2.3 Heat Stress Controls and Prevention

Contractors shall develop a work/rest regimen to maintain physiological parameters within limits described above and prevent development of initial symptoms of heat stress related

conditions. If the physiological limits are exceeded or symptoms develop, the work period shall be reduced and rest period increased. Rest areas should be cool (in areas such as shade, air-conditioned buildings, or vehicles) and away from heat exposure.

- In extreme heat conditions, employees may wear heat-control clothing such as ice vests or cool suits. Physiological monitoring shall still be conducted and work/rest regimens implemented to keep physiological parameters within recommended limits.
- Mobile showers or hoses can be used to cool down workers in waterproof protective clothing.
- Shield sources of radiant heat.
- Provide shaded work areas.
- When possible, conduct activities in early morning and late evening to avoid the hottest parts of the day.
- Allow employees to become acclimatized to the heat by performing less strenuous activities for the first few days. Schedule more physically demanding work later.
- Provide adequate, cool drinking water for consumption during break periods.
- Avoid consumption of beverages such as coffee, tea, or colas that act as diuretics and dehydrate the body.

10.3 COLD STRESS

Persons working outdoors in low temperatures, especially below freezing, or in wet or snowy weather are potentially subject to cold stress disorders (see safety guideline in **Appendix S**). The Arkema Project Area does experience low temperatures during the winter and does experience occasional snowfall. The temperature of the Willamette River in Portland generally ranges from 45 to 70 degrees Fahrenheit[8]. Factors that contribute to cold stress exposure include temperature, humidity, wind, sunlight, rain, snow, fog, exposure duration, clothing, and work activity. Individual susceptibility to cold stress disorders can vary widely. Individual physical factors that can affect a person's response to cold work environments include a person's general fitness and age.

The following guidelines should be considered when working in ambient air temperatures below 40°F, especially when other contributing weather conditions such as snow, rain, or wind are present.

[8] Based on 2009-2020 temperature data at the Morrison Street Bridge (https://nwis.waterdata.usgs.gov/usa/nwis/uv/?cb_00010=on&format=gif_stats&site_no=14211720&period=&begin_date=2009-05-30&end_date=2020-06-17).

10.3.1 Cold Stress Hazards

Hypothermia – Hypothermia results from a cooling of the body's core temperature and if left unattended can become a serious condition. Hypothermia can result in the loss of physical skills and impair judgment thereby contributing to the potential for other accidents. Severe hypothermia can result in death. Hypothermia can occur at temperatures above freezing as well as below.

- Symptoms include shivering, teeth chattering, fumbling hands, slurred speech, and loss of coordination. Eventually, the pulse and respiratory rate may slow. The victim may appear blue or lose color in the face.
- Treatment for hypothermia is to catch symptoms early and move the individual to a warm environment indoors or in a vehicle. If a warm location is not immediately available, the victim should be sheltered from the wind and provided extra clothing such as coats or blankets and observed to determine if their condition is improving. If the victim continues to deteriorate and becomes colder, they should be transported to a medical facility for assistance.

Frostbite – Frostbite is a condition in which the fluids around cells of body tissue freeze. The condition can lead to body tissue damage. The most vulnerable parts of the body are the nose, ears, cheeks, fingers, and toes.

- Symptoms of frostbite include body parts becoming white, firm, cold to the touch, and may feel waxy. The victim will not feel pain in the affected area.
- Treatment of frostbite requires that the victim be brought to a warm environment and the affected areas be allowed to thaw and warm. If frostbite has progressed beyond small patches of skin and affects whole body parts such as a hand, foot, or ear, the victim should be transported to a medical facility for treatment and observation.

10.3.2 Cold Stress Monitoring

Personnel should monitor themselves and each other for signs and symptoms of frostbite and/or hypothermia. If symptoms are observed in an employee or subcontractor, steps should be taken to treat the symptoms by having the individual go to a warm environment either in a nearby structure or vehicle.

10.3.3 Cold Stress Control and Prevention

Cold stress can easily be prevented with proper planning and prevention. Some basic controls and preventative measures are listed below:

- Forecasted conditions. Consider the effect of wind chill (Table 16-2 on next page).

- Dress in layers and stay dry. Avoid cotton clothing such as socks or T-shirts. Bring extra clothing.
- Wear hardhat liners and gloves. Wear rain gear in rain and snow.
- Curtail work if extreme weather conditions such as a blizzard, extreme wind chill (e.g., less than 0°F), torrential cold rains, or wind is expected.
- For long-term projects in cold environments, consider setting temporary structures with portable heaters.
- Take warming breaks as needed.
- Avoid beverages with caffeine, alcohol, or medications that restrict blood flow.
- Drink warm non-caffeinated beverages such as hot chocolate or soups on breaks.

10.4 BIOLOGICAL HAZARDS

Risk Characterization of biological hazards and the associated risks to personnel present at the site must be conducted before start of work. Such risks and hazards can include but are not limited to insects (chiggers, ticks, mosquitos, spiders, scorpions etc.), animals (i.e. snakes, lizards, etc.), plants (i.e. Poison Ivy, Poison Oak, Sumac etc.). The characterization of site-specific biological hazards may require periodic updating as work progresses in different locations at the site, with the passage of seasons, and per other changes in conditions which influence such hazards and risks. Such characterization should be performed by an appropriately qualified person familiar with the specific ecology of the biological hazards that could be present at the site.

The following table presents biological hazards that are expected to be present during field activities.

Potential Biological Hazards during Field Activities

Possible Hazard	Proposed Safety Procedure
Bees/wasps (allergic reaction)	Avoid wearing bright colors or scents. Use an appropriate insect repellent. Wear a long-sleeve shirt, hat, and gloves. Employees must notify the supervisor if they have allergies to bee/wasp stings, prior to engaging in field activities. Employees with allergies may be required to carry an appropriate antidote kit.

Potential Biological Hazards during Field Activities

Possible Hazard	Proposed Safety Procedure
Ticks (disease transmission)	Use an appropriate insect repellent. Wear long-sleeve clothing and ankle-length boots and try to avoid excessive contact with tall brush or grass. Change clothes and inspect skin and scalp for ticks after every day of fieldwork. If a tick is discovered embedded in skin, it should be removed as soon as possible. Grasp the tick with a blunt pair of tweezers as close to the skin as possible and remove it using slow, even pressure. Do not break off the head or release fluids from the tick. Gently scrub the area with soap and water after removal. Note the date of the bite and watch for symptoms such as fever, chills, aches, and rashes for a month after the bite. If these symptoms occur, consult a doctor.
Mosquitoes (primarily West Nile and Zika viruses)	Use an insect repellent containing N, N-diethyl-m-toluamide (DEET). Wear long-sleeve shirts, long pants, and hat; spray clothing with insect repellent containing DEET. Avoid handling dead animals. The risk of getting a mosquito-borne virus is very low. Symptoms include fever, headache, neck stiffness, stupor, disorientation, tremors, convulsions, muscle weakness, paralysis, and body aches. If any of these symptoms develop, contact your health care provider.
Poison ivy and poison oak (allergic reaction)	Poison ivy and poison oak generally have three green leaves on each stem. The color and appearance can vary throughout the year. Avoid contact with all parts of the plants. Contact with the oily resins on the plants may cause a skin rash. The rash usually appears within 24 to 48 hours and can last for weeks. If poison ivy or poison oak is contacted, remove the affected clothing and wash the skin with soap and water to remove the oil resins as soon as possible.

The following table is a summary of potential biological hazards posed by proposed site activities:

Biological Hazards Posed by Proposed Site Activities

Activity	Potential Hazard
Subsurface Sediment Sampling	Mosquitos
Riverbank Soil Sampling	Bees/wasps, ticks, mosquitos, poison ivy and poison oak
Porewater Sampling	Mosquitos
Groundwater Discharge Study	Bees/wasps, ticks, mosquitos, poison ivy and poison oak
IDW Management	Bees/wasps, ticks, mosquitos, poison ivy and poison oak

10.4.1 Biological Hazard Communication

Site specific biological hazards will be communicated to site personnel during safety orientation and safety meetings.

10.4.2 Management of Site Specific Risks Associated with Biological Hazards

Protection from the hazards associated with plants, animals and insects is highly site specific and often seasonal. The requirements presented in this document are minimal standards and may require additional measures on a site-specific basis.

Management of Insect Related Hazards - Insect related hazards include bites, stings, and infection due to insect-borne diseases.

Protection from the hazards associated with insects include (but are not limited to):

- PPE including netted hoods, appropriate work gloves, high-topped work boots worn in conjunction with (bloused) trousers and long sleeved cuffed shirts.
  - Clothing treated at the factory with DEET or Permethrin.
  - Where possible, professional treatment of breeding areas located within the site.
  - Destroying or marking nests by a licensed exterminator
  - Use of smudge pots and aerosols for protecting workers in small areas
  - Elimination of actions or conditions at the site that propagate harmful insects
  - Extermination measures will be conducted by a Certified Pesticide Applicator
  - Where over the counter products are used, the directions will be followed as provided by the manufacturer
  - All employees will receive specific instruction in the recognition of harmful insects present at the site, their nesting habits, and modes of aggressiveness.
  - All employees will receive specific instruction on approved first aid procedures in the event of a sting or bite.

Management of Plant and Vegetation Hazards - In areas where employees may be exposed to hazardous plants (e.g. poison ivy, oak, or sumac) protection of site personnel from such hazards include (but are not limited to) the following measures:

- Removal or destruction of plants where practical; however, burning poisonous plants will not be conducted at LSS sites due to the potential for contact with or inhalation of the toxic substances contained in the smoke.

- Use of appropriate PPE including gloves
- Use of protective ointments will be considered as appropriate
- Employees will be instructed in proper decontamination procedures using soap and water for exposed areas of the body
- Employees will be trained in the recognition, hazards and identification of hazardous plants present at the site
- Employees will be instructed in the proper treatment procedures for exposures associated with hazardous plants present at the site.
- While not poisonous, employees shall be cautious when near or working with thorny plants (i.e. mesquite trees) and wear suitable protective clothing to avoid injury. Plant thorn arthritis is a noninfectious inflammation of a joint as a result of a thorn puncturing the joint and leaving residual plant matter lodged within the joint. Plant thorn arthritis can be prevented by avoiding exposure to the thorns of plants.

11 HEARING CONSERVATION

11.1 PURPOSE AND SCOPE

Contractors shall develop a hearing conservation program for their employees that comply with the practices outlined in this section.

11.2 DEFINITIONS

Action Level – An exposure to an 8-hour time-weighted average of 85 decibels (dB) measured with a dosimeter or sound-level meter on the A-scale at slow response; or equivalently, a dose of 50 percent measured as per Subsection 11.5.5. The action level is the criterion for instituting noise surveys and employee participation in the audio metric testing program.

Administrative Control – Any procedure that limits noise exposure by control of work schedules.

Audiogram – A chart, graph, or table that results from an audiometric test. An audiogram shows an individual's hearing threshold level as a function of frequency (Hertz [Hz]).

Audiologist – A professional who specializes in the study and rehabilitation of hearing and who is certified by the American Speech, Hearing, and Language Association or licensed by a state board of examiners.

Audiometer – An electronic instrument that measures hearing threshold levels and conforms to the requirements and specifications of the current ANSI Standard S3.6.

Baseline Audiogram – An audiogram against which future audiograms are compared. It may also be described as a reference, pre-placement, pre-assignment, or entrance audiogram.

Biological "Functional" Calibration Check – An audiometric test that uses one or more individuals with known, stable hearing levels to check proper functioning and stability of an audiometer and to identify any unwanted or distracting sounds.

Cut-Off Level – All sound levels at or above the cut-off level are averaged into the calculations that relate to noise exposure. All sound levels below the cut-off level are not included.

Deafness – The condition in which the average hearing threshold level for pure tones at 500; 1,000; 2,000; and 3,000 Hz (frequencies used for speech) is at least 93 dBs (reference ANSI S3.6-1969). This is generally accepted as representing a 100 percent hearing handicap for normal speech.

Decibel – A unit of measurement of sound-pressure level. The dB level of a sound is related to the logarithm of the ratio of sound pressure to a reference pressure. The dB has meaning only when the reference is known. The internationally accepted reference pressure used in acoustics is 20 micropascals.

Decibels, A-Weighted (dBA) – A sound level reading in decibels made on the A-weighting network of a sound-level meter at slow response.

Decibels, Peak (dBP) – A unit used to express peak sound-pressure level of impulse noise.

Dose Criterion Sound Level – The average sound level at a given dose criterion length for which the dose represents 100 percent of the allowable exposure. OSHA requires a dose criterion sound level of 90 dBA for exposure duration of 8 hours. ARC has a dose criterion level of 85 dBA for an 8-hour exposure, per Section 29.6.

Dose Criterion Length – The permissible exposure duration (in hours) for a given dose criterion sound level for which the dose represents 100 percent of the allowable exposure.

Eight-Hour Dose – The actual dose (as a percentage) accumulated over the duration of the work shift and based on a regulation defined criterion level and criterion length.

Engineering Control – Any mechanical device, physical barrier, enclosure, or other design procedure that reduces the sound level at the source of noise generation or along the path of propagation of the noise to the individual. This does not include protection equipment such as earmuffs, plugs, or administrative controls.

Hazardous Noise – Noise generated by an operation, process, or procedure that is of sufficient duration and intensity to be capable of producing a permanent loss of hearing in an unprotected person. Generally, this is interpreted as persistent noise levels equal to or greater than 85 dBA or combinations of higher intensities for durations shorter than 8 hours.

Hertz – A unit of measurement of frequency that is numerically equal to cycles per second.

Impulsive or Impact Noise – Variations in noise levels that involve peaks of intensity that occur at intervals of greater than 1 second. If the noise peaks occur at intervals of 1 second or less, the noise is considered continuous.

Lav – The average sound level (in dBA) computed for a chosen averaging time duration.

Lav (80) – The average sound level (in dBA) computed for a chosen averaging time duration, using an 80-dBA cut-off level. The 80-dBA cut-off level is used by Fed-OSHA for hearing conservation compliance requirements.

Manager – A broad term that can refer to managers, program and project managers, direct managers, site managers, supervisors, department heads, group heads, branch chiefs, owners, and/or persons that operate in a management capacity or supervisory roll with respect to affected employees.

Medical Pathology – A disorder or disease. For the purposes of this chapter, a condition or disease that affects the ear and should be treated by a physician specialist.

Monitoring Audiogram – An audiometric test obtained at least annually to detect shifts in an individual's threshold of hearing by comparison to the baseline audiogram.

Noise – Unwanted sound.

Noise Dose – A measure of cumulative noise exposure over a stated period, which takes into account both the intensity of the sound and the duration of the exposure.

Noise Dosimeter – An electronic instrument that integrates cumulative noise exposure over time and directly indicates a noise dose.

Noise Hazard Area – Any work area with a noise level of 85 dBA or greater.

Otolaryngologist – A physician who specializes in the diagnosis and treatment of disorders of the ear, nose, and throat.

Representative Exposure – The measurements of an employee's noise dose, or an 8-hour time-weighted average sound level that a qualified person deems representative of the exposure of other employees in that work area or job classification.

Standard Threshold Shift (STS) – An average hearing threshold shift of 10 dB or more at 2,000; 3,000; and 4,000 Hz in either ear. A threshold shift can be temporary or permanent. Temporary threshold shift is a change in hearing threshold, primarily due to exposure to high-intensity noise that is usually recovered in 14 to 72 hours. Any loss that remains after an adequate recovery period is termed permanent threshold shift.

Sound-Pressure Level – The term used to identify a sound measurement (expressed in decibels) obtained with a sound-level meter that has a flat frequency response. This is mathematically equivalent to 20 times the common logarithm of the ratio of the measured A-weighted sound pressure to the standard reference pressure of 20 micropascals (measured in decibels). For use with this standard, slow time response is required in accordance with the current ANSI.S1.4.

Sound-Level Meter (SLM) – An electronic instrument for the measurement of sound levels that conforms to the requirements for a Type II sound-level meter as specified in ANSI S1 .4-1971.

Time-Weighted Average (TWA) Sound Level – The sound level that, if constant over an 8-hour workday exposure, would result in the same noise dose as is measured.

TWA (80) – The time-weighted average level that corresponds to a noise dose computed with an 80-dBA cut-off level.

11.3 RESPONSIBILITIES

Responsibilities of all contractor employees who work in high noise areas are:

- Wear and maintain hearing protection as required
- Cooperate with H&S personnel in activities undertaken to evaluate hazardous noise
- Notify direct or project manager of areas, operations, or equipment that may produce hazardous noise
- Attend hearing conservation training when necessary
- Participate in the medical surveillance program

11.4 NOISE EXPOSURE LIMITS

Protection against the effects of noise exposure shall be provided by each contractor to its employees when sound levels exceed those in **Table 11-1** and **Table 11-2** below. Noise exposure limits are generally applied as an 8-hour exposure limit of 85 dBA. For exposures of shorter or longer durations, the exposure limit may be adjusted as indicated in the table. Hearing conservation program elements are expected to be implemented whenever employee noise exposures equal or exceed an 8-hour time-weighted average of 80 dBA measured as per Subsection 11.5.5. Hearing conservation program elements include exposure monitoring, audiometric testing, medical monitoring, and training. The dose criterion of 80 dBA for an 8-hour exposure is referred to as the action level.

Table 11-1. Continuous Noise Permissible Exposure Limits

Duration (Hours)	Sound Level (dBA)*
16	80
8	85
4	90
2	95
1	100
0.5	105

Duration (Hours)	Sound Level (dBA)*
0.25	110
0.125 or less	115

*Measured on the A-scale of a standard sound-level meter set at slow response.

Table 11-2. Impulse Noise Permissible Exposure Limits

Sound Level (dBP)*	Permitted Impulses/Day
140	100
130	1,000
120	10,000

*Peak sound-pressure level.

11.5 HEARING PROTECTION METHODS

11.5.1 Engineering Controls

Where feasible, facilities and equipment will be procured, designed, operated, and/or modified in such a manner as to prevent employee exposure to continuous noise levels above 85 dBA over an 8-hour TWA or impulsive noise above 125 dBP. Any reduction in employee noise exposure, even if not reduced below 85 dBA, is beneficial. If engineering controls fail to reduce sound levels to within the limits of this section, hearing-protective equipment, and/or administrative methods of noise-exposure protection must be used.

11.5.2 Personal Hearing Protection

PPE is to be used only temporarily or if engineering controls are not feasible or practical.

The contractor's SHSO shall enforce the use of earmuffs and/or plugs by employees assigned to work in areas where they will be exposed to continuous noise (without regard to duration of exposure) in excess of 85 dBA or to impulse noise in excess of 140 dB. Disposable earplugs and/or earmuffs will be made available for employee use (if desired) if noise exposures under 85 dBA create a nuisance. Earplugs will be provided for the exclusive use of each employee and will not be traded or shared.

Hearing protectors must attenuate employee noise exposure to a level of 85 dBA or below. Both earmuffs and plugs are required where noise levels equal or exceed 110 dBA. For employees

with standard threshold shift, protectors must attenuate exposure to an 8-hour TWA of 80 dBA. Estimation of the adequacy of hearing-protector attenuation should be performed according to the methods OSHA specifies in 29 CFR 1910.95 App B, Methods for Estimating the Adequacy of Hearing Protector Attenuation.

If reusable preformed earplugs are used, they will be permanently issued to the employee and fitted to the employee under medical supervision. During fitting, the employee will be instructed in the proper method of insertion, storage, and cleaning of the earplugs. Earplugs will be checked during annual medical examinations.

Earmuffs will be provided for employees when analysis of noise environments shows that the attenuation provided by earplugs is not sufficient to reduce noise exposures below 85 dBA. The user shall inspect earmuffs on a regular basis.

Special hearing-protective equipment, such as sound-suppression communication headsets, may be used in noise hazard areas. These devices should be inspected regularly. Sound-suppression headsets may not be used if they have been damaged, altered, or modified in any way that affects the attenuation characteristics. If replacement parts (such as ear cup seals) are available, the headsets may be repaired and reused. If sound-suppression headsets are not permanently issued to employees, such equipment must be cleaned and sanitized before reissuance.

11.5.3 Administrative Controls

If hearing-protective equipment or engineering controls are not sufficient to attenuate noise to less than 85 dBA, the duration of time spent in the noise hazard area shall be limited so as not to exceed the exposure limits specified in Section 11.4.

11.5.4 Noise Monitoring

Measurement of potentially hazardous sound levels shall be conducted when any information, observation, or calculation suggests that an employee could be exposed to a noise level in excess of an 8-hour TWA. This includes, but is not limited to, times when representative exposures need to be documented, when employees complain of excessive noise, or when it is difficult to understand a normal conversation if the speaker and the listener face each other at a distance of 2 feet. Any new equipment, operation, job, or procedure with the potential for creating hazardous noise should be evaluated with regard to noise emissions before startup. All continuous, intermittent, and impulsive sound levels from 80 to 130 dBA will be integrated into the noise measurements.

- Both noise dosimetry and area monitoring will be repeated periodically, or whenever any changes to facilities, equipment, work practices, procedures, or noise-control measures alter potential noise exposures.
- Employees and/or their representatives will be provided an opportunity to observe noise dosimetry and area monitoring activities.
- Areas determined to have noise levels at or above 85 dBA must be posted as noise hazard areas.
- Affected employees (employees whose exposures have been determined to exceed the action level) shall be notified of the results of noise monitoring.

11.5.5 Noise-Measurement Methods

- Sound-level meters must meet Type II requirements of ANSI S1.4 and must be capable of measuring sound in the range of 80 to 130 dBA.
- Noise dosimeters must meet Class 2A-90/ 80-5 requirements of ANSI S1.25 and be capable of integrating sound levels of 80 dB and above.
- Employee noise doses may be ascertained by using either a noise dosimeter or sound-level meter. If a sound-level meter is used to estimate an employee's dose, the noise survey will include a time and motion study to document the variations in the employee's noise exposure during the working shift. If an employee moves about or noise intensity fluctuates over time, noise exposure is more accurately estimated by personal dosimetry. Regardless of the method chosen, a sufficient number of readings/measurements will be made to accurately reflect noise exposure.
- Employee exposure measurements will be made in such a manner as to accurately represent the actual exposure to noise.
- When using a noise dosimeter to determine an employee's noise exposure, the microphone will be attached to the employee in the area of the employee's shoulder.
- When using a sound-level meter, the microphone should be positioned not less than 2 inches nor more than 2 feet from the employee's ear.
- Measurements will be made with the employee at his/her regular work stations(s).
- Before and after each use, dosimeters and sound-level meters will be calibrated using acoustical calibrators to verify the accuracy of the measuring equipment.
- If any sound-level meter or noise dosimeter is dropped, or if the microphone receives a sharp impact, a calibration check shall be performed to ensure that it is still working properly before taking additional measurements.
- Sound-level meters and noise dosimeters that are not working properly or are out of calibration shall not be used to determine an employee's noise exposure.

11.6 MEDICAL SURVEILLANCE PROGRAM

11.6.1 Program Participation

- Whenever an employee is routinely occupationally exposed to continuous noise at or above the action level or to impact or impulsive noise in excess of the limits specified in Section 11.4, the employee shall be enrolled in a medical surveillance program. Employee noise exposure shall be determined without regard to any sound attenuation provided by the use of hearing protectors.
- Each employee placed in a job that required participation in a medical surveillance program shall undergo a physical examination before being assigned to duties that involve exposure to high-intensity noise. The examination shall include a baseline audiogram, a medical examination to determine any preexisting medical pathology of the ear, and a work history to document past noise exposures. The history shall include a detailed review of past work histories and possible occupational and non-occupational noise exposures.
- When it is discovered that employees have been working where they encounter hazardous noise or incur exposures that exceed the action level and have not had a physical examination, one shall be conducted within 30 days. The audiogram must follow at least 14 hours of no known exposure to sound levels in excess of 80 dBA. This interval should be sufficient to allow recovery from noise-induced temporary threshold shift.
- Personnel who suffer from acute diseases of the ear shall not be placed in hazardous noise areas until the condition has abated, particularly if such diseases preclude the wearing of hearing protectors, cause hearing impairment, or produce tinnitus.
- All employees who are participants in a medical surveillance program must receive an annual audiogram.

11.7 NOISE HAZARD WARNING SIGNS

Caution signs that clearly indicate a hazard of high noise levels and the requirements to wear hearing protection shall be posted at the entrance(s) to, and the periphery of, noise hazard areas. Decals or placards with similar statements shall be affixed to power tools and machines that produce hazardous noise levels. Signs and decals shall have wording in black letters on a yellow background (refer to Section 11.10 for noise hazard warning sign specifications).

11.8 EMPLOYEE TRAINING

Each employee who participates in the hearing conservation program shall receive annual training. The training must include, a review of the effects of noise on hearing (including permanent hearing loss).

11.8.1 Noise Control Principles

- The purpose, advantages, disadvantages, and attenuation characteristics of various types of ear protectors
- Instruction on selection, fitting, use, and care of hearing protectors
- An explanation of the audiometric testing and its purposes

11.9 RECORDS MAINTENANCE

- Audiogram and noise-exposure records shall be maintained as a permanent part of employee medical records. If noise-exposure measurement records are representative of the exposures of other employees participating in the hearing conservation program, the range of noise levels and the average noise dose will be made a permanent part of the medical records of the other employee as well.
- In addition to audiometric test data, each medical record will, as a minimum, identify:
  - The audiometric reference level to which the audiometer was calibrated at the time of testing
  - The date of the last calibration of the audiometer
  - The name, social security number, and job classification of the employee tested
  - The employee's most recent noise exposure assessment
  - The date(s) hearing conservation training was received
- Records of the background sound-pressure levels in the audiometric test rooms and data and information concerning calibration and repair of sound-measuring equipment and audiometers (as well as all audiometric test data) will be maintained by the contractor's medical consultant in accordance with OSHA and other applicable regulations.
- Accurate records of noise surveys/monitoring, results of the special noise studies, and records of special actions or engineering controls installed to control noise exposures will be maintained for the duration of the affected employee's employment, plus 30 years.

11.10 SIGNS AND DECALS

11.10.1 Noise Hazard Warning Sign Specifications

Warning signs must read:

CAUTION

NOISE AREA

MAY CAUSE HEARING LOSS

USE PROPER

HEARING PROTECTION

IN THIS AREA

The lettering is almost always all caps, black, and on a yellow background.

11.10.2 Noise Hazard Warning Decal Specifications

Decals must have a yellow background and black lettering (all caps). The decal must be self-adhesive on the side opposite the written warning. The written warning must read:

CAUTION

NOISY EQUIPMENT MAY CAUSE HEARING LOSS
USE PROPER
HEARING PROTECTION

The word caution is in yellow lettering with a black background superimposed on the yellow background of the label. As shown, the word caution is 2 point sizes larger than the lettering in the rest of the warning.

12 EMERGENCY RESPONSE PLAN

The following sections present Integral's Emergency Response Plan and provide requirements and guidelines for the development of each contractor's emergency response procedures. Performing contractors shall include an Emergency Response Plan in their component-specific HASP. Emergency Response Plans and procedures to ensure employee's safety in case of emergencies shall be reviewed by each contractor with their employees. A list of key project contacts is provided as **Appendix F**.

12.1 INTEGRAL'S EMERGENCY RESPONSE PLAN

This section presents Integral's Emergency Response Plan for the Arkema site.

12.1.1 EMERGENCY RECOGNITION AND PREVENTION

It is the responsibility of all personnel to monitor work at the site for potential safety hazards. All personnel are required to immediately report any unsafe conditions to the SHSO/SS. The SHSO/SS is responsible for immediately taking steps to remedy any unsafe conditions observed at the work site.

The following are examples of some emergency situations that could occur during the Arkema pre-design investigation field activities:

- During air monitoring, the air monitoring action level is exceeded
- A person falls overboard
- Serious injury or illness (e.g., physical injury, heart attack)
- Slips, trips, and falls (e.g., barge decks, steep riverbank areas)
- Lacerations from scrap metal (e.g., riverbank fill material)
- Entrainment of clothes or objects in moving equipment or parts
- Severe thunderstorm with lightning.

Immediate actions will be taken by the field team under the leadership of the SHSO/SS in response to these emergencies.

12.1.2 EMERGENCY RESPONSE AND NOTIFICATION

If an emergency at the site warrants it, all personnel must immediately evacuate the affected work area and report to the SSO at this predetermined emergency assembly location:

The gated site entrance on Front Avenue when on the upland portion of the site, and the Cathedral boat ramp if working in the river (see site map and hospital route maps in Appendix A and Appendix P, respectively).

In the event of injury, field personnel should take action to protect the victim from further harm and notify local or facility emergency services. In remote areas, it is necessary to have first-aid-trained personnel on the field team. The victim may require decontamination prior to treatment if practicable—requirements will vary based on site conditions.

Emergency medical care should be provided by:

- [X] Local emergency medical provider (i.e., fire department)
- [ ] Facility emergency medical provider
- [ ] First-aid-trained field staff (for remote areas only)

Emergency Response Resources

Resources	Name	Telephone	Notified Prior to Work (Yes/No)?
Fire	--	911	No
Police	Emergency	911	
	Multnomah County Sheriff River Patrol	503-243-7952	Yes
USCG	USCG – Portland – Search & Rescue	503-240-9301	Yes
State of Oregon Public Health Division	--	971-673-1222	No
National Response Center		800-424-8802	No
EPA, Region 10	Hunter Young	503-326-5020	Yes
Hospital (from Arkema site)	Legacy Good Samaritan Hospital	503-413-7711	No
Hospital (from Cathedral Park boat ramp)	Legacy Emanuel Hospital	503-413-2200	No
Site phone (SSO/SS)	Jane Sund	512-779-3172	N/A
Site phone (alternate SSO/SS)	Andrew Halmstad	503-505-0114	N/A
Directions to hospital:	Consult maps in Appendix P.		

The SHSO/SS must confirm that the hospital listed is still in operation and that it has an emergency room. **It is required that the SHSO/SS drive to the hospital so that the directions are practiced and understood prior to initiating fieldwork.**

Corporate Emergency Contacts

Corporate Resource	Name	Work Telephone	Cell Phone
Integral CHSM	Matthew Behum	(410) 573-1982 ext. 512	(443) 454-1615
Integral president	William Locke	(720) 465-3315	(303) 548-1111
Integral human resources manager	Joseph Drew	(206) 957-0330	(206) 379-1289
Medical consultant	Dr. Peter Greaney (WorkCare)	(800) 455-6155 ext. 2114	NA
Incident Intervention (WorkCare)		(888) 449-7787	NA

Note:
If the CHSM cannot be reached, call Eron Dodak: office: (503) 943-3614; cell: (503) 407-2933.
If Eron Dodak cannot be reached, call David Livermore: office: (503) 943-3613; cell: (503) 806-4665.

In case of serious injuries, death, or other emergency, the Integral CHSM must be notified *immediately* at the phone number(s) listed above. The Integral CHSM will notify the project manager and Integral's president. The project manager or principal-in-charge will notify the client within the time frames presented in Appendix E.

12.1.3 EMERGENCY DECONTAMINATION PROCEDURES

In an emergency, gross decontamination procedures should be promptly implemented, as possible. If a life-threatening injury occurs and the injured person cannot undergo decontamination procedures onsite, then the medical facility should be 1) informed that the injured person has not been decontaminated and 2) provided with information regarding the most probable chemicals of concern.

Decontamination procedures should only be used if practical and if they will not further injure the person or delay treatment. Decontamination procedures should not be implemented if there is not a reasonable possibility that the injured party requires such intervention; the SSO/SS will make this determination. The following steps are to be followed for decontaminating injured personnel while onsite:

- If it will not injure the person further, cut off PPE (e.g., Tyvek® coveralls, work boots) using scissors, or scrub the gross contamination from the injured person's PPE with a Liquinox® or Alconox® solution followed by a rinse with tap or deionized/distilled water.
- Remove PPE, if feasible without further injuring the person.

12.1.4 SITE COMMUNICATIONS

Cell phone coverage is available at the site. Each field team will carry a cell phone that is in good working order. If there is any type of emergency that requires the site to be evacuated

(e.g., severe thunderstorm with lightning, chemical release), the field team leader will blow the air horn three times. When the horn sounds, all personnel will meet at the predetermined emergency assembly location, provided the muster point is in safe territory (the gated site entrance on Front Avenue when on the upland portion of the Site and the Cathedral boat ramp if working in the river). All other emergency notifications that do not require evacuation (e.g., a person falling overboard) will be conducted using a cell phone. Emergency phone numbers are listed above.

12.2 EMERGENCY COORDINATOR

Each contractor's SHSO shall be responsible for emergency coordination activities. A supervisor will be designated by each contractor prior to the start of work and will act as the primary emergency coordinator in the absence of the SHSO during emergency situations. The SHSO/supervisor will be familiar with all aspects of the site emergency response procedures, all operations and activities at the site, the location and characteristics of hazardous substances handled, the location of all records, and the site layout.

Personnel training shall be conducted by each contractor's SHSO or a qualified representative through initial briefings and periodic review for their personnel involved in site activities. Training elements shall include an overview of the facility, detailed instructions on site-specific operations, and the use of emergency equipment such as first aid kits, fire extinguishers, and two-way radios if alternate communication is needed. This training shall be included in each contractor's employee H&S orientation, and shall be documented and filed onsite.

12.3 MEDICAL EMERGENCIES

Emergency first aid treatment may only be administered by trained individuals. The purpose of treatment is to maintain life and/or prevent further injury until professional treatment can be obtained.

An emergency contact number and hospital map shall be maintained by each contractor (and included in the contractor's component-specific HASP) and distributed to on-site contractor personnel for all medical emergencies. Personnel shall have a means of contacting the emergency number or an available supervisor with the capability while in the field, and supervisors shall review availability of service prior to starting work activities. A map showing a nearby hospital is in the **Appendix P** and listed in Section 12.5.1; however, each contractor is responsible for verifying this information and the medical service availability prior to beginning onsite work.

Each contractor shall provide training to its employees in medical emergency contact procedures during their H&S orientation. Each contractor shall make emergency contact numbers and procedures available to its employees at each work location.

12.4 EVACUATION AND COMMUNICATIONS

Each contractor shall be responsible for designating an assembly point for employees. When an evacuation is necessary, all field team members shall go to the designated assembly point. This area will be located upwind of the site and will be dependent on the normal prevailing wind. Each contractor's SHSO will designate any other assembly points at the morning safety meeting or daily tailgate meeting, as appropriate.

All emergency communications will be conducted by direct vocal communication. If employees work on multiple areas concurrently, communication between employee groups will be by means of cell phones or hand-held radios.

12.5 MEDICAL SUPPORT

12.5.1 Offsite Medical Facility

It is essential that Site personnel be prepared in the event of an emergency. Emergencies can take many forms: illnesses or injuries, chemical exposure, fires, explosions, spills, leaks, releases of harmful contaminants, or sudden changes in the weather. The nearest hospital from the site and the Cathedral Boat Ramp are Legacy Good Samaritan Hospital and Legacy Emanual Hospital, respectively. Maps to the facilities are provided in **Appendix P**.

Each contractor shall be responsible for verifying the directions to the facility listed above and its availability of emergency services prior to arriving onsite. Other local facilities may need to be evaluated by each contractor.

12.5.2 First Aid Medical Support

In the event of an accident requiring first aid, each contractor's SHSO shall be responsible for coordinating the first aid and/or requesting aid from a medical service. If the person requiring attention is capable of being moved without further injury, the contractor's SHSO may transport the injured party to obtain medical assistance. Site support vehicles may be used to transport injured or ill personnel.

12.6 FIRE EMERGENCIES

Every member of each contractor's field team shall be responsible for observing and reporting any fire, and conditions that could potentially lead to fires.

If an employee observes a fire, the employee may attempt to quench the fire with a fire extinguisher if one is readily available and if it is safe to do so. If the fire cannot be readily extinguished, the employee shall notify all personnel onsite to evacuate the area immediately. All on-site personnel shall convene at the assembly point identified by the contractor's SHSO, who in turn shall immediately notify the fire department and applicable services.

When an employee observes a condition that potentially increases the chance for a fire, the employee shall immediately inform the contractor's SHSO of the condition. The contractor's SHSO shall immediately cease any field activity that increases the risk of fire until appropriate controls are in place. The contractor's SHSO shall be responsible to take whatever actions are necessary, including withdrawal from the area to eliminate or reduce the hazardous condition.

Each contractor shall be responsible for providing fire emergency information in their component-specific HASP, including emergency notification numbers and procedures. Each contractor shall also make this information available to its site employee at each work location.

12.7 SEVERE WEATHER RESPONSE PROCEDURES

The basic components of these severe weather response procedures provide a framework to manage early warning notification and response if severe weather conditions are encountered during operations at the site. Each contractor's severe weather response procedures shall be further defined in their component-specific HASP.

The contractor's SHSO is responsible for implementation of these severe weather response procedures.

Each contractor's SHSO shall have the capability to obtain local weather forecasts 24 hours in advance of expected operations. A means of obtaining real time weather reports for local conditions shall be maintained during all site operations. Each contractor's SHSO is responsible for communicating severe weather conditions to their field team, and ensuring that an appropriate rally point is established.

Efforts shall be made to secure equipment and materials in a severe weather event.

Severe weather events also impact driver safety, and must be emphasized during a severe weather evacuation event.

12.7.1 Expected Weather Hazards

Lightning

Prior to the start of field activities, the contractor's SHSO shall work with the field team to identify a site evacuation and rally point capable of providing protection from a lightning strike.

The weather forecast for the area shall be checked at the start of the day. A cursory risk assessment can be made on how probable lightning activity is. If lightning activity is reasonably probable that day, notify site personnel of the potential threat for increased lightning hazard.

A designated, responsible person will be appointed as the weather safety lookout. That individual will be issued a standard LSS-purchased lightening meter (a SkyScan P5-3 P5 Lightning Detector / Storm Detector).

The following warning action protocol is adopted for communicating the lightning hazard to operatives working on site:

Figure 12-1. Tree hit by a lightning strike at a RETIA site (Col-Tex)

- Yellow Alert – Lightning is over 20 miles (30-60 km) distant. Be cautious.
- Orange Alert – Lightning is 7-19 miles (16-30 km) distant. Be aware.
- Red Alert – Lightning is 0-6 miles (0-16 km) distant. Suspend activities and go to shelter.

Where thunder or lightning has been heard, or observed, all site activities must be suspended and shelter sought immediately. Abandon efforts to secure equipment if not completed.

In those situations, where thunder or lightning has not been heard or observed, all outdoor site activities shall be suspended and shelter sought when lightning crosses a 6-mile radius.

Always err on the side of caution.

If the lightning detectors or other weather media/services (e.g. TV, radio, websites, weather Apps) are indicating two different distances then always adopt the lower (i.e. closer) distance. Wait at least 30 minutes after the last observed lightning or thunder to resume activities.

LSS shall be notified of all lightning shutdowns, which must be documented in the form of an Anomaly Report.

Preparedness and quick responses are the best defenses towards the lightning hazard. The all-encompassing general rule, as promulgated by the National Lightning Safety Institute, shall be: "If you can hear it (thunder), clear it (evacuate); if you can see it (lightning), flee it."

Thunderstorms and Hail

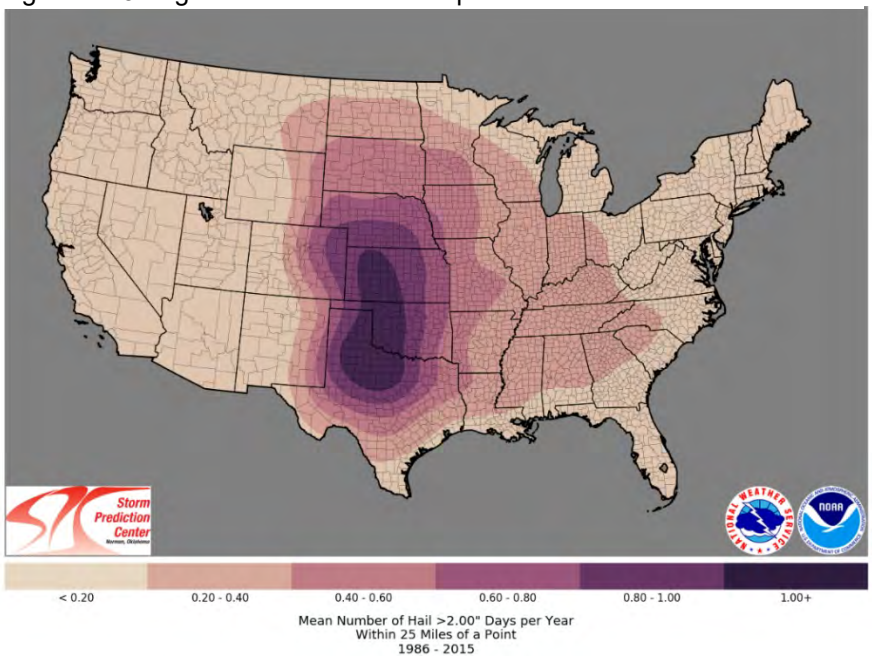
Flooding resulting from a thunderstorm presents a significant safety hazard, and must be continually monitored if a severe weather event is expected. If flooding can't be properly controlled and presents a hazard to personnel and the public, the contractor's SHSO or a site supervisor shall temporarily shut down operations until the hazards are abated.

Hail can form inside of thunderstorms when water droplets are picked up by updrafts of warm air and then carried high above the freezing level. The freezing process forms hailstones, which can grow as additional water freezes onto it. The hail can continue to cycle in the thunderstorm until the hailstone becomes too heavy for the updraft to support and falls to the ground.

Hail can fall from 30,000 feet and reach speeds of 120 miles per hour.

Figure 12-2. 3" Hail at a site in Texas following passage of a supercell thunderstorm in June 2018

Figure 12-3. Significant Hail Threat Map



The presence of large hail indicates very strong updrafts and downdrafts within the thunderstorm. These can also be possible indicators of tornadic activity. Large hail is often observed immediately north of a tornado track.

The Site is located in an area of low hail threat.

High Winds

If high winds are expected, or are encountered during work activities, appropriate action shall be taken to ensure the protection of site workers and the surrounding community. The contractor's SHSO or a site supervisor shall determine if the winds prevent proper dust suppression or present a hazard to personnel and the public that warrants a temporary shutdown of operations.

12.8 SPILL RESPONSE AND REPORTING

Contractor shall develop spill response and reporting procedures in accordance with Federal, State, and local requirements and included in their component-specific HASP. Applicable notifications should be made to the following:

- Local fire, police or ambulance will be notified in the event of an emergency requiring outside assistance from emergency responders.
- National Response Center (NRC): provide immediate verbal notification for all spills that impact or threaten navigable waters of the U.S. An impact to navigable waters would be a spill that causes a film or "sheen" upon, or discoloration of the surface of the water or adjoining shorelines; or causes a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines.
- U.S. Environmental Protection Agency: provide immediate verbal notification for all discharges that impact or threaten navigable water or adjoining shorelines.
- Neighbors and adjacent property owners: inform all adjacent private citizens and businesses that are expected to be immediately impacted by a spill or discharge.

12.9 SPILL CONTAINMENT

All decontamination chemicals should be dispensed from the manufacturers' capped containers directly into laboratory safety squirt bottles that have been permanently marked with the name of the chemical and that have screw caps. Decontamination chemicals should be poured into the prelabeled squirt bottles while they are over shallow Rubbermaid® (or similar) tubs to capture any possible overflow or spills. Any spills must be cleaned up and disposed of in accordance with applicable regulations.

Will the proposed fieldwork include the handling of bulk liquids, oil, or chemicals (other than water)?	Yes X (hexane) No
If yes, describe spill containment provisions for the site:	Hexane will be used on top of a large plastic tote to capture any spills. Absorbent pads will be available in case of a spill.

13 INCIDENT REPORTING

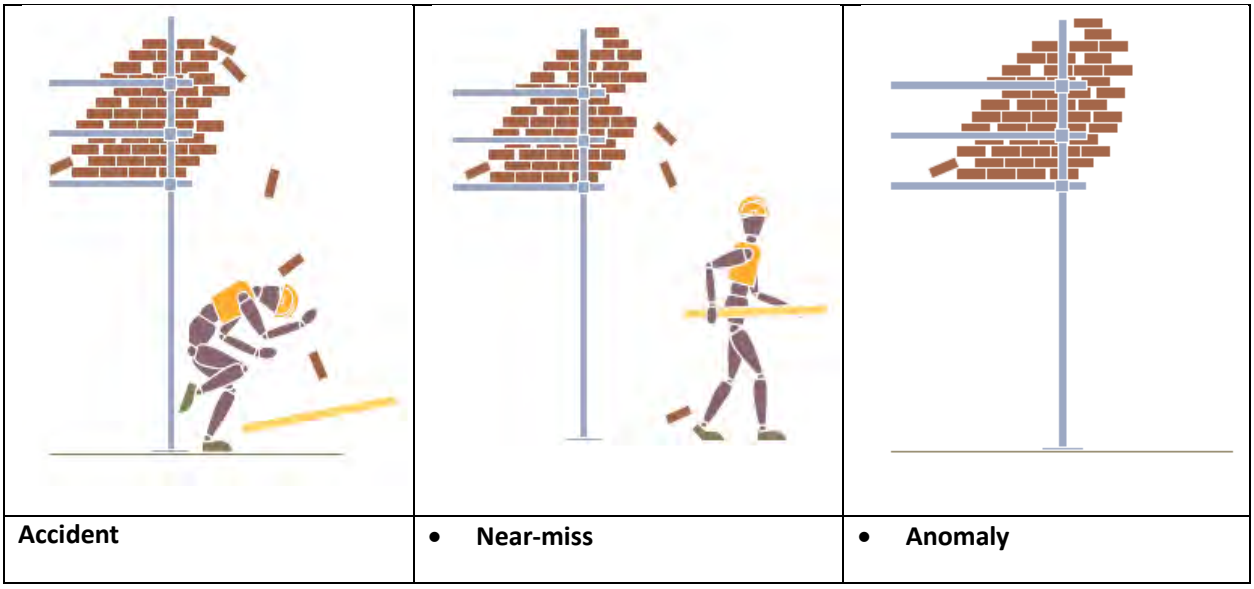
An **Incident** is defined as an event which could or does result in unintended harm or damage to people, equipment, materials, the process, or the environment. Incident is a broad term that covers all undesired events, including actual loss events (Accidents), a near miss event and Anomalies

An **Accident** is an event which does result in unintended harm or damage to people, equipment, materials, the process, or the environment.

A **Near Miss** is an undesired event where there is no loss, but in slightly different circumstances could have generated consequences identical to those of an accident.

An **Anomaly** is a warning sign that conditions may lead to unintended loss, harm or damage to people, equipment, materials, the process, or the environment and include, undesired circumstances, substandard acts, and substandard conditions. LSS encourage all project members to get involved and report any condition or situation that believe to be unsafe (or potentially unsafe) as an anomaly; reporting anomalies should be viewed as positive actions to help reduce injuries and loss.

The relative differences between accidents, near-misses and anomalies is illustrated on **Figure 13-1** below:



Accident	• **Near-miss**	• **Anomaly**

Figure 13-1. Types of Incidents

While the argument for investigating an accident is clear, the need to investigate near misses and anomalies may not be so obvious. However, investigating near misses and anomalies is as useful, and very much easier than investigating accidents. An investigation is not an end but the first step in preventing future adverse events. The investigation should identify why the existing risk control measures failed and what improvements or additional measures are needed. More general lessons on why the risk control measures were inadequate must also be learned. The following section sets this out in more detail.

13.1 INVESTIGATIONS

13.1.1 When Investigations Are Conducted

The need to conduct a formal accident investigation shall be determined by LSS in conjunction with the site contractors. A project manager or equivalent position may also request a formal investigation.

13.1.2 Purpose and Guidelines of Investigations

The purpose of the investigation is to objectively determine factors that contributed to or caused the incident and to identify corrective actions to be taken to prevent re-occurrence. It is not intended to find fault with individuals or companies. Guidelines for conducting investigations are provided below:

- Initiate the investigation as soon as possible. While priority should be given to ensure injured employees receive proper first aid and medical care, the passage of time delays corrective actions and allows facts to become distorted, forgotten, or lost.
- Where possible, the accident scene should remain undisturbed until the investigation is conducted. Some changes and alterations may need to be done to prevent further injury or damage.
- If possible, take photographs of the scene. Take pictures from multiple angles and the surrounding area.
- Prepare sketches/diagrams.
- Accurately measure distances, weights, and other factors associated with the accident.
- Identify and interview witnesses independently as soon as possible after the accident.
- Interview the injured employee/individual as soon as their condition allows. In many instances, the injured may be the only witness.
- The following information should be considered when interviewing witnesses and collecting observations:

- Weather conditions at time of accident
- Adjacent distractions
- Employee attitudes
- Training records
- Pre–job planning efforts
- Fatigue.

13.2 INCIDENT REPORTING

Each contractor will immediately report all accident including work-related injuries or illnesses, equipment, material, or process damage of harm to the environment, regardless of how minor, to the SHSO, and LSS. Each contractor shall be responsible for following RETIA USA's incident reporting procedure shown as **Appendix E** and shall include the procedures for written documentation of incidents in their component-specific HASP. The initial notification to LSS should be made immediately for fatalities and major injuries (potential lost time or recordable injuries) and within 8 hours for first aid cases. Unless there are extenuating circumstances, the completed reporting documentation shall be provided to LSS within 2 working days of the incident.

The employee or the employee's manager shall first report the accident to their contractor's SHSO as soon as practical. Priority shall be given to securing necessary medical services and employee care prior to the initiation of reporting and investigation.

Contractor employees are required to report the near miss details to their SHSO or manager immediately following its occurrence. The contractor's SHSO or manager shall be responsible for informing LSS. Near misses are to be reported in all cases. Near misses have serious potential consequences to the safety of site personnel and all cases are to be investigated for root cause to prevent a reoccurrence at the site.

Anomalies shall be reported as soon as practical but not later than the end of the working day to their SHSO. An anomaly may be elevated to a near miss depending on severity of the hazardous exposure. Anomalies are a warning and:

- Often have the same causes as major accidents.
- Letting an Anomaly go unreported provides an opportunity for a serious accident to occur.
- Correcting these actions or conditions will enhance the safety on site and provide a better working environment for everyone involved.

The RETIA USA Incident Report form will be completed and submitted to the LSS Project Coordinator to document all incidents. This includes accidents, near misses and anomalies. Upon notification of an incident, RETIA USA will conduct an incident investigation which may include: visiting the location of the incident, jointly conducting a root cause analysis to assess the contributory factors and causes, and follow up with Senior management to ensure corrective measures are implemented and lessons are learnt.

RETIA's Incident Procedure and Reporting Form are included in **Appendix E**.

13.3 EMPLOYEE'S DUTY

It is the duty of all site employees to inform their SHSO or manager of any incidents. Only by doing so can the project adequately ensure that future incidents are prevented. Every employee who does so is free from reprisal in any way.

Employees may request and receive the results of site incident investigations and safety inspections.

13.4 LESSONS LEARNED

Each contractor shall evaluate the lessons that can be learned following each incident, and shall share this information among their site personnel. This knowledge will be a powerful influence in preventing future incidents and creating a safer, more protective work environment. Examples of means to communicate lessons learned include, but are not limited to, the following—activity-specific safety training, tool box safety meeting reviews, H&S committee meetings, safety memos, and safety inspections.

14 REFERENCES

American National Standards Institute (ANSI)/American Industrial Hygiene Association's (AIHA) Z10, *Occupational Health and Safety Management Systems*. 2005.

ANSI Z87.1. *Eye and Face Protection*.

ANSI Z88.2. *Standard Practice for Respiratory Protection.*

ANSI Z41.1. *Safety Requirements for Industrial Head Protection*.

ANSI Z41.1. *Men's Safety Toe Footwear*.

ANSI / ISEA 107. *National Standard for High-Visibility Safety Apparel*.

Part 6 of the Manual on Uniform Traffic Control Devices (MUTCD), *Temporary Traffic Control*, Federal Highway Administration. 2003.

National Fire Protection Association (NFPA) 70E. *Standard for Electrical Safety in the Workplace*.

29 Code of Federal Regulations (CFR) 1910, Occupational Safety and Health Administration (OSHA) *Safety and Health Standard for General Industry*.

29 CFR 1904, OSHA *Recording and Reporting Occupational Injuries and Illnesses*.

29 CFR 1926, OSHA *Safety and Health Standards for the Construction Industry*.

41 CFR Part 50-204.7 *General Requirements for Personal Protective Equipment*.

OSHA Rulemaking.

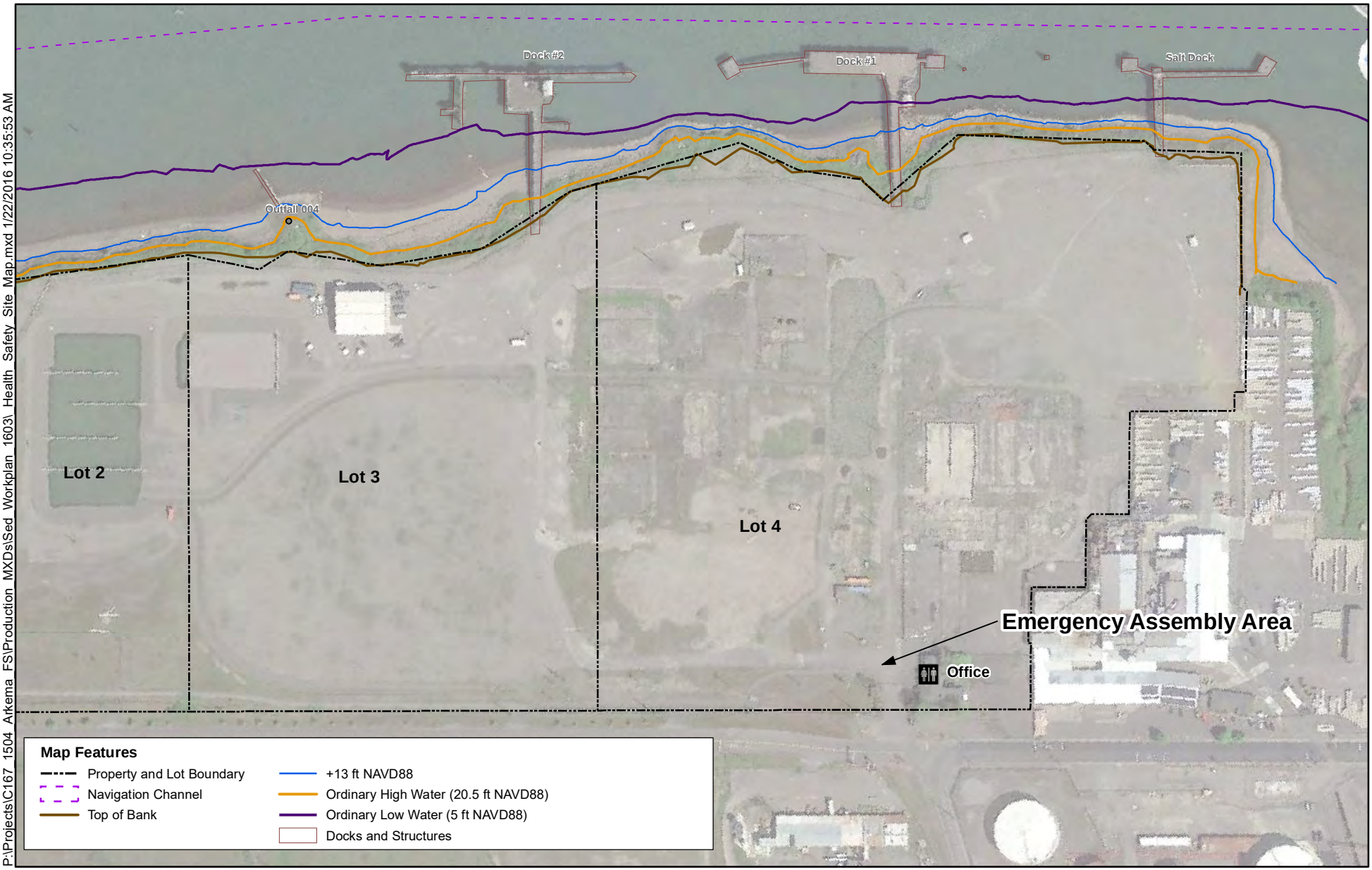
41 CFR 50-204.10. *Occupational Noise Exposure. OSHA Rulemaking*.

"Guidance on Human Factors Safety Critical Task Analysis", Energy Institute, London, March 2011

Total Golden Rules for Safety, March 2017 Ed.

Appendix A

Site Map



P:\Projects\C167_1504_Arkema_FS\Production_MXDs\Sed_Workplan_1603_Health_Safety_Site_Map.mxd 1/22/2016 10:35:53 AM

integral consulting inc.

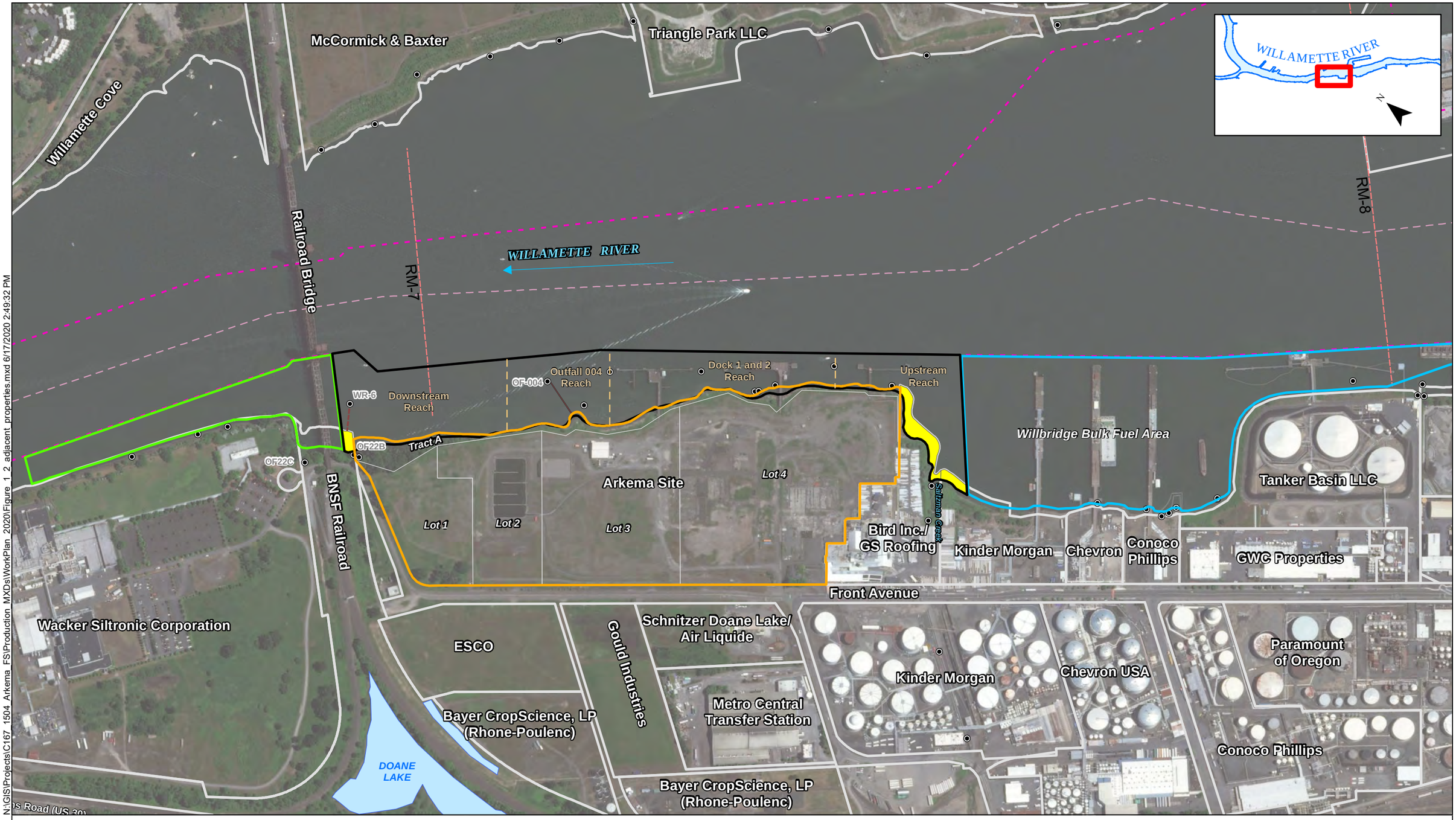
FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Aerial: Google Earth, 2015
Area above +16 ft: 2007 DEA Topographic Survey

0 100 200 Feet

N

DRAFT

Pre-remedial Design Investigation Work Plan
Health and Safety Plan
Site Map



N:\GIS\Projects\C167 1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 1_2 adjacent properties.mxd 6/17/2020 2:49:32 PM

integral consulting inc.

Sources:
Aerial: ESRI, Metro, 2017
Property Boundaries: Metro RLIS

0 250 500
Feet

N

- Arkema Project Area
- Arkema Property
- Bayer CropScience Project Area
- Willbridge Cove Project Area
- Portions of Adjacent Properties within Arkema Project Area
- Navigation Channel Centerline
- Navigation Channel
- Waterfront Taxlot
- Doane Lake (Current)
- Outfall

DRAFT

Figure 1-2.
Arkema Project Area, Arkema Site, and Adjacent Properties
Arkema Project Area Pre-design Investigation Work Plan

Appendix B

Total's Golden Rules Brochure

total.com

Total is the world's fourth-ranked international oil and gas company[1] and a global leader in solar energy through our affiliate SunPower. We discover, produce, transform, market and distribute energy in a variety of forms, to serve the end customer. Our close to 100,000 employees in more than 130 countries are committed to better energy.

[1] Based on market capitalization (in U.S. dollars) at December 31, 2015.

HSE Division
TOTAL S.A.
Headquarters:
2, place Jean Millier – La Défense 6
92078 Paris-La Défense Cedex – France
Tel. +33 (0)1 47 44 45 46
Share capital: 6 321 148 030 €
542 051 180 RCS Nanterre

TOTAL'S GOLDEN RULES

SAFETY AT WORK

Objectives

SAFETY AT WORK

TOTAL'S GOLDEN RULES

To prevent occupational accidents and protect lives, we must:

- Share the basic rules that everyone should know and apply.
- Strengthen prevention by encouraging people to step in whenever they see something being done unsafely.
- Stop work if the risk is not being properly managed.
- Report anomalies.

Editorial

Safety is a core value, the cornerstone of our operational excellence and that of our partners.

All accidents can be prevented, even though our activities present a variety of risks. Shared rules are vital to prevention.

Our Golden Rules on safety at work are based on feedback and experiences. They set out what must and must not be done. All Total stakeholders — our own employees and contractors alike — are required to apply them.

Everyone must ensure buy-in, strict compliance and field checks. In the event of unsafe actions or situations, the Stop Card gives the authority to step in and stop ongoing work, especially in the case of failure to comply with one of these rules.

I firmly believe that applying the Golden Rules stringently "for me, for you, for all" will lift our safety culture, aligning it with Total's stated ambition of being recognized as an industry benchmark in this area.

Patrick Pouyanné,
Chairman & Chief Executive Officer

Appropriate steps — set out in a recognition and sanction policy — will be taken in response to any breach of the rules, which are expressed as 50 instructions on what must and must not be done.

Anyone that:

- Flagrantly breaks a safety rule
- Refuses to obey an order in the event of immediate danger

will immediately be removed from the work in progress and be subject to appropriate disciplinary action.

Total's Golden Rules

1. High-Risk Situations
2. Traffic
3. Body Mechanics and Tools
4. Protective Equipment
5. Work Permits
6. Lifting Operations
7. Powered Systems
8. Confined Spaces
9. Excavation Work
10. Work at Height
11. Change Management
12. Simultaneous Operations or Co-Activities

RULE 1

HIGH-RISK SITUATIONS

YOU MUST NOT:

- Smoke outside designated areas.
- Work or drive under the influence of alcohol.
- Work or drive under the influence of drugs.

YOU MUST:

- Assess all risks prior to the start of non-routine or complex operations or in downgraded situations.
- Report all downgraded situations to management, monitor them, take appropriate measures to mitigate the risks and formally notify the personnel concerned.
- Follow start-up and shutdown procedures and check progress.

RULE 2

TRAFFIC

YOU MUST NOT:

- Exceed the speed limit and authorized driving time.
- Use a mobile phone, even with a hands-free kit, while driving.

YOU MUST:

- Check condition and conformity of vehicles and machinery before use.
- Wear your seat belt.
- Use designated pedestrian paths/sidewalks and hold the handrail when taking the stairs.

RULE 3

BODY MECHANICS AND TOOLS

YOU MUST NOT:

- **Use defective tools or tools not intended for the task or the area where the work is being performed.**
- **Use a tool, including those for pressure tests, under conditions that exceed the manufacturer's specified design limits.**

YOU MUST:

- **Use the tools specified in the work permit or procedures and adapt your body mechanics to the tool rating and repetitive nature of the task.**

RULE 4

PROTECTIVE EQUIPMENT

YOU MUST NOT:

- **Cross a barrier or reposition protective equipment without authorization.**

YOU MUST:

- **Wear the designated personal protective equipment (PPE) for the area and task and check its condition before use.**
- **Wear a life jacket whenever required.**
- **Report any damage to or malfunctioning of safety barriers.**

RULE 5

WORK PERMITS

YOU MUST NOT:

- Perform any work without an approved work permit.

YOU MUST:

- Assess risks before starting work.
- Use any required additional permits.
- Re-issue a work permit if the conditions on the original permit change or the work procedure is modified.

RULE 6

LIFTING OPERATIONS

YOU MUST NOT:

- Walk or stand under a suspended load.

YOU MUST:

- Perform a risk assessment, implement the lift plan and clearly mark out the area.
- Ensure all lifting equipment and gear is fit for purpose, in good condition and regularly inspected.
- Check that the load is securely slung and bundled.
- Designate a signaler and control the moving load at all times.

RULE 7

POWERED SYSTEMS

YOU MUST NOT:

- **Begin any work until you have checked that all energy and fluid sources have been isolated, unless you are specifically authorized to do so.**

YOU MUST:

- **Follow the isolation plan and supervision instructions attached to the work permit.**
- **Check all isolations, locks and tags before performing any work and remove them before restarting operations.**

RULE 8

CONFINED SPACES

YOU MUST NOT:

- **Enter a confined space without checking isolations and all atmospheric hazards.**

YOU MUST:

- **Cover suffocation, falls, explosion, crushing, drowning and other risks in the specific work permit.**
- **Ensure that you will be continuously monitored.**
- **Have an emergency response and rescue plan.**

RULE 9

EXCAVATION WORK

YOU MUST NOT:

- Place machinery or spoil piles within one meter of a trench being excavated.

YOU MUST:

- Perform excavation work with a permit comprising a map of all buried hazards.
- Apply precautions for work in confined spaces, as necessary.
- Clearly mark all excavation areas and identify underground structures.

RULE 10

WORK AT HEIGHT

YOU MUST NOT:

- Work under or near power lines without respecting the minimum safe clearance distance.
- Work on building or tank roofs without first checking their integrity and ensuring that the appropriate protective devices have been installed.
- Move a deployed mobile elevated work platform (MEWP), unless you are specifically authorized to do so.

YOU MUST:

- Put away tools when working at height (above 2 meters).
- Use a safety harness that is safely anchored, outside fixed barriers or in an MEWP.
- Use scaffolding that is fit for purpose and has been inspected.

RULE 11

CHANGE MANAGEMENT

YOU MUST NOT:

- **Make technical or organizational changes without getting prior authorization.**

YOU MUST:

- **Have a risk assessment and apply mitigation measures.**
- **Give workers appropriate training and update all relevant documentation.**

RULE 12

SIMULTANEOUS OPERATIONS OR CO-ACTIVITIES

YOU MUST NOT:

- **Perform simultaneous operations or co-activities without completing a preliminary field check.**

YOU MUST:

- **Conduct a risk assessment with the personnel concerned.**
- **Increase supervision and appoint a duly authorized coordinator.**

In the event of an unsafe situation, particularly noncompliance with a Golden Rule, you must step in. This shared vigilance helps us to improve safety together.

One measure is the Stop Card, which gives everyone working at the company — employees and contractor personnel alike — the authority to step in and stop ongoing work if they feel that actions or situations are unsafe or have the potential to lead to an accident.

Raising a problem or asking a question will not lead to sanctions.

Brochure published by the HSE Division, prepared in cooperation with the businesses |
Design and Production: because. www.because.fr
Photo credits: P. Dureuil, K. Gerhardt/Capa Pictures, T. Gonzalez, M. Labelle, V. Miloserdov, J. Muguet, V. Paul, H. Piraud, M. Sowinski, B. Uhart, L. Zylberman © TOTAL |
First issue: April 2010 – Reprinted: March 2017

Appendix C

HSE Recognition

Group Directive

DIR -GR-RH-009

HSE performance recognition policy

Further to the decision (post Referentials Business Review dated 31st august 2017) to remove the Policy level from the hierarchy of REFLEX documents, the policy POL-GR-RH-002 is from 06th November 2017 onwards categorized as **Group Directives** under the reference **DIR-GR-RH-009**.

Human Resources

Industrial Safety Division

HSE performance recognition policy, for Use by Total Managers

The HSE performance recognition policy should be designed to drive **improvement in three areas**:

A. How management exercises its HSE responsibilities.
B. How individual performance is rewarded and/or sanctioned.
C. How collective performance is rewarded.

A. How management exercises its HSE responsibilities

Everyone's HSE commitment should be based on clearly defined expectations. Managers should be sensitive to HSE issues and appropriately trained to support HSE performance. They should clearly express their expectations in practical terms during frequent field visits.

To meet these objectives, four recommendations have been made:

1) Review job descriptions and ensure that they state the direct manager's HSE expectations clearly and strongly

Job descriptions are signed by the employees concerned.

2) Train managers about their responsibility in managing HSE performance

The *HSE Management* training course will be enhanced and expanded on issues concerning HSE management systems and human and organizational factors in safety. The course will be mandatory for all managers scheduled for promotion to NP15 positions.

In addition, training sessions will be designed specifically for top executives (NP 17 and higher positions).

3) Make management's HSE commitment more visible

Safety tours will become systematic, to make sure managers understand that frequent field visits and listening to employees are key ingredients in motivating their HSE commitment.

Total's Management Committee will participate actively in this process.

Management's demonstrated commitment to HSE must become an integral part of career development. It should also be taken into account when appointing top executives.

4) Emphasize the importance of HSE functions

Management must ensure that operational managers emphasize the importance of HSE functions.

B. How individual performance is rewarded and/or sanctioned

While bearing in mind that safety is a collective endeavor, reflecting a spirit of teamwork and the ability to catch and correct individual errors (see C), the individual aspects of HSE performance have to be emphasized, starting with management, who must demonstrate exemplary conduct.

To meet this objective, four recommendations have been made:

5) Increase the importance and visibility of HSE objectives in the Annual Performance Review

Objectives must be as tangible and measurable as possible, so that they can be used more effectively to assess individual performance.

6) Reinforce positive practices that reward individual performance

For managers who are paid both a salary and a performance bonus, management should decide on the portion of the performance bonus to be awarded for meeting previously defined HSE criteria (or awarded only if such criteria are met).

For all employees, management must strengthen practices that reward individual performance wherever appropriate, through merit raises or other recognizable rewards.

7) Instill Total's basic safety rules and make sure everyone embraces them

These rules go hand-in-hand with a commitment to **zero tolerance** and any non-compliance should be noted as soon as it is observed. Management must act decisively and immediately when a safety rule is broken, by stopping work, making sure the rule is complied with and explaining the reasons why. The distribution of **Total's Golden Rules** is fully aligned with this objective. In addition, during the onboarding process, an HSE booklet will be handed out to each newcomer, who will sign his or her copy.

8) Explain practices regarding disciplinary actions

When an employee fails to comply with HSE practices or breaks a basic rule, particularly a Golden Rule, management must respond, either immediately or after an analysis of the accident or near miss, by, at very least, discussing the incident with the employee concerned. This interview may be followed by an official comment in the next Annual Performance Review or by disciplinary action, as specified in the subsidiary or site's internal rules.

C. How collective performance is rewarded

Collective success should be celebrated more effectively, to encourage employees to rise to new challenges. Collective success also helps to gauge how much individual behavior contributes to group performance. The focus should be on "people-sized" scopes so that everyone feels that they can influence overall performance. In the same way, processes tailored to contractors must be developed.

To meet this objective, three recommendations have been made:

9) Use safety awards (actual awards and HSE challenges for contractors) **much more often**

They combine both recognition of collective performance and strong communication to maintain forward momentum and commitment.

10) Use collective reward systems based on operational and HSE performance criteria more widely

These systems will be as **decentralized** as possible (production facilities, subsidiaries, etc.) in order to ensure the participants themselves recognize their contribution, and may be separate from existing profit-sharing agreements.

11) Expand the use of HSE reward systems for contractors

These systems will be discussed with contractors, will include simple and jointly auditable criteria, and will directly benefit contractor employees (bonuses, gifts, special events, etc.).

Cooperative audits (site/subsidiary and contractor) at all levels (supervisors, business engineers, departments, etc.) will be used to jointly assess results.

(b) (4)

(b) (4)

This document is set by and for DGRC. It is for internal use and it shall not be distributed to third parties without its authorization.

(b) (4)

Refining & Chemicals

(b) (4)

[redacted]

(b) (4)

Refining & Chemicals

(b) (4)

This English version is translated from the original French reference version.
This document is set by and for DGRC. It is for internal use and it shall not be distributed to third parties without its authorization.

(b) (4)

(b) (4)

This document is set by and for DGRC. It is for internal use and it shall not be distributed to third parties without its authorization.

(b) (4)

(b) (4)

This document is set by and for DGRC. It is for internal use and it shall not be distributed to third parties without its authorization.

(b) (4)

(b) (4)

This document is set by and for DGRC. It is for internal use and it shall not be distributed to third parties without its authorization.

(b) (4)

(b) (4)

This document is set by and for DGRC. It is for internal use and it shall not be distributed to third parties without its authorization.

Appendix D

Total's Stop Work Guidance Manual

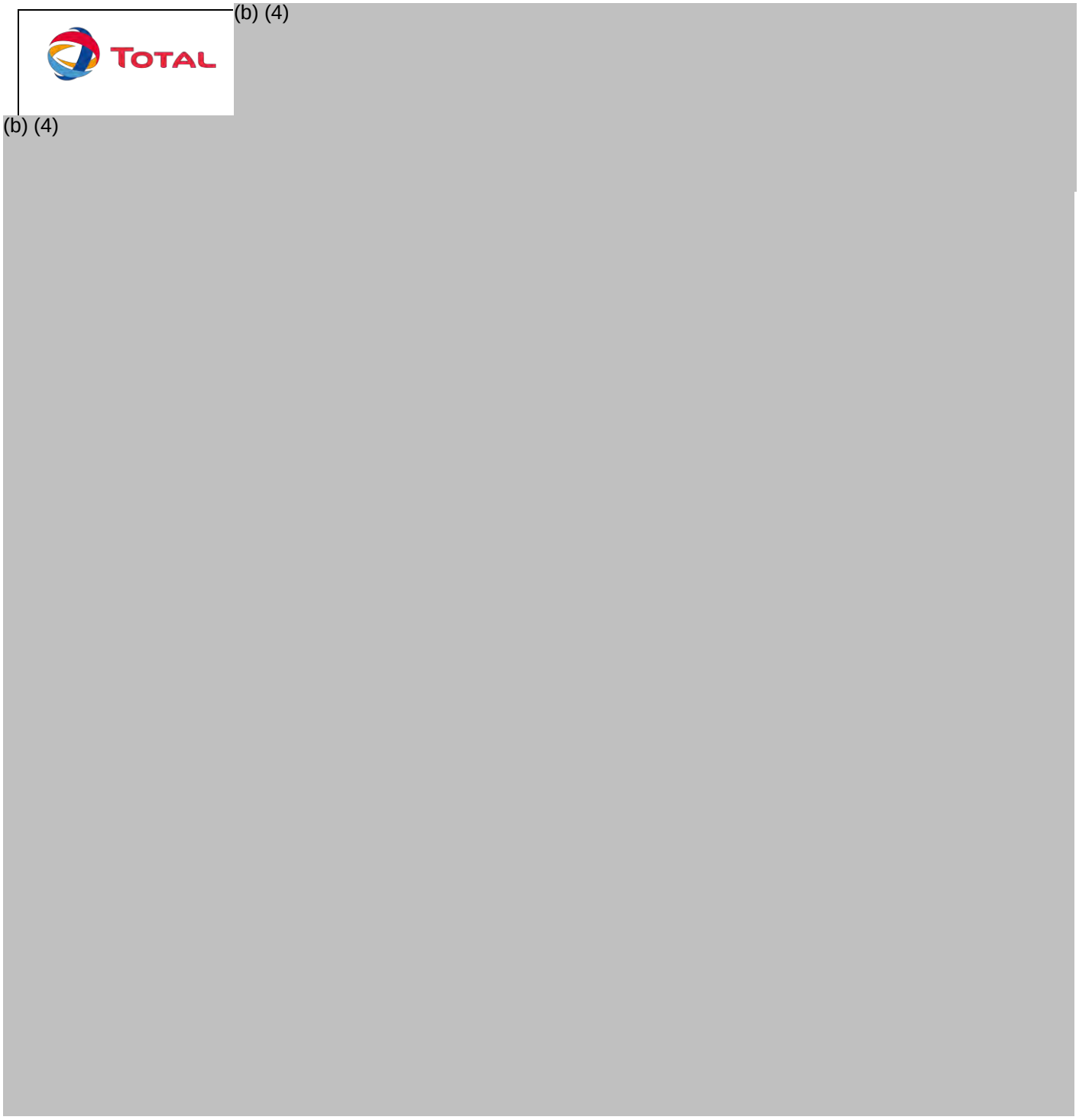
TOTAL
COMMITTED TO BETTER ENERGY

Group Safety Guides and Manuals
GM-GR-SEC-029

Stop Card

Industrial Safety Division

(b) (4)



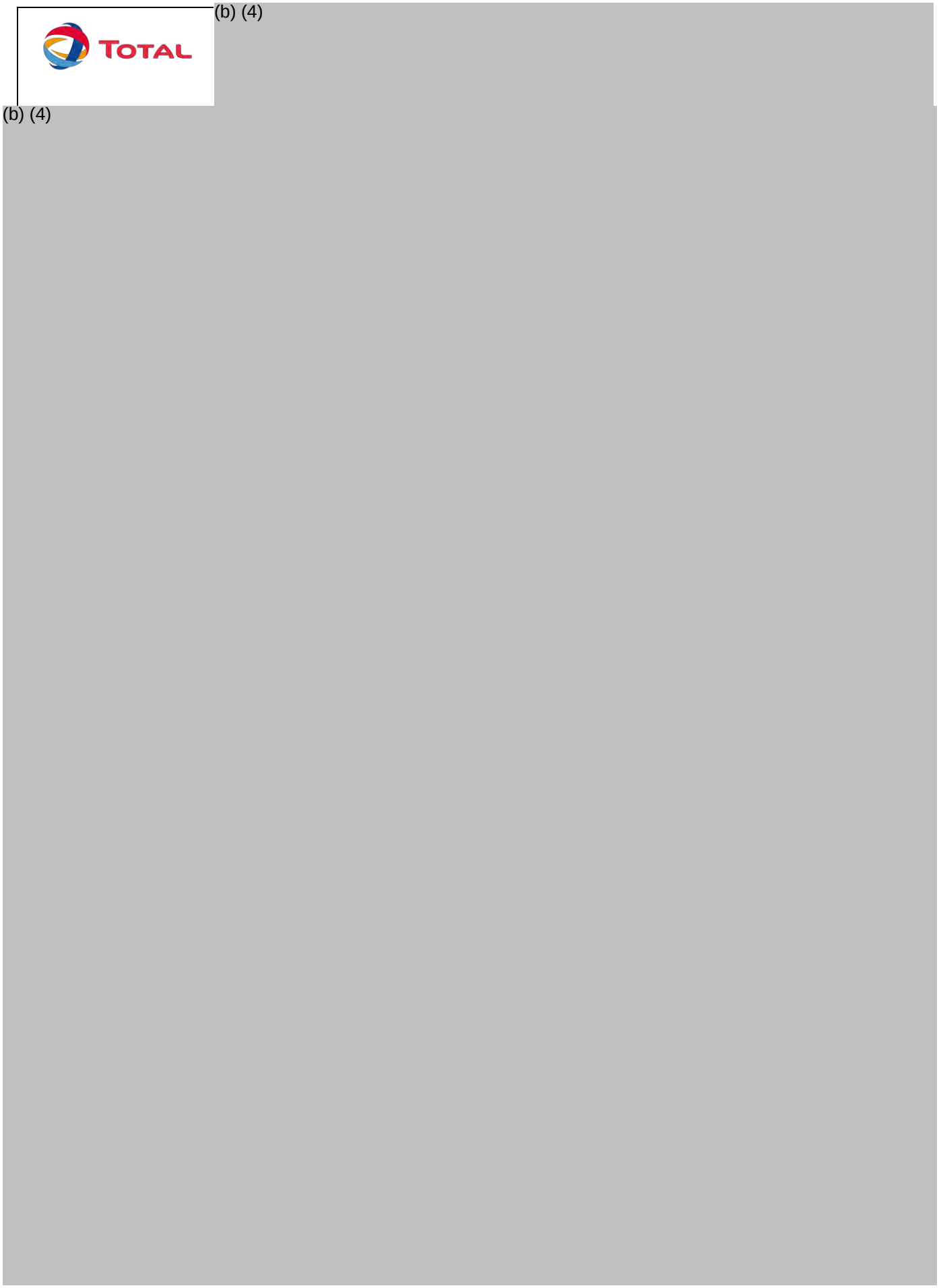
(b) (4)

(b) (4)

(b) (4)

(b) (4)

(b) (4)



(b) (4)

(b) (4)

Appendix E

RETIA USA Near Miss and Incident Notification Procedures

Near Miss and Incident Notification Procedure

0	Document created	08/15/2012
Reviews / Modifications		
Version n°	*Comment*	*Date*
1	General Rewrite and update	10/16/2013

Author	Verifier	Approver
Darrell Bailey	Darrell Bailey	Danny Kite

1. PURPOSE

This procedure describes near-miss and incident notification guidelines for sites managed by RETIA USA.

2. RESPONSIBILITY

The RETIA (R-DM) is responsible for administrating the RMS.

The Lead Contractor Project Manager (LC-PM) on site, RETIA Project Manager (R-PM), RETIA Site Supervisor (R-SS), RETIA Project Coordinators (R-PC), RETIA Department Heads (R-DM) and RETIA Company President (R-CP) have responsibility for executing this procedure.

The R-PC is responsible for ensuring that any recommended Corrective Actions are implemented.

3. Scope/Applicability

The RMS applies to remediation sites managed by RETIA USA.

4. DESCRIPTION

The following procedures should be followed for notification and reporting of near-misses and incidents which occur at remediation site managed by RETIA USA. These procedures are designed to ensure timely, clear, and consistent communications between the company, responsible agencies, and the community (as appropriate).

General Notification and Reporting Requirements

Near Miss Reporting

RETIA USA defines a near miss as an event which had the potential to cause an injury, illness, property damage, or other loss, but did not. Near miss reporting and investigations provide valuable 'lessons learned' which are crucial to reducing the occurance of incidents.

All RETIA employees, contractors and consultants are encouraged to report near misses to their supervisors within 24-hours. Subsequent investigations to determine root causes and establish corrective actions should be conducted and reported to RETIA USA.

Incident Notification

RETIA USA defines an incident as any occupational injury or illness; any damage to equipment, or any unintentional or undesirable release of a chemical or petroleum product from its designed container, tank, pipeline, hose, dispenser, pump, or other transfer equipment.

The *Incident Notification Guide (Table 1*) and the *Retia Usa Incident Notification Hierarchy* (described below) should be used as guidelines for *internal* incident notification. *External* stakeholder incident notifications, such as notifications to affected neighbors, regulatory authorities, etc. should be made by RETIA management in a timely manner, as appropriate.

Table 1 – Incident Notification Guide

INCIDENT TYPE	HIGH (LEVEL 3)	MEDIUM (LEVEL 2)	LOW (LEVEL 1)
Casualties	• Fatality or 3 or more persons hospitalized • Life-threatening injuries/illnesses to employees or third parties on or off-site • Missing employees or third parties	• Serious injuries/ illnesses to employees or contractors requiring hospitalization • Injuries/illnesses to any offsite third parties	• Injuries/illnesses to employees not requiring hospitalization
Fires/Explosions	• Major damage (>$250M) • Mutual Aid activated • Fire not controlled/ contained	• Significant damage (>$50M) • Fire extinguished or controlled • Unit shutdown	• Minimal, if any damage • Fire extinguished
Environmental Spills/Releases (including third party damage to TPI property)	• Major spills/releases **(>RQ of materials involved)** • Extensive cleanup (days/weeks) • Serious environmental impact (e.g. spills to water) • Tank overfills – not contained	• Significant spills/ releases **(>RQ of materials involved)** • Source isolated/ eliminated • Simple cleanup (days) • Small environmental impact • Any offsite impact	• Small spills/ releases **(<RQ level of material involved)** • Little, if any cleanup • Source eliminated • Tank overfills- contained
Media	• National Coverage • Adverse publicity probable	• Local, regional and/or state coverage • Adverse publicity possible	• Local coverage only • No adverse publicity expected
Equipment Failure/ Incident (e.g., tank car, tank truck, marine vessels/ barges***, vessels, tanks, other heavy equipment)	• Vehicle/equipment (not leaking) with major damage (>$250M) • Damage to non-TPI equipment/facilities • Marine vessel/barge grounding (spill)	• Vehicles/equipment (not leaking) with significant damage (>$50M) • Any incident involving hazardous materials cargo	• Minor incidents/ collisions, no spill • Minimal, if any damage
Emergency Shutdowns	• Total plant shutdown for more than 8 hours	• Total plant shutdown for more than 4 hours	• Single unit shutdown for more than 8 hours
Well Control Problems	• Blow out to surface • Fatalities • Major property damage (>$250M) • Fire	• Blowout to surface • Fire • Major property damage (>$50M)	• Blow out to surface
Criminal Incidents (on-site or while on company business)	• Homicide • Extortion • Kidnapping • Rape • Aggravated Robbery	• Embezzlement (>$1,000) • Theft (>$1,000) • Robbery • Assault	• Minor thefts
Community	• Major offsite property damage • Evacuation or Shelter-in-Place • Disruption of basic services	• Significant damage claims • Major complaints • Assault on TPI personnel	• Minor complaints • Minimal, if any, damage claims • Alleged odors
Public Authority/ Regulatory Agency Involvement	• Potential for substantial adverse action: fines, penalties, preemptive action	• Multi-Agency involvement • EPA Multimedia inspections	• Routine involvement • Compliance inspections • Fines and Penalties
INTERNAL REPORTING REQUIREMENTS**	**NOTIFY Retia Project Coordinator IMMEDIATELY R-PC - NOTIFY (800) 322-3462 WITHIN 2 HOURS**	**Notify Retia Project Coordinator IMMEDIATELY R-PC - NOTIFY (800) 322-3462 WITHIN 8 HOURS**	**NOTIFY RETIA Project Coordinator as soon as possible**

Note - Once the TPRI Emergency number has been called, the TPRI Incident Support Coordinator will contact the R-PC to ensure that needed support is available, and to make sure timely communications have been made to management and support personnel (Legal, etc).

RETIA USA INCIDENT NOTIFICATION HIERARCHY

The "Incident Notification Guide" (Table 1) is used to determine whether an incident falls in the High, Medium or Low category. Notification of **all** incidents is made through the RETIA USA hierarchy as follows :

LOW Level Incident (as defined in Table 1):

1. The Lead Contractor Project Manager (LC-PM), RETIA Project Manager (R-PM) or Site Supervisor (R-SS) will contact the RETIA Project Coordinator (R-PC) as described in Table 1.
2. The R-PC will contact the RETIA Department Manager (R-DM), RETIA Site Manager (R-SM) and RETIA Company President (R-CP) by phone or e-mail immediately upon being informed of the incident.
3. Incident investigation, actions and reporting will be implemented as required by customer.

MEDIUM Level Incident (as defined in Table 1):

1. The LC-PM or R-SS will contact the R-PC by phone immediately. (**This contact must be verbal and 'person to person' – i.e. notification of Medium level incidents through voicemail, text message or email is <u>not acceptable</u>.)**
2. Upon notification, the R-PC will immediately notify TPRI through theTPRI Emergency call center, (800) 322-3462 which is manned 24 hrs/day, **AND** the R-DM or R-SM, who will in turn contact the R-CP within at least 8 hours after being notified of the incident.
3. Incident investigation, actions, and reporting will be implemented as required by customer, and communicated within RETIA.
4. The R-DM or R-CP will inform the customer's HSE branch organization immediately upon notification.

HIGH level Incident (as defined in Table 1):

1. The LC-PM or R-SS will contact the R-PC, R-DM, R-SM or R-CP by phone immediately. **(The contact must be verbally, person to person and not via a voicemail, text message, or email)** (Contact to R-DM and R-CP can be made by R-PC).
2. The R-PC will immediately notify TPRI through the TPRI Emergency number, (800) 322-3462 (manned 24 hrs/day) within 2 hours of the incident, or sooner if at all possible.
3. The incident investigation, actions and reporting will be implemented as required by customer and communicated within RETIA.
4. The R-DM or R-CP will inform the customer's HSE branch organization immediately.

Notes:

- **Any** media attention during an incident of any severity must be reported to R-PC, R-DM and R-CP immediately
- The R-DM will communicate all incidents in a weekly report to TPRI (TPRI report).

Initial Incident Report

Following (or concurrent with) incident notification as described above, an initial written report is to be completed and submitted to the R-PC using the *Near-Miss and Incident Reporting Form (RMS 2.2.3.4).* The R-PC will distribute the report to the R-DM, R-CM and R-CP. The Initial Incident Report should include, at a minimum:

- Location, date, time ;
- Circumstances around the incident;
- Description of the accident / incident / near-miss;
- Description of the actual consequences (human / material);
- Description of the potential consequences (human / material);
- Immediate emergency reponse actions (if any);
- Possible causes of incident;
- Corrective action / preventive action implemented or to be considered;
- Timing for follow-up reporting if required;
- Indentification of assistance/resources needed to implement corrective actions.

Final Incident Report

Subsequent to the initial notification and reporting, the incident will be investigated according to customer guidelines. The R-PC will compile a final report which includes results of the investigation as well as information contained in the initial report. The R-PC will distribute the Final Incident Report to the R-DM and R-CM. The R-PC will be responsible for sharing investigation results with the R-PT and ensuring that any recommended Corrective Actions identified in the incident investigation.are implemented.

5. REFERENCE DOCUMENTS

EMERGENCY CONTACT NUMBERS

RMS 2.2.3.4 Near-Miss and Incident Reporting Form

RETIA USA	RMS 2.2.3.2	13/12/2018 Version: 2

HSE EVENT REPORTING FORM

SITE: Location:

Person Reporting Incident: Company:

Date of Report: Date of Incident: Time:

Type of Incident: Potential

Lighting: Weather: STOP CARD Used: ☐

DESCRIPTION OF HSE EVENT (include photo's)

INCIDENT CATEGORY:

APPLICABLE GOLDEN RULE(S)

☐ #1 ☐ #2 ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ #10 ☐ #11 ☐ #12

SAFESTART STATE (if applicable)

☐ RUSHING? ☐ FRUSTRATION? ☐ FATIGUE? ☐ COMPLACENCY?

DESCRIPTION OF POSSIBLE OUTCOME

IMMEDIATE ACTIONS TAKEN TO PREVENT ACCIDENT

1	
2	
3	
4	
5	

ANALYSIS (i.e underlying & root causes) & LESSONS LEARNED

PROJECT COORDINATOR Contacted:

Date/Time:

Forward copy to RETIA USA Safety Director

POST-CORRECTIVE ACTION VERIFICATION & FOLLOW-UP

Reviewed by: Date:

Effectiveness of implemented Corrective Action:

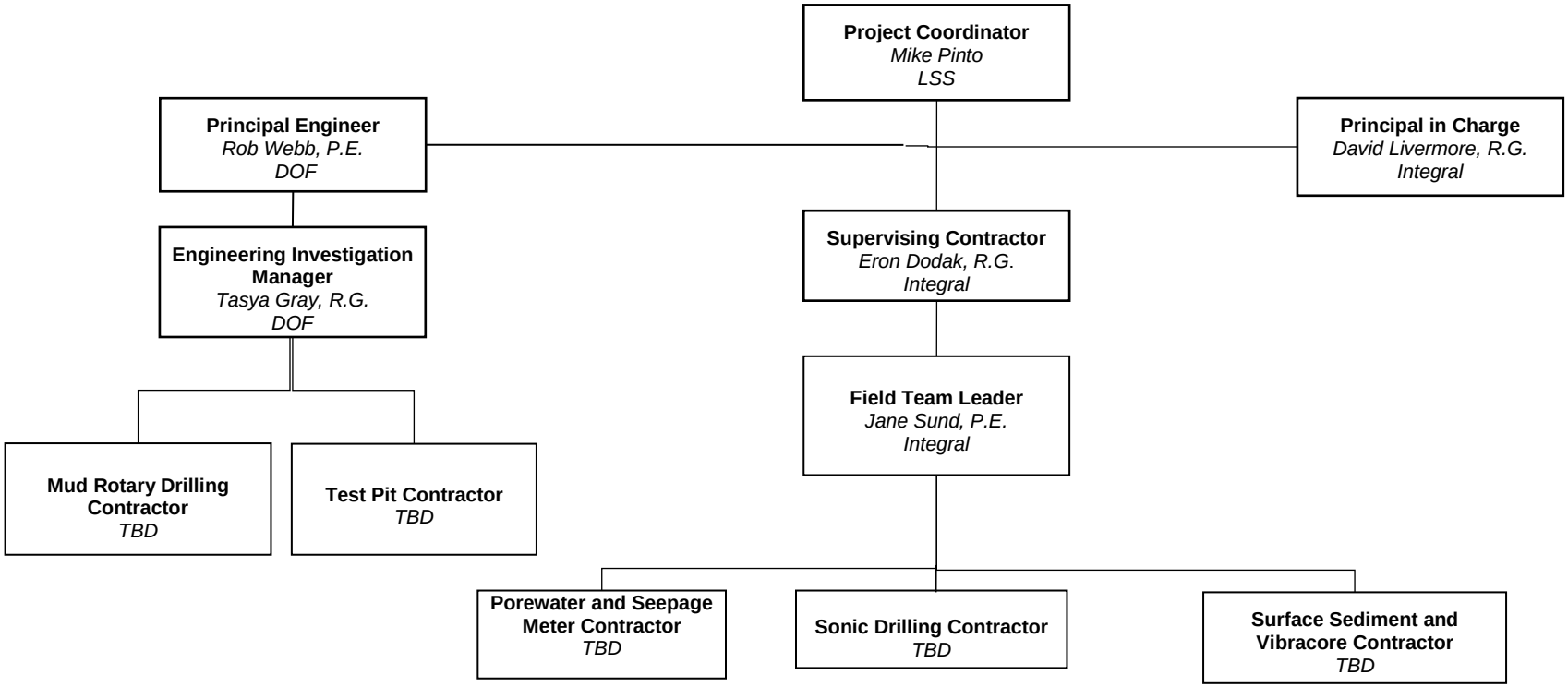
Comments/Action Required:

Appendix F

Key Contacts List

Key Contacts

	Name (affiliation)	Work Telephone	Cell Phone
Supervising Contractor	Eron Dodak (Integral)	503-943-3614	503-407-2933
Project Coordinator	Mike Pinto (LSS)	484-875-3465	484-437-1991
Client Safety Director	Fraser Will (RETIA USA)	713-483-5051	832-248-2834
Integral Health and Safety Manager	Matt Behum (Integral)	410-573-1982 ext. 512	443-454-1615
Site Health and Safety Officer/Site Supervisor	Jane Sund (Integral)	503-943-3615	512-779-3172
Alternate Site Safety Officer/Site Supervisor	Andrew Halmstad (Integral)	503-943-3633	503-505-0114



DRAFT

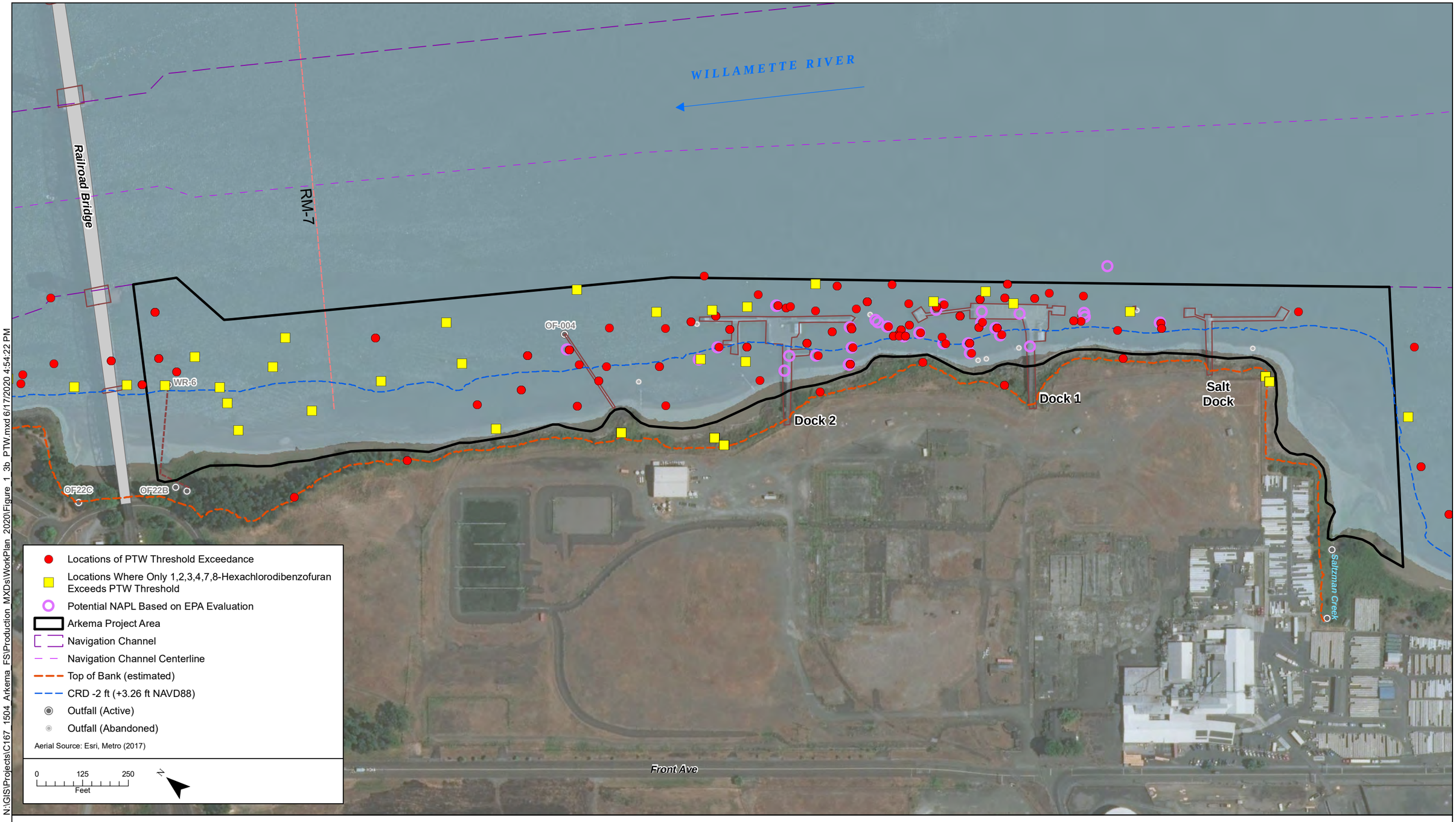
Figure 1
Arkema Sampling Team

Appendix G

RESERVED FOR
Site Specific H&S Plan(s)

Appendix H

Area of Concern (AOC) Maps

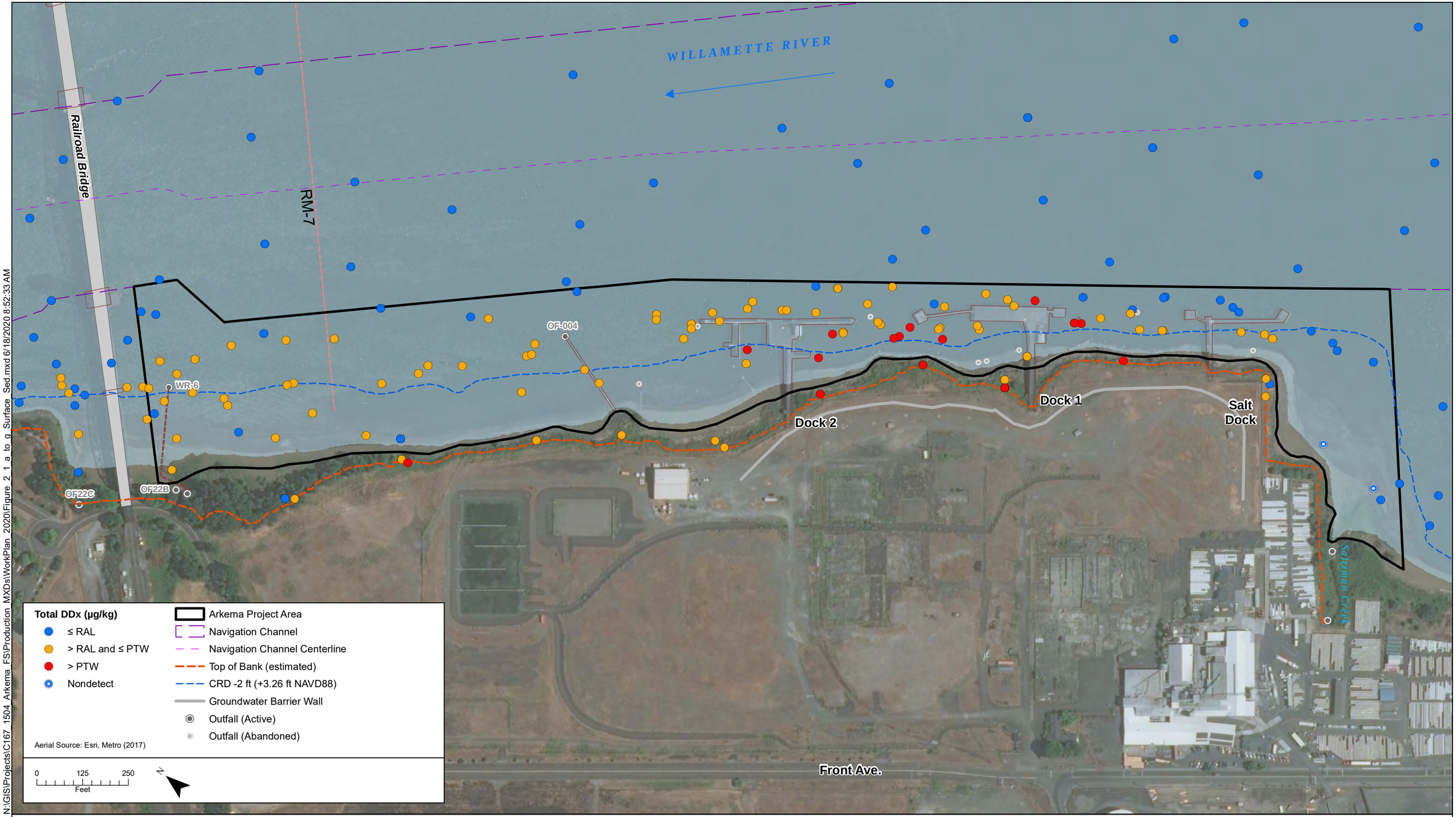


N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_1_3b_PTW.mxd 6/17/2020 4:54:22 PM

integral consulting inc.

DRAFT

Figure 1-3b.
Locations of PTW Threshold Exceedances and Potential NAPL
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_1_a_to_g_Surface_Sed.mxd 6/18/2020 8:52:33 AM

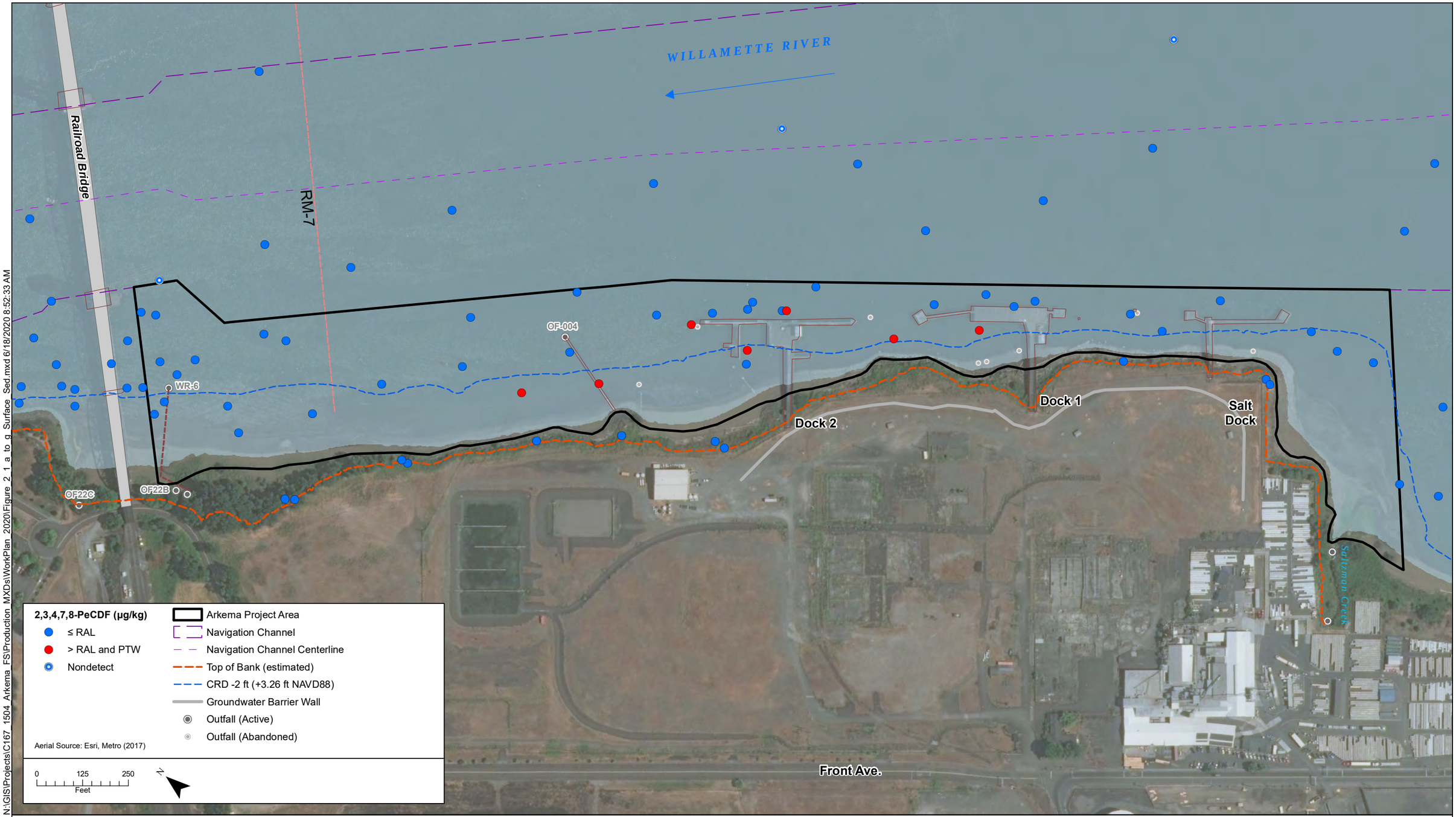
integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 160
Navigation Channel Remedial Action Level = 650
Principal Threat Waste = 7,050

DRAFT

Figure 2-1a.
DDx Surface Sediment and Riverbank Soil Data
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_1_a_to_g_Surface_Sed.mxd 6/18/2020 8:52:33 AM

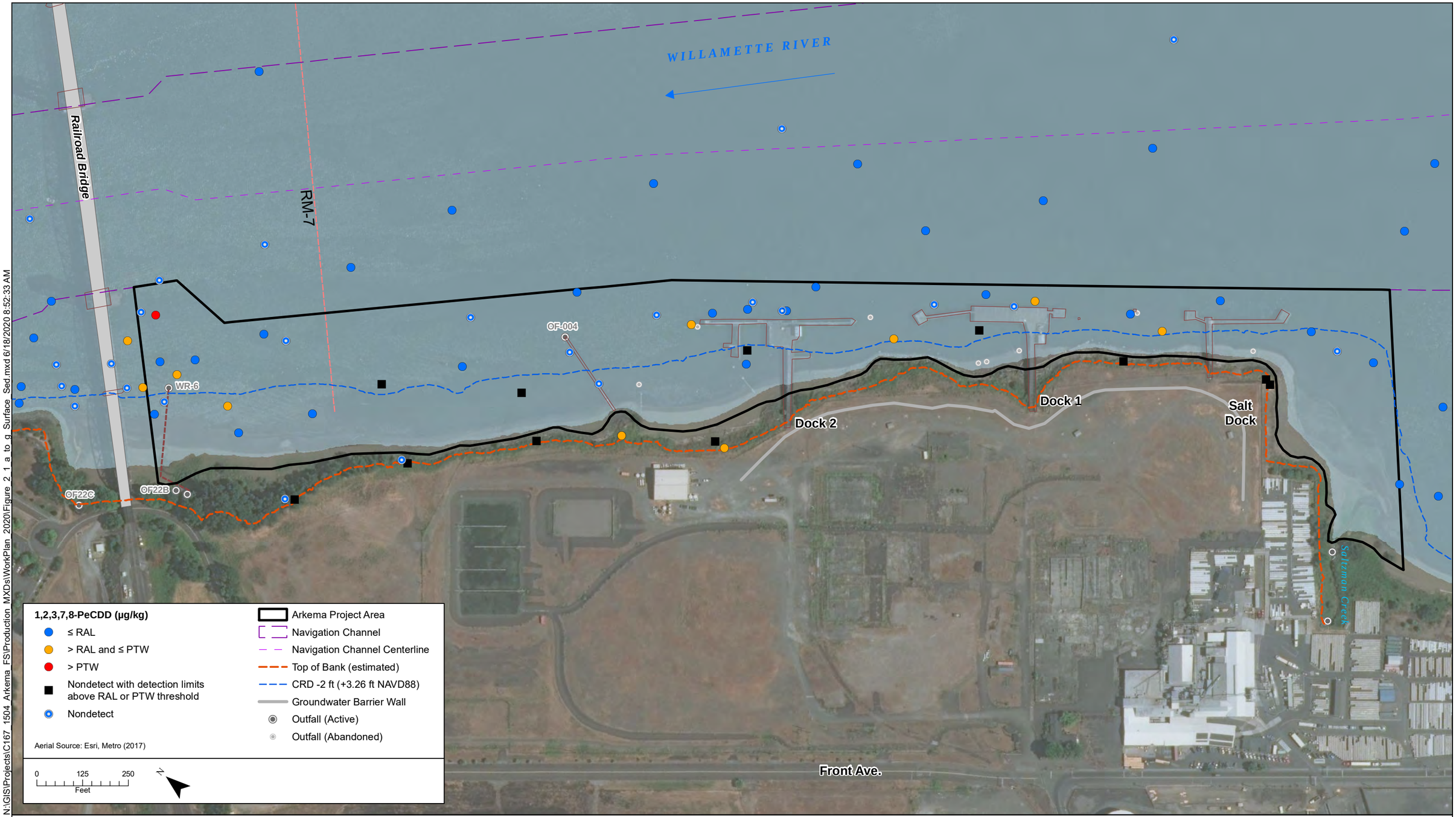


integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 0.2
Navigation Channel Remedial Action Level = 1
Principal Threat Waste = 0.2

DRAFT

Figure 2-1b.
2,3,4,7,8-PeCDF Surface Sediment and Riverbank Soil Data
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_1_a_to_g_Surface_Sed.mxd 6/18/2020 8:52:33 AM

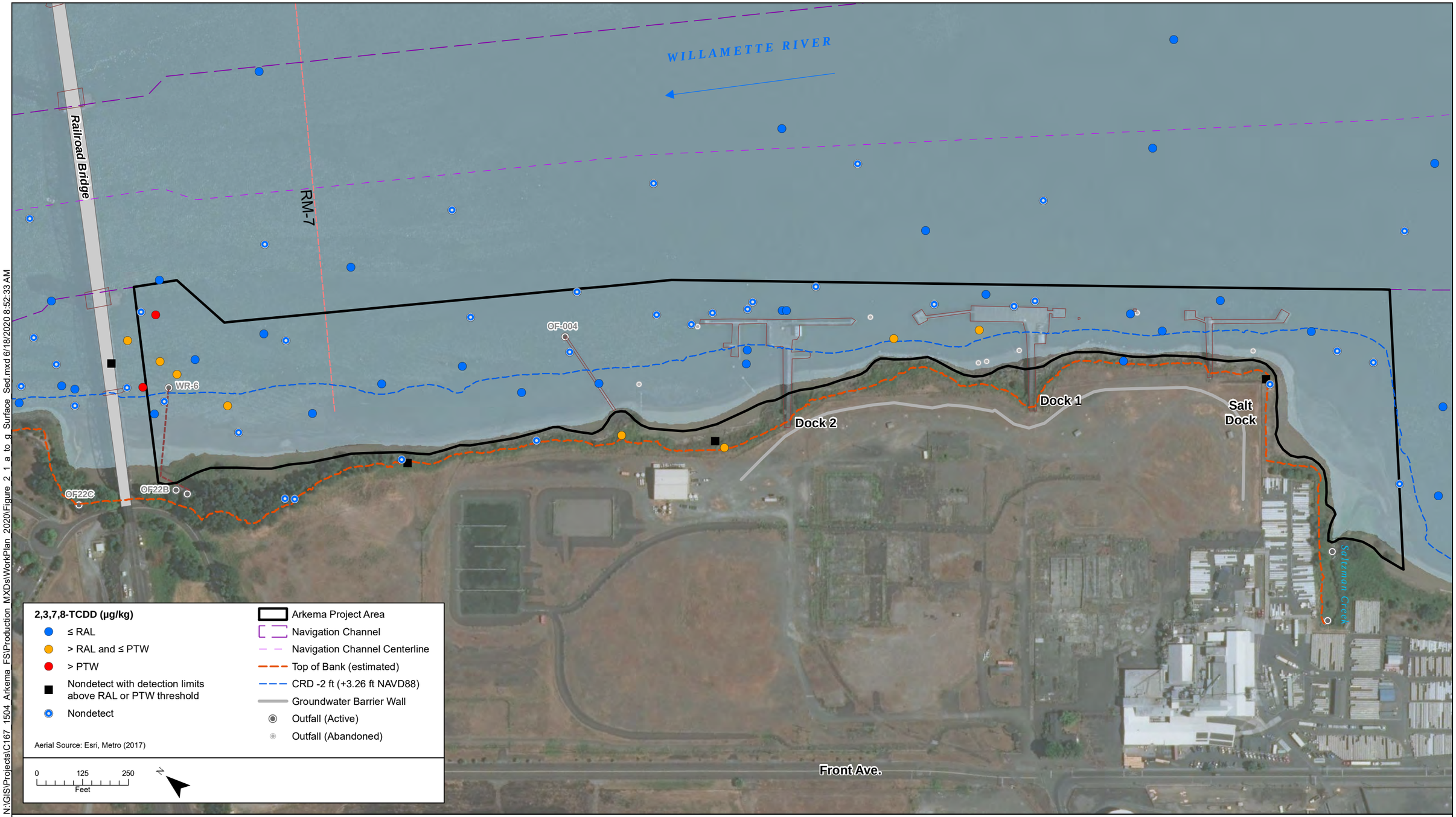
integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 0.0008
Navigation Channel Remedial Action Level = 0.003
Principal Threat Waste = 0.01

DRAFT

Figure 2-1c.
1,2,3,7,8-PeCDD Surface Sediment and Riverbank Soil Data
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_1_a_to_g_Surface_Sed.mxd 6/18/2020 8:52:33 AM



integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 0.0006
Navigation Channel Remedial Action Level = 0.002
Principal Threat Waste = 0.01

DRAFT

Figure 2-1d.
2,3,7,8-TCDD Surface Sediment and Riverbank Soil Data
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_1_a_to_g_Surface_Sed.mxd 6/18/2020 8:52:33 AM

WILLAMETTE RIVER

Railroad Bridge

RM-7

OF-004

WR-6

OF22C

OF22B

Dock 2

Dock 1

Salt Dock

Salzman Creek

Front Ave.

Total PCBs (µg/kg)

- ≤ RAL
- > RAL and ≤ PTW
- > PTW
- Nondetect with detection limits above RAL or PTW threshold
- Nondetect

Aerial Source: Esri, Metro (2017)

- Arkema Project Area
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Groundwater Barrier Wall
- Outfall (Active)
- Outfall (Abandoned)

0 125 250
Feet

integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 75
Navigation Channel Remedial Action Level = 1,000
Principal Threat Waste = 200

DRAFT

Figure 2-1e.
Total PCBs Surface Sediment and Riverbank Soil Data
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_1_a_to_g_Surface_Sed.mxd 6/18/2020 8:52:33 AM

WILLAMETTE RIVER

Railroad Bridge

RM-7

OF-004

WR-6

OF22C

OF22B

Dock 1

Dock 2

Salt Dock

Salzman Creek

Front Ave.

Total PAHs (µg/kg)

- ≤ RAL
- > RAL and ≤ PTW
- > PTW
- Nondetect

- Arkema Project Area
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Groundwater Barrier Wall
- Outfall (Active)
- Outfall (Abandoned)

Aerial Source: Esri, Metro (2017)

0 125 250
Feet

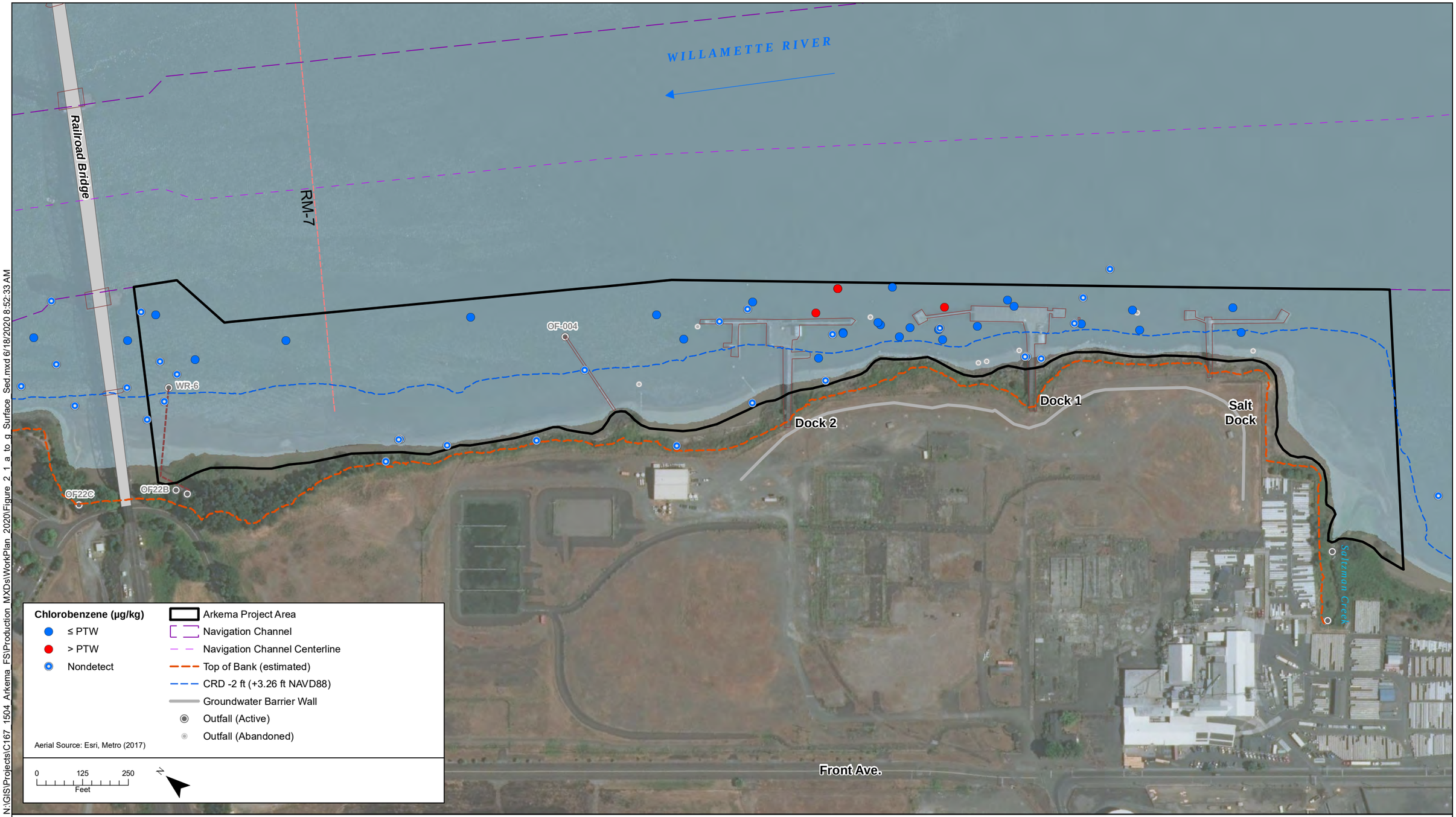
N

integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 30,000
Navigation Channel Remedial Action Level = 170,000
Principal Threat Waste = N/A

DRAFT

Figure 2-1f.
Total PAHs Surface Sediment and Riverbank Soil Data
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_1_a_to_g_Surface_Sed.mxd 6/18/2020 8:52:33 AM

integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = NA
Navigation Channel Remedial Action Level = NA
Principal Threat Waste = 320

DRAFT

Figure 2-1g.
Chlorobenzene Surface Sediment and Riverbank Soil Data
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_2_a_to_g_Sub_Subsurface_Sed.mxd 6/18/2020 9:37:07 AM

WILLAMETTE RIVER

Railroad Bridge

RM-7

OF-004

WR-6

OF22B

OF22C

Saltzman Creek

DDx (µg/kg)

- ≤ RAL
- > RAL and ≤ PTW
- > PTW
- Nondetect

- Arkema Project Area
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Groundwater Barrier Wall
- Outfall (Active)
- Outfall (Abandoned)

Aerial Source: Esri, Metro (2017)

0 125 250 Feet

N

integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 160
Navigation Channel Remedial Action Level = 650
Principal Threat Waste = 7,050

2.3 ← Maximum Depth of RAL Exceedance (ft below mudline)
11 ← Maximum Depth of Core (ft below mudline)

n/a = not applicable because remedial action level was not exceeded

DRAFT

Figure 2-2a.
DDx Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_2_a_to_g_Sub_Subsurface_Sed.mxd 6/18/2020 9:37:07 AM

WILLAMETTE RIVER

Railroad Bridge

RM-7

OF-004

WR-6

OF22B

OF22C

Saltzman Creek

2,3,4,7,8-PeCDF (µg/kg)

- ≤ RAL
- > RAL and PTW
- Nondetect

- Arkema Project Area
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Groundwater Barrier Wall
- Outfall (Active)
- Outfall (Abandoned)

Aerial Source: Esri, Metro (2017)

0 125 250 Feet

N

integral consulting inc.

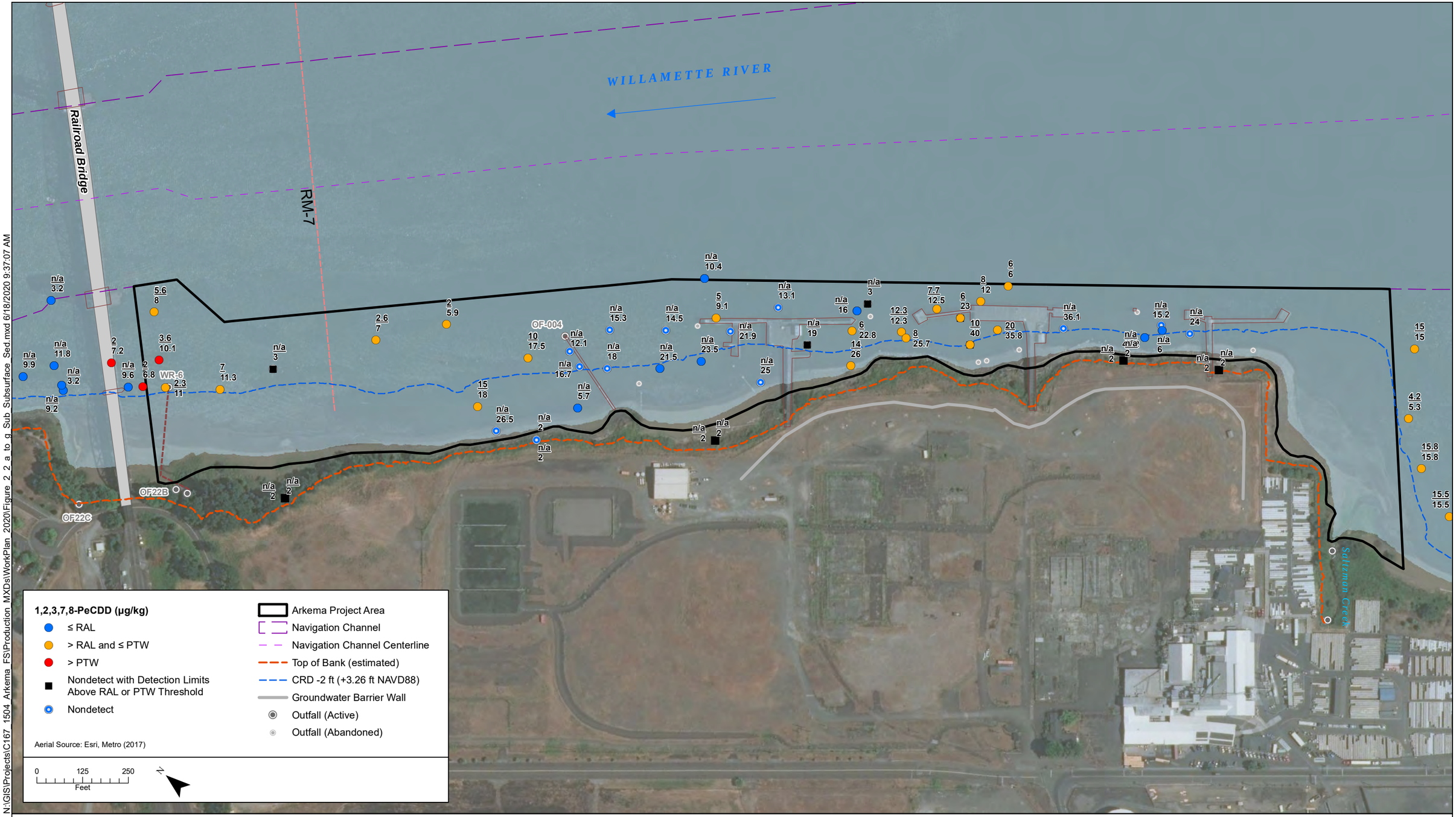
Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 0.2
Navigation Channel Remedial Action Level = 1
Principal Threat Waste = 0.2

2.3 ← Maximum Depth of RAL Exceedance (ft below mudline)
11 ← Maximum Depth of Core (ft below mudline)

n/a = not applicable because remedial action level was not exceeded

DRAFT

Figure 2-2b.
2,3,4,7,8-PeCDF Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167 1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 2_2 a to g_Sub Subsurface Sed.mxd 6/18/2020 9:37:07 AM

integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 0.0008
Navigation Channel Remedial Action Level = 0.003
Principal Threat Waste = 0.01

2.3 ← Maximum Depth of RAL Exceedance (ft below mudline)
11 ← Maximum Depth of Core (ft below mudline)

n/a = not applicable because remedial action level was not exceeded

DRAFT

Figure 2-2c.
1,2,3,7,8-PeCDD Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_2_a_to_g_Sub_Subsurface_Sed.mxd 6/18/2020 9:37:07 AM

WILLAMETTE RIVER

Railroad Bridge

RM-7

OF-004

OF22B

OF22C

WR-6

Salzman Creek

2,3,7,8-TCDD (µg/kg)

- ≤ RAL
- > RAL and ≤ PTW
- > PTW
- Nondetect with Detection Limits Above RAL or PTW Threshold
- Nondetect

Aerial Source: Esri, Metro (2017)

- Arkema Project Area
- Navigation Channel
- Navigation Channel Centerline
- Top of Bank (estimated)
- CRD -2 ft (+3.26 ft NAVD88)
- Groundwater Barrier Wall
- Outfall (Active)
- Outfall (Abandoned)

0 125 250 Feet

N

integral consulting inc.

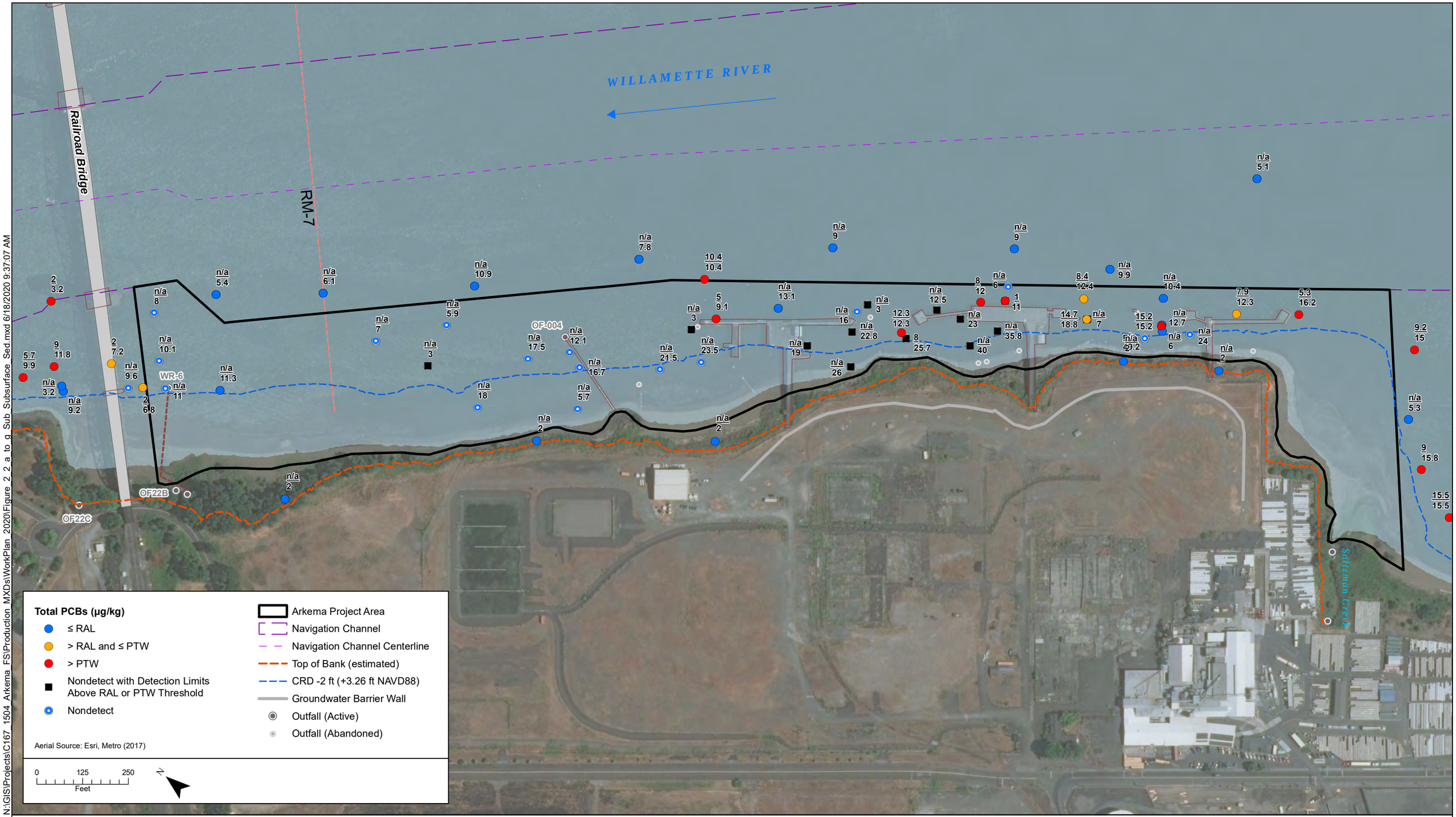
Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 0.0006
Navigation Channel Remedial Action Level = 0.002
Principal Threat Waste = 0.01

2.3 ← Maximum Depth of RAL Exceedance (ft below mudline)
11 ← Maximum Depth of Core (ft below mudline)

n/a = not applicable because remedial action level was not exceeded

DRAFT

Figure 2-2d.
2,3,7,8-TCDD Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_2_a_to_g_Sub_Subsurface_Sed.mxd 6/18/2020 9:37:07 AM

integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 75
Navigation Channel Remedial Action Level = 1,000
Principal Threat Waste = 200

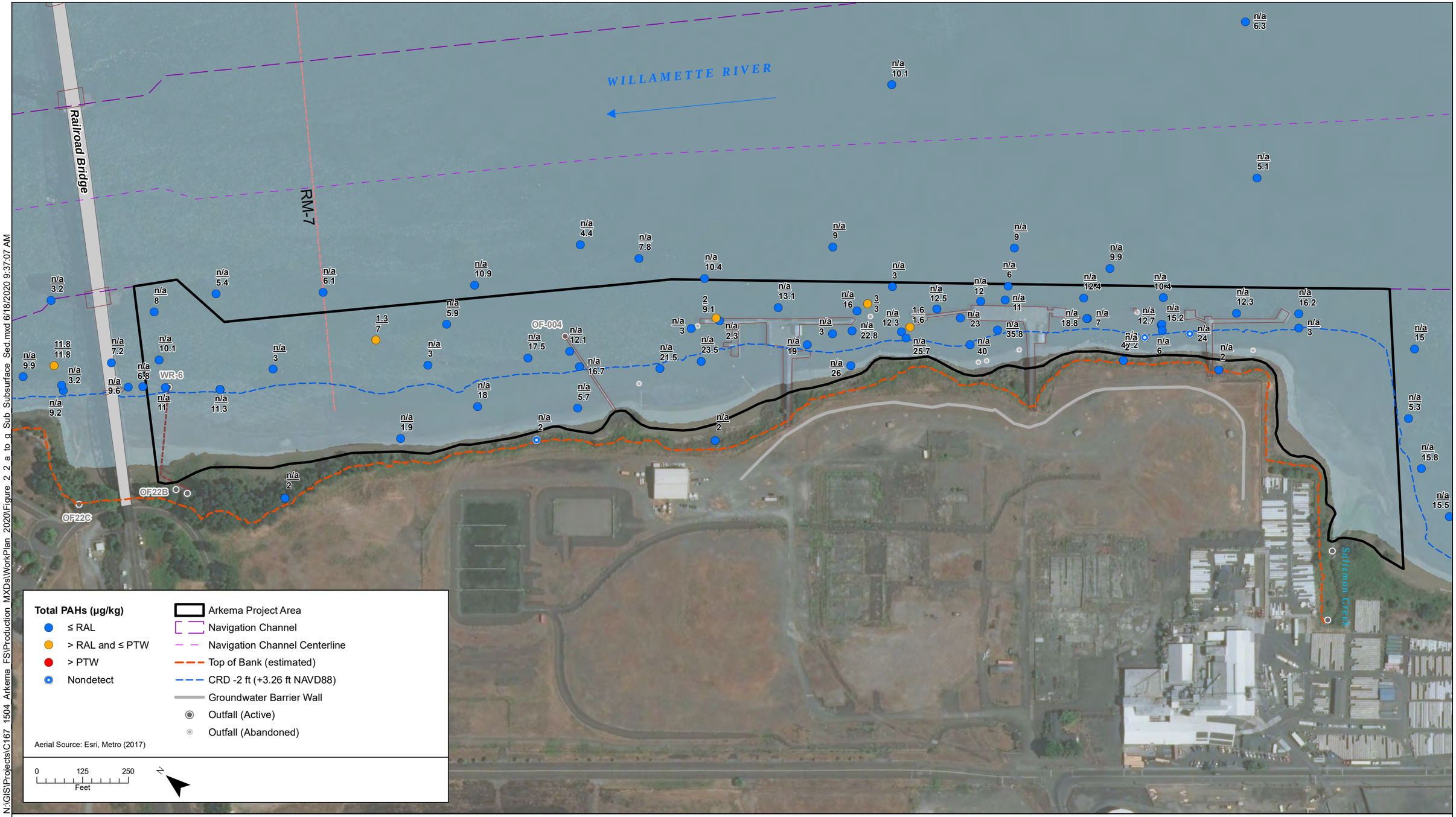
2.3 ← Maximum Depth of RAL Exceedance (ft below mudline)
11 ← Maximum Depth of Core (ft below mudline)

n/a = not applicable because remedial action level was not exceeded

DRAFT

Figure 2-2e.
Total PCBs Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance
Arkema Project Area Pre-design Investigation Work Plan

N:\GIS\Projects\C167 1504 Arkema FS\Production MXDs\WorkPlan 2020\Figure 2_2 a to g_Sub Subsurface Sed.mxd 6/18/2020 9:37:07 AM



integral consulting inc.

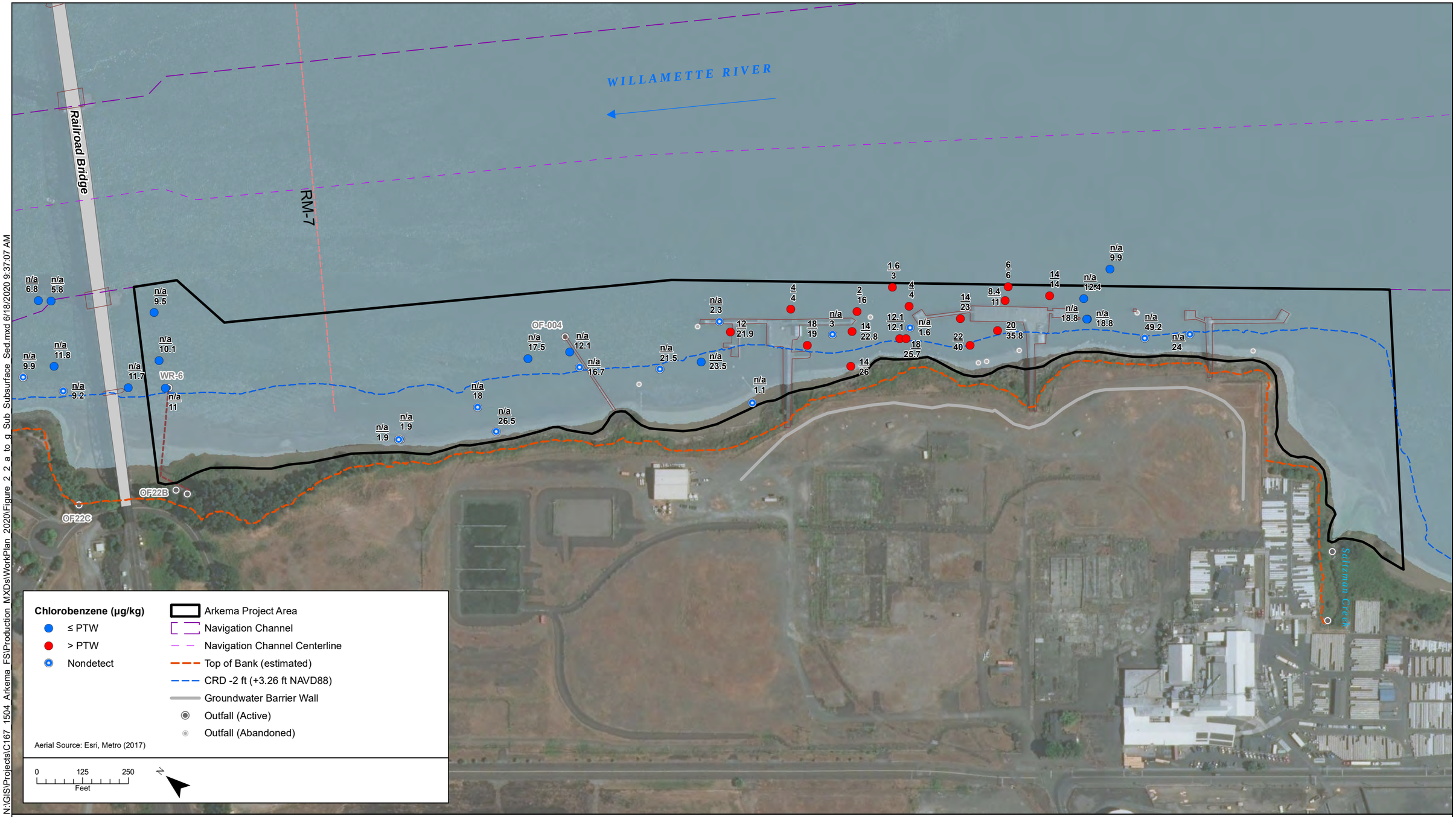
Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = 30,000
Navigation Channel Remedial Action Level = 170,000
Principal Threat Waste = N/A

2.3 ← Maximum Depth of RAL Exceedance (ft below mudline)
11 ← Maximum Depth of Core (ft below mudline)

n/a = not applicable because remedial action level was not exceeded

DRAFT

Figure 2-2f.
Total PAHs Subsurface Sediment and Riverbank Soil Data with Maximum Depth of RAL Exceedance
Arkema Project Area Pre-design Investigation Work Plan



N:\GIS\Projects\C167_1504_Arkema_FS\Production_MXDs\WorkPlan_2020\Figure_2_2_a_to_g_Sub_Subsurface_Sed.mxd 6/18/2020 9:37:07 AM

integral consulting inc.

Portland Harbor ROD Sediment Thresholds (µg/kg)
Remedial Action Level = NA
Navigation Channel Remedial Action Level = NA
Principal Threat Waste = 320

2.3 ← Maximum Depth of RAL Exceedance (ft below mudline)
11 ← Maximum Depth of Core (ft below mudline)

n/a = not applicable because remedial action level was not exceeded

DRAFT

Figure 2-2g.
Chlorobenzene Subsurface Sediment and Riverbank Soil Data with Maximum Depth of PTW Exceedance
Arkema Project Area Pre-design Investigation Work Plan

Appendix I

RESERVED FOR
Contractor Pre-Start Safety Checklist

Appendix J

Total Critical Analysis of Task Procedure & Example

Purpose:

Provide guidance in reviewing probability of risk in the execution of various work activities through the **C**ritical **A**nalysis of **T**ask**s (CATs)**. The CATs Analysis process will help identify those significant hazards that may result in an undesired event that may cause injury if not properly mitigated.

Scope:

This procedure provides an overview of the CATs Analysis which is a structured semi-quantitative assessment conducted when a task is associated with greater hazards or complexities.

Definitions:

- **Hazard Identification** - Recognizing tasks that could cause harm.
- **Hierarchy of Controls** - A system used in industry to minimize or eliminate the hazards.
- **Job** - A general activity, including several different tasks that occur when working.
- **JSA (Job Safety Analysis)** - A process that identifies, analyzes and documents the potential hazards associated with each step of a task.
- **Project -** A one-time planned set of interrelated jobs having defined start and end dates, a clearly specified objective or scope of work to be performed, a pre-defined budget and usually a temporary organization (such as project team) that is dismantled once the project is complete.
- **Probability** - The likelihood that something will happen.
- **Risk Assessment** - A methodical way to analyze and quantify the level of risk posed by a hazard that may be associated with the job task.
- **Risk** - A measure of loss/harm to people, the environment, compliance status, reputation, assets or business performance in terms of the product of the probability of an event occurring and the magnitude of its impact.
- **Risk control** - Implementing suitable measures to reduce or eliminate significant hazards.
- **Safe Task Analysis (STA)** - A listing of job tasks with significant hazards and the required mitigation.
- **Severity** - The level of consequence as the result of an event.
- **Significant Hazard** - An unsafe condition or act with the potential to result in a serious injury or death.
- **Task** - One of several specific actions as part of the process to complete a job.

Task Risk Assessment Principles:

Utilize the following principles to assist in identifying the significant risks in the task being conducted.

- The team makeup should include key personnel, HSSE, and/or technical authorities.
- Indentify all the possible energy sources affiliated with the work activities.
- Indentify who or what could be affected.
- Reduce the risks by establishing a suitable combination of controls.
- Evaluate the remaining residual risk when all the planned controls are in place.
- Document the significant risks and the controls in the CATs work sheet.
- Record and document the approvals on the CATs worksheet.
- Communicate the hazards and controls to all those involved in performing the task.
- Identify any new hazards that may be introduced during the activity.

Sources of Energy and Exposure:

The potential sources of energy and exposure listed below should be considered when conducting a CATs analysis.

✓	***Biological***	✓	***Mechanical***
✓	***Body Mechanics***	✓	***Noise***
✓	***Chemical***	✓	***Pressure***
✓	***Electrical***	✓	***Radiation***
✓	***Gravity***	✓	***Thermal***

Hierarchy of controls:

The Hierarchy of Controls is the preferred method of mitigating the significant hazards.

1. **Engineering Controls** - The use or substitution of engineered machinery or equipment to reduce or eliminate significant hazards.
2. **Administrative Controls** - The use of procedures or work schedule adjustments to reduce or eliminate significant hazards.
3. **PPE Controls** - The use of personal protective equipment in the absence of or in addition to engineering and/or administrative controls.

If the severity is high, the most effective hierarchy order of control should be used. Sometimes they may have to be used in combination.

Safe Task Analysis:

The Safe Task Analysis is the prerequisite to conducting a CATs analysis. The owner of the work activity is responsible for documenting the steps in the work flow to identify significant hazards for each job.

The STA consist of the following:

- Task Sequence
- Significant Hazards
- Mitigations
- Equipment
- Responsible Party

The **STA** form must be maintained throughout the project and is subjected to a site audit by site personnel at anytime.

CATs (Critical Analysis of Tasks)

Step 1: Determine the Category 1 risk impact level

If the severity and probability Risk Impact Level results **5 or below**, no further action is required if the proper mitigations are put into place. Proceed to Step 4 **only if the risk impact level exceeds 5.**

Step 2: Determine the severity level

Document the severity level into the CATs Analysis worksheet.

Severity Level		
5	**Catastrophic**	**Several fatalities**
4	**Major**	**Permanent disability, fatality, or injuries to the offsite population**
3	**Serious**	**Accident with lost time**
2	**Moderate**	**Accident without lost time, medical treatment only**
1	**Minor**	**First Aid**

Step 3: Determine the probability level

Document the probability level into the CATs Analysis worksheet.

Risk Impact Levels		Probability Levels				
Severity Levels		1 Remote possibility, rare occurrence.	2 Similar Event has Occurred in Industry & within Total Group	3 Likely to Occur Once or Twice in Lifetime of Facility	4 Likely to Occur Several Times in Lifetime of Facility	5 Common Occurrence at Facility
5	**Catastrophic**	6	8	10	11	12
4	**Major**	5	7	9	10	11
3	**Serious**	4	6	8	9	10
2	**Moderate**	3	5	7	8	9
1	**Minor**	2	4	6	7	8

Reasons that could result in escalation to a Category 2 CATS:

- New or unfamiliar task to a site
- Variance to site written procedure or routine
- Previous near miss or incident involving similar tasks
- Task has simultaneous operations and/or greater complexity
- Safety concerns of anyone involved in the CATs Analysis

Step 4: Determine the Category 2 risk impact level

If the severity and probability Risk Impact Level results are **6 or higher** additional mitigation is required to reduce it to an acceptable level.

Step 5: Obtain the appropriate approval signatures

Risk Impact Levels	Total Approval Requirements (Approval titles may vary from site to site)
10-12	Plant Manager or designee
8-9	Senior Manager
6-7	Superintendent
2-5	Area Authority

Note:
If the risk impact level is a 10 or higher after the Category 2 review, alternative measures should be pursued. Plant management involvement is required for further review.

JSA's:
The information from the CATs Analysis is used to generate the JSA.

Record keeping:
Keep all records of the CATs analysis for future references to be utilized on other projects.

- Keep records on CATs analysis of all task
- Update the Safe Task Analysis form when needed
- Know what has been done and what needs to be done
- Summary of identified Hazards
- What new measures have been identified to control the risk
- What risk control measures have been implemented
- Who was involved in the hazard identification
- Who consulted in the hazard identification, risk assessment and risk control process

Monitor the job – it is important to identify any new hazards that may be introduced during or because of the activity the crew is conducting.

Example of a CATs Analysis worksheet:

CATs Analysis Worksheet							
Task Step	**Significant Hazards**	**Severity/ Probability**	**Category 1**	**Mitigations**	**Severity/ Probability**	**Category 2**	**Approvals**
Change of Equipment to complete the task	How the task is done. The new equipment does not secure the load as well as the other piece of equipment.	**4/5**	**11**	Secure load with proper restraints, Need the proper straps to make sure load is secure. A flagman will monitor work area and keep personnel away from load. Discuss new hazards with work crew. Revise JSA.	**4/2**	**7**	Superintendant Signature.

Reference the Safe Work Control Policy Procedure for more information and CATs forms.

Revision Log	
Revision Date	**Changes/Reasons for change**

EXAMPLE OF COMPLETED CAT MATRIX

The attached matrix is provided to illustrate the format and typical level of detail and assessment required when performing a CAT assessment

VIASANT

Job Description: DEMOLITION OF TCC UNIT

STEP	SIGNIFICANT HAZARDS/RISKS	SEVERITY/ PROBABILITY	LEVEL 1	MITIGATION/CONTROL MEASURES	RESIDUAL SEVERITY/ PROBABILITY	LEVEL 2	APPROVER INITIALS
1.0 PREPARATION OF STRUCTURE FOR EXPLOSIVE DEMOLITION							
1.1 Concrete Coating Removal: Concrete surround must be removed from the structural members to allow the explosives to be attached to the structural steel members. The concrete is 3-4" thick, and will need to be removed by mechanical means. Concrete must be surgically removed on the first floor of the structural legs in order for torch cutting and explosive placement to be effective.	1. Unplanned Toppling of Structure/Structure Alteration: There is a risk of unintended and/or non-deliberate (premature) collapse of any portion of the structure/equipment during the works due to the presence of weak/deteriorating materials and structural elements. Catastrophic failure can occur without warning. Careful and detailed consideration must be given to any partial demolitions and structural alterations that may interfere with the structural stability of the Tower. The integrity of the structure shall be maintained at all times.	5/3	10	a.) Clearly indicate the removal area for each member by using red spray-paint to only the concrete which is necessary while structure remains standing b.) FPM to supervise the work at all time. Inspect each beam regularly and remove the least amount of concrete necessary. c.) Extreme care must be taken when removing concrete surround to avoid excessive vibrations or stress on the structure. Hydraulic hammer must be used and operated by a very competent operator. d.) Use a spotter for hammer operator when removing concrete to assist in limiting the firing of the hammer against bare steel and to reduce steel deformation e.) Completely restrict access around the TCC unit (75' minimum) for all personnel who are not essential to the preparation activities. f.) VIASANT will use the smallest hammer (5000lbs on 260 excavator) available which still allows for proper operator protection to minimize vibration and impact on the structure. g.) Once the concrete surround has been removed, an exclusion zone shall be created around the TCC Unit and all access completely restricted to the TCC Unit for a period of 72 hours. The waiting period is to allow the Unit to settle and provide an opportunity for any loose or dislodged material to fall to the ground without risk of injury. Only after 72 hours will the torch cutters and blasters be allowed access to the steel columns.	4/2	7	FW
	2. Falling Material/Flying Debris: Vibration from concrete removal could dislodge loose materials or structurally weakened piping, equipment etc and cause material to fall from higher in the unit. As material falls it could also result in flying debris which could strike workers in the area.	4/4	10	a.) Ensure spotter has face shield in addition to standard Level D PPE. b.) Establish exclusion zone for the working area, and limit entry to within a 75' radius of the working area for authorized personnel only c.) All concrete removal to be performed remotely using an excavator with a minimum 20ft boom with appropriate guards and operator protective devices are fitted (i.e. FOPS guard.) d.) Completely restrict passage on foot to the TCC unit while performing concrete removal operations.	4/2	7	FW

STEP	SIGNIFICANT HAZARDS/RISKS	SEVERITY/ PROBABILITY	LEVEL 1	MITIGATION/CONTROL MEASURES	RESIDUAL SEVERITY/ PROBABILITY	LEVEL 2	APPROVER INITIALS
	3. Equipment Damage: During Concrete removal work, debris could strike and damage the equipment\shatter equipment glass, and cause other damage	3/4	9	a.) Establish exclusion zone for the working area, and limited entry to within a 75' radius of the working area for authorized personal only b.) Ensure that all equipment guards are installed and in good working order to protect equipment c.)Inspect each area during set up to determine structural stability around the work area and ensure equipment has a clear path for egress prior to beginning work d.) Travel paths will be kept clear of metal and other debris as work progresses. A clear and direct pathway for exiting of the area will be maintained at all times	2/2	5	RM
1.2 Torch cutting of structural members to accommodate shaped charge: Thick steel support legs must be minimally torch cut and prepared in order to be receive the linear shaped charges to ensure the cutting detonation effect is properly directed. Structural members will be cut immediately prior to explosive demolition to the minimum extent possible to limit the amount of time the structure remains in a weakened state.	1. There is a risk of unintended and/or non-deliberate (premature) collapse of any portion of the structure/equipment during the works due to the presence of weak/deteriorating materials and structural elements. Catastrophic failure can occur without warning. Careful and detailed consideration must be given to any partial demolitions and structural alterations that may interfere with the structural stability of the Tower. The integrity of the structure shall be maintained at all times.	5/3	10	a.) Clearly indicate the exact cut for each structural member. Confirm with FPM and VRH blaster prior to beginning cut, and proceed accordingly to VRH cut plan. b.) Follow prepared cut plan from VRH. Inspect each beam regularly by FPM and VRH personnel to ensure that cuts are made to the proper extent c.) Completely restrict access around the TCC unit (75' minimum) for all personnel who are not essential to the preparation activities. d.) The FPM shall supervise all activities during pre cutting of structural members in preparation for blasting	4/2	7	FW
	2. Hot Work will be required: Torch cutting of the steel structural members is required to accommodate the linear shaped charges to ensure the cutting detonation effect is properly directed.	4/3	9	a.) Use appropriate PPE, per VIASANT SPs # 125, 137 and inspect PPE before each use (GR#4). b.) Obtain appropriate permits as required by task\SP# 149 (GR#5). c.) Inspect tools and equipment per SP#133 (GR#3). d.) Station bottles away from work area a minimum of 20'. e.) Provide Fire Watch per VIASANT SP #137. f.) Inspect arms and hands of personnel performing hot work for burns or pock marks at the end of each shift. g.) Only one cutting torch to be used at all times while working under the base of the TCC Unit.	3/2	6	FW
	3. Cuts and abrasions: The torch cut members could have sharp edges.	3/5	10	a.) Wear proper PPE (i.e. Kevlar or FR Gloves). b.) Watch hand placement carefully. c.) Identify and mark sharp edges as needed. d.) Remove hazards where possible.	2/2	5	RM

STEP	SIGNIFICANT HAZARDS/RISKS	SEVERITY/ PROBABILITY	LEVEL 1	MITIGATION/CONTROL MEASURES	RESIDUAL SEVERITY/ PROBABILITY	LEVEL 2	APPROVER INITIALS
	4. Falling Piping\Debris: During hot work and structural member preparation, unstable piping or equipment can become dislodged and can fall to grade in an unplanned fashion	4/4	10	a.) Limit access to work area (authorized and required personnel only) during hot work and mechanical demolition activities per VIASANT SP#122. b.) Fire Watch must alert for any changing conditions above the person performing hot work c.) Have torch cutter set up outside of the footprint of the unit to the greatest extent possible to ensure materials within the footprint are not an issue (GR#10) d.) Use good body positioning, and ensure an escape route in the event that piping or equipment's shifts in a manner other than intended. e.) Walkways will be kept clear of metal and other debris as work progresses. A clear and direct pathway for exiting of the area will be maintained at all times. f.) No personnel will be allowed in the area under the TCC Unit while prep work is being performed. (with the exception of torch cutter, if absolutely necessary). g.) Concrete removal will be completed at least **72 hours** prior to performing torch cutting or charge placement on structural members to allow for any setting or shifting of materials which may have been jarred loose during concrete removal. h.) A peripheral inspection with the man-lift on every level up to 60 feet. The operator will have a long pole to push small objects as necessary or to note the location and thereby restrict areas below. The interior decking is largely intact except for the center of the lowest deck and specific identifiable voids which can be marked. I.) Peripheral inspection by ground spotters with binoculars or preferably spotting scopes, during all activities. j.) A defined entry point that visually appears without unsecured debris.	4/2	7	FW
	5. Struck By or Against: Personnel can be struck by debris or other equipment while in the work area	4/3	9	a.) The absolute minimum number of personnel shall be allowed to access the lower portion of the TCC Unit. b.) All pedestrians are required to remain on walking paths, and must notify operator prior to approaching within 75' of the working area. c.) All workers must use stable footing and remove all debris from the work area as soon as it is demolished to grade d.) Walkways will be kept clear of metal and other debris as work progresses. A clear and direct pathway for exiting of the area will be maintained at all times.	3/2	6	FW
	6. Slips/trips/falls: while the 1st floor area has been cleared there are tight areas, edges and other obstructions.	2/4	8	a.) Identify and remove or mark any hazards. b.) Focus on awareness, always look around you and walk your space before beginning a task. C.) Do not allow unnecessary people to walk through the work zone. (SP 122)	1/2	4	RM

CATs
(Critical Analysis of Tasks)

STEP	SIGNIFICANT HAZARDS/RISKS	SEVERITY/ PROBABILITY	LEVEL 1	MITIGATION/CONTROL MEASURES	RESIDUAL SEVERITY/ PROBABILITY	LEVEL 2	APPROVER INITIALS
1.3 Installation of Debris Shields/Megaphones: Steel shields and earthen berms will be installed per VRH plans to control debris from shaped charges placed on south side structural members to block any flying debris from the explosive demolition	1. Hot Work may be required: Steel sheets may need to be hot cut for proper sizing before placement	4/3	9	a.) Use appropriate PPE, per VIASANT SPs # 125, 137 and inspect PPE before each use (GR#4). b.) Obtain appropriate permits as required by task\SP# 149 (GR#5). c.) Inspect tools and equipment per SP#133 (GR#3). d.) Station bottles away from work area a minimum of 20'. e.) Provide Fire Watch per VIASANT SP #137. f.) Inspect arms and hands of personnel performing hot work for burns or pock marks at the end of each shift.	3/2	6	FW
	2. Cuts and abrasions: The steel sheets could have sharp edges which can cause cuts and scrapes	2/5	9	a.) Wear proper PPE (i.e. Kevlar or FR Gloves). b.) Watch hand placement carefully. c.) Identify and mark sharp edges as needed. d.) Remove hazards where possible.	1/2	4	RM
	3. Struck By or Against: Personnel can be struck by debris or other equipment while in the work area	4/3	9	a.) All pedestrians are required to remain on walking paths, and must notify operator prior to approaching within 75' of the working area. b.) All workers must use stable footing and remove all debris from the work area as soon as it is demolished to grade c.) Walkways will be kept clear of metal and other debris as work progresses. A clear and direct pathway for exiting of the area will be maintained at all times d.) Use a spotter when excavator and bobcat are working in tandem to ensure constant awareness of positioning in blind spots, etc. e.) Operators must be aware of their surroundings at all times	3/2	6	FW
	4. Equipment Damage: Equipment can be damaged due to striking objects in the surrounding area, other equipment, or during demolition due to poor positioning	2/3	6	a.) Operator must monitor work area and use appropriate positioning to ensure swing radius is outside of structures and other equipment in the work area. b.) While working within tight access (between beams and supports) operators must use care to ensure structure or equipment is not damaged. Use a spotter if needed. c.) In the event that equipment was to break down while inside of the exclusion zone, and be rendered immobile, the equipment will be removed from the work area by dragging or rigging if possible. If this is not possible, the mechanic will be allowed to access the exclusion zone only while escorted, and with no other work occurring within the area. d.) Use a spotter when excavator and bobcat are working in tandem to ensure constant awareness of positioning in blind spots, etc. e.) Operators must be aware of their surroundings at all times	1/2	4	RM

CATs
(Critical Analysis of Tasks)

STEP	SIGNIFICANT HAZARDS/RISKS	SEVERITY/ PROBABILITY	LEVEL 1	MITIGATION/CONTROL MEASURES	RESIDUAL SEVERITY/ PROBABILITY	LEVEL 2	APPROVER INITIALS
1.4 Preparation of Fall Zone and Blast Area: Prepare Fall Zone for felling of TCC Unit. Elevated concrete and other hazards which could cause additional hazards once the unit is on the ground must be removed prior to the felling of the unit.	1. Hot Work may be required: Steel or rebar may need to be hot cut for removal from the fall zone	4/4	10	a.) Use appropriate PPE, per VIASANT SPs # 125, 137 and inspect PPE before each use (GR#4). b.) Obtain appropriate permits as required by task - SP# 137 & 149 (GR#5). c.) Inspect tools and equipment per SP#133 (GR#3). d.) Station bottles away from work area a minimum of 20'. e.) Provide Fire Watch per VIASANT SP #137. f.) Inspect arms and hands of personnel performing hot work for burns or pock marks at the end of each shift. g.) Ensure first aid kits and burn cream is onsite. h.) Check all hoses/connections before every use. i.) Properly store propane and oxygen bottles. (GR #1 & 5) (SP 137)	3/2	6	FW
	2. Cuts and abrasions: The steel or rebar could have sharp edges which can cause cuts and scrapes	3/5	10	a.) Wear proper PPE (i.e. Kevlar or FR Gloves). b.) Watch hand placement carefully. c.) Identify and mark sharp edges as needed. d.) Remove hazards where possible.	1/2	4	RM
	3. Struck By or Against: Personnel can be struck by debris or other equipment while in the work area	4/3	9	a.) All pedestrians are required to remain on walking paths, and must notify operator prior to approaching within 75' of the working area to remain clear of flying debris caused by concrete removal b.) All workers must use stable footing and remove all debris from the work area as soon as it is demolished to grade c.) Walkways will be kept clear of metal and other debris as work progresses. A clear and direct pathway for exiting of the area will be maintained at all times d.) Operators must be aware of their surroundings at all times	3/2	6	FW
	4. Equipment Damage: Equipment can be damaged when breaking concrete due to concrete becoming airborne during breaking	2/3	6	a.) Operator must monitor work area and use appropriate positioning to ensure swing radius is outside of structures and other equipment in the work area. b.) Ensure all guards are in place and in good working condition to prevent damage from airborne concrete pieces during concrete breaking. c.) In the event that equipment was to break down while inside of the exclusion zone, and be rendered immobile, the equipment will be removed from the work area by dragging or rigging if possible. If this is not possible, the mechanic will be allowed to access the exclusion zone only while escorted, and with no other work occurring within the area. d.) Operators must be aware of their surroundings at all times	1/2	4	RM
	5. Electrocution: To avoid the potential for damage, the overhead powerlines along B and C Streets will be disconnected and removed in advance of the blast.	4/4	10	a.) LWR shall arrange for the overhead powerlines to be disconnected; all electricity work will be undertaken by EDH Electric. b.) Ensure powerlines are locked and tagged out before commencing. c.) EDH Electric shall reconnect the powerlines after the blast and all clear has been given.	3/2	6	FW

CATs
(Critical Analysis of Tasks)

STEP	SIGNIFICANT HAZARDS/RISKS	SEVERITY/ PROBABILITY	LEVEL 1	MITIGATION/CONTROL MEASURES	RESIDUAL SEVERITY/ PROBABILITY	LEVEL 2	APPROVER INITIALS
2.0 EXPLOSIVE DEMOLITION OF TCC UNIT (shall be read in conjunction with the approved VR HABLIS WORK PLAN)							
2.1 Preparing and Loading of Explosives: Explosives must be placed with precisions on structural members as defined in the VRH Work Plan. All loading and firing shall be directed and supervised by competent persons thoroughly experienced in this field.	1. Unintended Explosion\Mass Detonation: There is always a chance of detonation when handling explosives. Explosives will be in appropriate containers and will be unloaded by experienced and trained personnel.	5/3	10	a.) Only qualified VRH personnel to handle explosives (GR#1) b.) Suspend all other operations on site. No one but VRH personnel are authorized to be within 100' of the work area. c.) Have fire extinguishers available within 25' of explosive handling area d.) Remove all heat and spark producing devices from the work area e.) Maintain charge separation at all times f.) Do not expose charges to unnecessary heat, friction, or shock g.) Do not install detonation lines until absolutely necessary and ensure they are not connected to detonator. h.) Explosives stored in DOT approved container and in possession of licensed blasting personnel at all times until they are set in place. i.) Lock out and Tag out Electrical lines along 8 Street.	5/1	6	FW
	2. Flying Debris and Piping: If explosion were to occur prematurely, debris could be let loose in the area	4/3	9	a.) Only qualified VRH personnel allowing in the work zone when placing explosives. b.) Maintain exclusion zone of at least 420' around the work area for any non-essential personnel c.) Ensure debris shields are stable and in place	3/2	7	FW
	3. Improper Felling of Structure: If explosives were to detonate expectantly, the structure could be impacted and it could partially fall, become unstable, or collapse in an unintended direction	5/3	10	a.) Maintain exclusion zone of 420' in a 360 degree area around work area and ensure all personnel are evacuated from this area. b.) Only qualified VRH personnel allowing in the work zone when placing explosives. c.) Walkways will be kept clear of metal and other debris as work progresses. A clear and direct pathway for exiting of the area will be maintained at all times in case of emergency egress being required	4/1	5	RM

CATs
(Critical Analysis of Tasks)

STEP	SIGNIFICANT HAZARDS/RISKS	SEVERITY/ PROBABILITY	LEVEL 1	MITIGATION/CONTROL MEASURES	RESIDUAL SEVERITY/ PROBABILITY	LEVEL 2	APPROVER INITIALS
	4. Inclement Weather: In the event of an approaching electrical storm, both VRH employees and the explosives will be exposed and vulnerable.	4/4	10	a.) Weather shall be continually monitored. The existing warning action protocol (Section 14, HASP) shall be adhered to. b.) In the event of an approaching electrical storm, blasting operations shall be suspended and VRH personnel will retreat to a safe distance away from the blasting area until the electric storm has passed. c.) VRH has selected to use NONEL initiating explosives that significantly reduces the risk of electrical stray current initiation.	3/2	6	FW
2.2 Detonating of Explosives: Once explosives have been placed and the area secured, explosives will be detonated to fell the TCC unit tower.	1. Unintended Explosion\Mass Detonation: There is always a chance of detonation when handling explosives. Explosives will be in appropriate containers and will be unloaded by experienced and trained personnel.	5/3	10	a.) Only qualified VRH personnel to handle detonator and detonation lines (GR#1) b.) Explosives, blasting agents, and blasting supplies that are obviously deteriorated or damaged shall not be used. c.) Suspend all other operations on site. No personnel are authorized to be within 420' of the work area once the detonation has been announced. d.) Have fire extinguishers available within 25' of explosive handling area. Remove all heat and spark producing devices from the work area e.) Eliminate all radio\phone transmission in area and use only intrinsically safe radios for essential communication only. f.) Detonator will remain in the presence of the VRH Supervisor at all times. g.) Detonation lines will not be connected to the detonator until absolutely necessary. h.) Ensure Lock out and Tag out Electrical lines along B Street is still in place.	5/1	6	FW
	2. Fly material and shrapnel: Once detonation occurs, fly material will be generated and shrapnel could become airborne in the work area.	3/5	10	a.) Maintain exclusion zone of at least 420' around the work area for all personnel. b.) Ensure debris shields are stable and in place c.) Maintain site security at all times to ensure that there are no unauthorized entrants to the blasting area	3/2	6	FW
	3. Improper Felling of Structure: If explosives were to detonate unexpectedly, the structure could be impacted and it could partially fall, become unstable, or collapse in an unintended direction	5/3	10	a.) Maintain exclusion zone of 420' in a 360 degree area around work area and ensure all personnel are evacuated from this area. b.) Perform final inspection prior to connection detonation lines to ensure that all charges are properly set. c.) Do not approach TCC unit during felling, or after until all clear if given by VRH. d.) Use appropriately shaped charges with redundancy to ensure complete severing of structural members during detonation. e.) In the event of an unintended collapsed, all work will stop, a contingency plan shall be developed that shall include a separate assessment of risks/CAT.	4/1	5	RM

STEP	SIGNIFICANT HAZARDS/RISKS	SEVERITY/ PROBABILITY	LEVEL 1	MITIGATION/CONTROL MEASURES	RESIDUAL SEVERITY/ PROBABILITY	LEVEL 2	APPROVER INITIALS
	4. The explosives will generate loud noise and unavoidable vibration: Detonation of explosives and felling of the structure will create noise and cause subsurface seismic waves. This may disturb neighboring properties/inhabited buildings and generate complaints.	4/4	10	a.) VRH have provided expert opinion and technical justification in their Workplan that no offsite impacts are anticipated. b.) Third party seismic monitoring company will be on site to ensure that seismic disturbance is recorded for verification purposes. c.) All surrounding businesses and residents will be notified as required prior to blasting. d.) An authorized warning signal shall be given before firing the shot. The time of the blast shall be fixed by the BIC. e.) The Titus County Fire Marshall and Local Sheriff department have been informed in advance of the blast date. f.) RETIA will request that a local Sheriff's deputy be stationed at the entrance to the site in the hour leading up to the blast.	4/2	7	FW
	5. Projectiles, including ejection of debris and fragments: as the structure falls material may drop or move outward. Upon hitting the ground fragments of structure (e.g. rivet heads, pieces of steelwork, blast protection debris) may be ejected from the blast site. There is also the "slap effect" due to impact on landing area, which may throw clods of earth, concrete, fragments of the structure into the air.	4/5	11	a.) Maintain exclusion zone of at least 420' around the work area for all personnel. b.) All persons not directly involved in security or blasting shall retreat to a safe, designated area (i.e. on top of the stockpile), outside of the designed line of collapse (i.e. the area extending 20° either side of the direction of fall). c.) Remove and clear all loose materials and objects in the immediate vicinity of the TCC Unit to minimize the potential for them to become fly material and projectiles.	4/1	5	RM
2.3 Post Felling of TCC: a number of inherent risks exist immediately after the felling of the TCC unit including smoke, gases, fires, incomplete detonation, or secondary explosions. All unused explosive materials will need to be disposed of onsite via a controlled explosion ("cleanup shot").	1. Incomplete Detonation/Misfires: There is always a chance that a detonation line malfunctions and one or more explosives do not completely detonate during the explosion.	5/3	10	a.) Only qualified VRH personnel to handle detonator and detonation lines (GR#1) b.) VRH Blaster in Charge will inspect area for hazards and explosive remnant's before any work or other personnel enter the area.	5/1	6	FW
	2. Fires: Unit is a former petroleum refining structure. While lines have been drained and removed to the greatest extent possible, residual products and other flammable materials could still be present which could be ignited during the demolition process. There have been several fires at the site on other vessels and units so this is a very real risk.	4/5	11	a.) Inspect structural members for coatings or other flammable residues prior to detonation b.) Ensure that local Fire Marshall has been notified as required and that fire units are ready in the event of a fire. c.) Prior to explosive demolition ensure any remnant flammable or combustible material is removed from the detonation area d.) The water truck will be in stand by near to the blast area . e.) All fires shall be reported. f.) As a precaution, the Mount Pleasant Fire Department will provide an onsite fire watch during the cracker demolition. In the unlikely event that a fire breaks out, this will ensure that the situation is quickly handled and brought under control. ENSAFE have confirmed that the MPFD has the appropriate assets and fire-fighting equipment to deal with an industrial oil fire.	2/3	7	FW

STEP	SIGNIFICANT HAZARDS/RISKS	SEVERITY/ PROBABILITY	LEVEL 1	MITIGATION/CONTROL MEASURES	RESIDUAL SEVERITY/ PROBABILITY	LEVEL 2	APPROVER INITIALS
	3. Secondary Explosions: If charges did not detonate completely, a secondary explosion could initiate, or if other vapors within the unit are compressed, a secondary explosion could occur	5/3	10	a.) Only qualified VRH personnel to handle detonator and detonation lines (GR#1) b.) VRH Blaster in Charge will inspect area for hazards and explosive remnants before any work or other personnel enter the area c.) Inspect structural members for coatings or other flammable remnants prior to detonation	5/1	6	FW
	4. The explosion may generate smoke, gases and dust.	3/5	10	a.) Only qualified VRH personnel to handle detonator and detonation lines (GR#1) b.) VRH Blaster in Charge will inspect area for hazards and explosive remnants before giving the "ALL CLEAR" and allowing any work or other personnel enter the area c.) Sufficient time shall be allowed for the smoke and gases to dissipate (at least 15 mins) before returning to the Blast Area. d.) Prevailing wind direction shall be checked before the blast to ensure there is no risk of fugitive emissions outside the site boundary.	4/2	7	FW
	5. Post detonation Clean Up Shot: In the event that not all the explosives are used for the felling of the structure, a "clean up" shot will need to be performed. VRH does not anticipate having more than 10-lbs of leftover material.	4/4	10	a.) Only qualified VRH personnel to handle detonator and detonation lines (GR#1) b.) A suitable location shall be identified in advance and excavated (depth of hole to be determined by BIC) prior to blasting. c.) Explosives shall be slowly and safely lowered into the ground. d.) Excavation will be backfilled and tamped to contain the explosion. e.) The procedures set out in the VRH Workplan shall be followed, with the BIC detonating and destroying the balance of explosives with nothing to remain.	4/1	5	RM
3.0 ON GRADE DEMOLITION OF TCC UNIT							
3.1 Demolition of Felled Structure: Once the TCC unit is on the ground, demolition must be performed in order to segregate the structure and manage the remaining materials and equipment	1. Unstable Structure\Work Area - The TCC unit will be configured in an unnatural and potentially compressed state after felling. Proper precautions must be taken in order to prevent shifting of material and equipment. Catastrophic failure can occur without warning.	5/3	10	a.) Prior to beginning any work on the felled structure, operators and torch cutters will perform an inspection of the unit with the FPM to identify areas where supports or equipment could shift or spring. b.) Area will be inspected for any liquid or solid leaks which could contain flammable materials c.) Remove liquids\solids\catalysts as completely as safely possible from in and around vessels and piping. d.) Perform demolition of the unit using excavator mounted with shear to the greatest extent possible to reduce worker exposure to shifting materials e.) If hot work must be performed, workers will be required to work out of a lift with the man basket positioned above the area they are cutting to reduce risk of being struck by shifting debris and/or steel members under tension.	4/2	7	FW

STEP	SIGNIFICANT HAZARDS/RISKS	SEVERITY/ PROBABILITY	LEVEL 1	MITIGATION/CONTROL MEASURES	RESIDUAL SEVERITY/ PROBABILITY	LEVEL 2	APPROVER INITIALS
	2. Due to the shift in loads, some steel members may have a hidden load and a high level of potential energy stored in them. This may be released when cut posing a risk to health and safety and can cause damage to property. The identification of how these loads are transferred to various structural components of the TCC Unit before they are cut is even more important.	5/3	10	a.) Prior to commencing demolition, the felled Unit will be surveyed and a detailed demolition schematic (including but not limited to demolition sequence, identifying load paths, condition and strength of the load bearing members etc) shall be prepared by a competent person and provided to ENSAFE and RETIA for review. b.) Demolition shall be planned to take account of the stability of both the load bearing elements and the whole structure; and continue for the whole operation to ensure continued stability. c.) Demolition shall progress in such a manner so as to ensure the tortional stability of the weakened structure is maintained. d.) Unit shall be checked for lateral ties and lateral support at all levels of the structure prior to cutting. e.) A high level of supervision will be maintained to ensure work is carried out in a safe manner during each activity. f.) The potential risks shall be communicated to all employees on the project.	4/2	7	FW
	3. Potential for Explosive Atmosphere exists - Any atmosphere containing an LEL rating of 0.1% or higher where vapor ignitions could occur. This is an unknown until vessels are accessed and tested	3/5	10	a.) Inspect tanks, vessels, and lines prior to performing hot work on them, drill and drain low points and perform first breaks as necessary. b.) Use cold cutting methods for opening of tanks until atmosphere can be confirmed to have 0.0% LEL. c.) Remove liquids\solids\catalysts as completely as safely possible. d.) Perform demolition with excavator mounted with shear to the greatest extent possible in order to reduce this risk	3/2	7	FW
	4. Hot Work will be required - Torch cutting of structural members, tanks, or equipment to prepare for mechanical felling will generate sparks, and cause fires, or explosions if conditions are right	4/3	9	a.) Use appropriate PPE, per VIASANT SPs # 125, 137 and inspect PPE before each use (GR#4). b.) Obtain appropriate permits as required by task\SP# 149 (GR#5). c.) Inspect tools and equipment per SP#133 (GR#3). d.) Station bottles away from work area a minimum of 20'. e.) Provide Fire Watch per VIASANT SP #137. f.) Inspect arms and hands of personnel performing hot work for burns or pock marks at the end of each shift. g.) Use torch to remove structural members and equipment which is too thick to be sheared h.) Chock vessels and equipment to prevent rolling or shifting while hot work is being performed i.) Stage water truck near where the hot works operations are taking place.	3/2	7	FW

STEP	SIGNIFICANT HAZARDS/RISKS	SEVERITY/ PROBABILITY	LEVEL 1	MITIGATION/CONTROL MEASURES	RESIDUAL SEVERITY/ PROBABILITY	LEVEL 2	APPROVER INITIALS
	5. Liquid Release: Vessels may contain residual petroleum liquids which could be released during the demolition process.	3/3	8	a.) An pre-inspection of V-3 Reactor and V-2 Kiln using a ultra high reach aerial lift did not find any significant quantities of residual liquid (refer to VIASANT Letter dated June 2, 2014) b.) VIASANT has drained the TCC Unit as far as is reasonably practicable and verified that vessels and low points are free of excess liquid prior to demolition. c.) Have spill kit on site and present in the work area to collect any spills immediately. d.) Use excavator to clear materials away from liquid spills in order to clean them up and collect any free liquids. e.) Have appropriate storage containers on site to contain any fluids or catalyst for draining.	2/2	5	RM
	6. Catalyst Release: It is highly likely that there are (unknown) quantities of catalyst stored in the upper section of the TCC Unit (i.e. V-6 Separator Surge and V-5 Hot CAT Storage which could be inadvertently released when the TCC Unit hits the ground and/or during the demolition process.	3/3	8	a.) Due to inaccessibility, RETIA has accepted this risk and opted to demolition the TCC unit with catalyst left in situ. Given their robust construction, the catalyst is anticiapted to remain within the vessels upon impact. b.) In the event of a release, the TCC Unit catalyst and fines (In V-7 Fresh CAT storage vessel) have been tested and determined to be non-hazardous. c.) Any spillages of catalyst or fines will be collected, containerized and managed appropriately before being disposed of.	3/2	7	FW
	7. Equipment Damage: Equipment can be damaged due to striking objects in the surrounding area, other equipment, or during demolition due to poor positioning	3/4	9	a.) Do not allow large quantities of steel to accumulate in the work area. b.) Both workers in man lift basket must inspect area for hang up locations or pinch points prior to beginning other operations in the area when performing hot work. c.) Operator must monitor work area and use appropriate positioning to ensure swing radius is outside of structures and other equipment in the work area. d.) Excavator operators must position equipment to allow for potential shifting of material away from the machine, or where it will not strike cab or arm of machine e.) Establish a 75' exclusion zone which only essential personnel are allowed to enter.	2/2	5	RM
	8. Falling Piping\Debris: During hot work and mechanical separation\felling, unstable piping or equipment can become dislodged and can fall to grade in an unplanned fashion	4/3	9	a.) Establish fall zone for demolition of the TCC unit on grade as materials are segregated (min 75') b.) Limit access to work area (authorized and required personnel only) during hot work and mechanical demolition activities per VIASANT SP#122. c.) Separate equipment and piping which must be torch cut to the greatest extent possible to allow hot works to be performed on grade d.) If needed, use appropriately sized rigging to remove sections of the unit to grade to prevent excessive shifting	3/2	7	FW

CATs
(Critical Analysis of Tasks)

STEP	SIGNIFICANT HAZARDS/RISKS	SEVERITY/ PROBABILITY	LEVEL 1	MITIGATION/CONTROL MEASURES	RESIDUAL SEVERITY/ PROBABILITY	LEVEL 2	APPROVER INITIALS
	9. Struck By or Against: Personnel can be struck by debris or other equipment while in the work area	4/3	9	a.) All pedestrians are required to remain on walking paths, and must notify operator prior to approaching within 75' of the working area. b.) Operators must maintain attention to their surroundings at all times. c.) Exclusion zone will be limited to authorized personnel only. No other personnel will be allowed within 75' of the TCC unit while demolition is being performed. d.) Operators will segregate material which must be torch cut and move to a centralized burning area as much as possible	3/1	6	RM
	10. Flammable liquids have been used in the structure, pipes, tanks and other equipment and any residual product may ignite during torch cutting. Due to the interconnectivity of the TCC Unit and presence of wall residues, there is potential for any flames to migrate vertically up pipework into a tank or other unreachable parts of the TCC Unit causing fire, smoke, flashovers etc.	4/4	10	a.) Tanks, vessels and pipework shall be tested for flammable and toxic vapors both before and during all work on them. b.) Prior to beginning hot work on a closed vessel, the vessel will have an opening created by using the shear or flanges removed by wrenches. c.) All lines previously feeding into or discharging from a tank or vessel shall be air gapped to prevent fire from moving vertically upward. d.) A mobile firefighting foam-attack cart will be obtained and available on site to suppress any fires. e.) The water truck will be in stand by in the work area with the 1 1/4" inch hose laid out near the hot work operations. f.) All fires shall be reported.	4/2	7	FW
	11. Unintended collapse of structure being demolished - The structure is sill 35 - 50 feet high, even while laying on its side, and significant collapse could still occur	5/2	8	a.) Per #2 a demolition schematic to be prepared and document the methodology with ENSAFE/ RETIA. b.) Ensure the demolition team are fully briefed on the agreed methodology. c.) Discuss any deviations or changes from the agreed plan and revise demolition schematic accordingly. d.) Ensure all employees are in a safe area prior to felling.	4/1	7	RM
	12. Presence of asbestos and its safe removal: Asbestos was known to have been used in the TCC Unit esp. pipe insulation of interior insulation on vessels and for gasket material.	4/4	10	a.) The structure has been checked throughout for materials containing asbestos by Brock and identified ACM will be abated at grade. b.) Any additional PACM found during the works shall be tested and removed according to applicable standards and regulations.	4/1	5	RM

CATs
(Critical Analysis of Tasks)

STEP	SIGNIFICANT HAZARDS/RISKS	SEVERITY/ PROBABILITY	LEVEL 1	MITIGATION/CONTROL MEASURES	RESIDUAL SEVERITY/ PROBABILITY	LEVEL 2	APPROVER INITIALS

Level	Retia Representative / Construction Contractor
10 - 12	Plant Manager/RETIA Company President [R-CP]
8 - 9	Senior Manager/RETIA Department Manager [R-DM]
6 - 7	Superintendent/RETIA Project Coordinator [R-PC]
2 - 5	Area Authority/ENSAFE Safety & Construction Manager [LC-SSO]

APPROVALS

Contractor Project Manager Acceptance Signature:

Date:

Contractor FPM Acceptance Signature:

Date: 7/31/14

ENSAFE Safety Manager Review Signature:

Date: 7/31/14

RETIA Project Coordinator Review Signature:

Date: 31-JUL-14

Appendix K

Arkema Project Area
Job Hazard Analyses (JHAs)

Job Hazard Analysis (JHA) Assessment Form

JHA Title: Arkema Project Area PDI	**JHA Number: 001**	**Date: June 18, 2020**
Job Description: Sampling Steps for pre-Design Investigation	**Project Number:** CF167.1903	
General Personal Protective Equipment (PPE) Required: Hard hats, safety glasses, safety gloves, nitrile gloves, steeltoe boots, life vests, ear plugs	**JHA Team Names: Eron Dodak**	**Approved by:** Matthew Behum
Additional PPE Required:		

Job Steps	Photographs	Hazard Type	Potential Hazards	Control Type	Existing Controls	SEV	OCC	EFF	HPN	Control Type	Recommended Controls	SEV	OCC	EFF	HPN
Surface and subsurface sediment sampling		Env	Environmental—Adverse weather	Adm	Atmospheric monitoring (describe)	4	3	0.50	**6**						**0**
		Env	Environmental—Rough water (overwater work)	PPE	PPE—Other (specify) - life vests										
		Phys	Heavy equipment / drill rigs	Adm	Buddy system (describe) - regular communication; clear responsibility delegation										
		Phys	High noise levels	PPE	Hearing—Ear plugs										
		Phys	Overboard	PPE	PPE—Other (specify) - life vests										
		Chem	Inhalation of hazardous chemicals	Eng	Ventilation (fans, if needed))										
Porewater sampling (Trident probe and seepage meter **[does not include diving, which is covered under a separate dive plan]**)		Env	Environmental—Adverse weather	Adm	Atmospheric monitoring (describe)	4	3	0.50	**6**						**0**
		Env	Environmental—Rough water (overwater work)	PPE	PPE—Other (specify) life vests										
		Phys	Slip/trip/fall—Same level	Adm	Slip/trip/fall protection—"Eyes on path"										
		Phys	Overboard	PPE	PPE—Other (specify) - life vests										
Riverbank soil sampling (test pits)		Env	Environmental—Adverse weather	Adm	Atmospheric monitoring (describe)	3	3	0.50	**4.5**						**0**
		Phys	Slip/trip/fall—Same level	Adm	Slip/trip/fall protection—"Eyes on path"										
		Phys	Ergonomics—Highly repetitive musculoskeletal actions	Adm	Buddy system (describe) Rotate staff effort										
		Phys	Heavy equipment / drill rigs	Adm	Buddy system (describe) - regular communication; clear responsibility delegation										

JHA Title: Arkema Project Area PDI	**JHA Number: 001**	**Date: June 18, 2020**
Job Description: Sampling Steps for pre-Design Investigation	**Project Number:** CF167.1903	
General Personal Protective Equipment (PPE) Required: Hard hats, safety glasses, safety gloves, nitrile gloves, steeltoe boots, life vests, ear plugs	**JHA Team Names: Eron Dodak**	**Approved by:** Matthew Behum
Additional PPE Required:		

Job Steps	Photographs	Hazard Type	Potential Hazards	Control Type	Existing Controls	SEV	OCC	EFF	HPN	Control Type	Recommended Controls	SEV	OCC	EFF	HPN
Riverbank soil sampling (hand auger boreholes)		Env	Environmental—Adverse weather	Adm	Atmospheric monitoring (describe)	3	2	0.50	**3**						**0**
		Phys	Slip/trip/fall—Same level	Adm	Slip/trip/fall protection—"Eyes on path"										
		Phys	Ergonomics—Heavy lifting (material handling)	Adm	Ergonomics—Assisted lifts (>40 lb)										
Groundwater discharge study (piezometer installation)		Env	Environmental—Adverse weather	Adm	Atmospheric monitoring (describe)	3	3	0.50	**4.5**						**0**
		Phys	Slip/trip/fall—Same level	Adm	Slip/trip/fall protection—"Eyes on path"										
		Phys	Heavy equipment / drill rigs	Adm	Buddy system (describe) - regular communication; clear responsibility delegation										
		Phys	High noise levels	PPE	Hearing—Ear plugs										
		Chem	Inhalation of hazardous chemicals	Eng	Ventilation (fans, if needed))										
Groundwater discharge study (groundwater monitoring)		Env	Environmental—Adverse weather	Adm	Atmospheric monitoring (describe)	2	2	0.50	**2**						**0**
		Phys	Slip/trip/fall—Same level	Adm	Slip/trip/fall protection—"Eyes on path"										
		Phys	Ergonomics—Heavy lifting (material handling)	Adm	Ergonomics—Assisted lifts (>40 lb)										
Investigation-derived waste (IDW) management		Env	Environmental—Adverse weather	Adm	Atmospheric monitoring (describe)	2	1	0.50	**1**						**0**
		Phys	Ergonomics—Heavy lifting (material handling)	Adm	Ergonomics—Assisted lifts (>40 lb)										
		Phys	Slip/trip/fall—Same level	Adm	Slip/trip/fall protection—"Eyes on path"										

Appendix L

RETIA USA Utility or Structure Clearance and Isolation Procedure

Utility or Structure Clearance and Isolation Procedure

0	Document created	02/08/2013
Reviews / Modifications		
Version n°		
1	Final version approved for distribution	10/22/2013

Author	Verifier	Approver
Fred Wolf	Darrell Bailey	Danny Kite

1. PURPOSE

In accordance with Total Golden Rule # 9 *Excavation Work,* this procedure describes the Underground Utility or Structure Clearance Procedure to be followed at RETIA USA managed sites located in the United States of America where personnel may encounter subsurface or overhead utilities.

2. RESPONSIBILITY

The RETIA Department Manager (R-DM) is responsible for administrating the RMS, and may delegate day to day responsibility to the RETIA Compliance Manager (R-CM).

The Lead Contractor Project Manager (LC-PM) on site, RETIA Site Supervisor (R-SS), RETIA Project Coordinators (R-PC), RETIA Department Manager (R-DM) and RETIA Company President (R-CP) have responsibility for executing this procedure

3. Scope/Applicability

The RETIA Management System (RMS) applies to remediation sites managed by RETIA USA located in the United States of America.

During remediation, many field activities are conducted in the proximity of aboveground and underground utilities. The purpose of this procedure is to establish requirements that will allow employees to work safely in the vicinity of electrical, natural gas, fuel, water, and other utility systems and installations. An additional objective of this procedure is to prevent economic damage to utility systems from remediation related project activities.

4.0 DESCRIPTION

Utility or Structure Clearance and Isolation Procedure

The RETIA Project Coordinators (R-PC) will be responsible for the implementation of this procedure ,.

All underground line and utilities (which include water, sewer, natural gas, fuel, electrical distribution, communications, lines, vaults, sumps) and other engineered structures (such as foundations, pilings, etc) shall be identified prior to the start of work in the area of any utility that could feasibly result in contact with or damage to the utility or structure.

The R-PC will research local and state codes and regulations regarding utility locating and isolation requirements. Utility companies and locating services are appropriate resources Utility Clearance includes the following activities:

1. The positive identification of the location of utility systems in the work area.

2. A signed statement from the appropriate representative of the utility attesting to the location of underground utilities and/or the positive de-energizing (lockout/tag out) and testing of electrical utilities. Utility representatives may determine that insulating blankets are required to isolate a power line. While this is an acceptable procedure, only a representative of the power utility can make the determination.

3. Identification of potential hazards associated with work to be performed in the vicinity of overhead powerlines.

On-site utilities and emergency shut off locations shall be identified on a utility drawing or plot plan. Emergency shut off locations will be verified before work activities begin. This utility drawing or plot will be maintained at the job site and by the R-PC.

Overhead Power Lines

Proximity to Power Lines

Contact with overhead power lines is considered to occur when equipment is closer to power lines than permitted by the criteria in this standard.

No operations involving heavy equipment that could come into contact with overhead power lines work is allowed within 50 feet (15 meters) of overhead power lines without first contacting the utility company to determine the voltage of the system and the height (at lowest point) of the line. No part of any equipment is to be operated within 50 feet (15) of overhead lines without making this determination.

An exclusion zone will be created at ground level below and 50 feet (15 meters) perpendicular to overhead power lines on each side. This exclusion zone will be marked by visual indicators (including signage and flagging). No equipment will enter the exclusion zone without approval from RETIA site management.

Operations adjacent to overhead powerlines are prohibited unless one of the following conditions is satisfied:

1. Power has been shut off and appropriate lockout/tag out procedures have been implemented to prevent the line from being energized, lines have been tested to confirm the outage, and the utility company has provided a signed certification of the outage.

2. The minimum clearance from energized overhead lines as presented in the following table is achieved. Equipment must be positioned and blocked so that no part, including cables, can come within the minimum clearances presented in the following table:

Nominal System (kilovolts,kV)	Minimum Required Distance
0-50	10 feet (3 meters)
51-100	12 feet (3.6 meters)
101-200	15 feet (4.6 meters)
201-300	20 feet (6.1 meters)
301-500	25 feet (7.6 meters)
501-750	35 feet 10.7 meters)
751-1000	45 feet (13.7 meters)

3. Alternatively, the power lines can be isolated by use of insulating blankets when properly placed and installed by the power utility. If insulating blankets are used, the utility will determine safe operating distances. This determination will be obtained in writing with the utility representative's signature affixed.

All inquiries regarding electric utilities must be made in writing and a written confirmation of the outage or isolation must be received by the RETIA representative prior to the start of any task that may impact the utility.

Underground Utilities

No subsurface work (trenching, excavations, drilling, etc) will begin until a check for utilities and underground structures has been conducted.

Utility companies and or state utility protection services will be contacted at least two (2) working days prior to subsurface work. One call utility locating services (811) can be utilized. Where these services are not available, (as is the case when the work location is on private property), the project will contract an independent locating service to perform an evaluation of underground utilities at the site.

The R-PC or qualified designee will obtain written clearances signed by the party who conducted the clearance.

Utility locations will be marked as described below.

Mechanical assisted subsurface work (involving powered drill rigs, mechanical excavators, etc) will not be used within five (5) feet (1.5 meters) of a confirmed or suspected utility or other subsurface structure.

Nondestructive clearance techniques (vacuum extraction or other hand clearing techniques) are required prior to drilling or excavating in higher risk locations which include manufacturing plants, retail service stations and other locations where complex underground utility systems may be present or at locations with poor documentation regarding the location of underground utilities and structures.

Subsurface work within five feet (1.5 meters) of a confirmed or suspected utility or subsurface structure must be performed using nondestructive clearing techniques until the obstruction is clearly located and visually confirmed.

If a utility strike occurs (i.e. an unplanned contact with a utility resulting in damage to the utility or its protective coating) the event will be reported by the R-PC in accordance RMS 2.2.3.2 Near-Miss and Incident Notification. All damaged utilities will be repaired by a qualified and licensed professional. Additional clearance activity including the use of nondestructive clearance techniques may be required if the strike resulted from contact with an unknown object or structure.

Site-specific Health and Safety Plans and/or Job Safety Analyses will address hazards and precautionary measures associated with working near utilities when applicable. More information for the preparation of HASPs can be found in RMS 2.2.3 HSE Requirements The R-PC or qualified designee will conduct a briefing for all site personnel regarding the hazards.

It will be the responsibility of the R-PC to maintain appropriate documentation in the project files to include: Documentation of requests for utility clearance and Documents confirming utility clearance.

Marking Criteria

Marking is performed only by qualified utility owners or third party mark and locate contractors. RETIA USA staff, remediation contractors (except for qualified mark and locate contractors) and consultants will not perform utility location marking. The marking criteria are listed below.

Color Code Identifiers (APWA Uniform Color Code)

Color Code	Type of Utility
Red	Electrical
Yellow	Gas/oil/steam
Orange	TV/Communications
Blue	Water
Green	Sewer
Purple	Reclaimed Water
White	The Proposed Excavation Area
Pink	Temporary Survey Marks

In accordance with the APWA Color Code; utilities will be designated by the color as follows:

- White will be used to designate and delineate the excavation area;
- Red will be used to designate electrical power, distribution, transmission lines and facilities;
- Yellow will be used to designate gas distribution and transmission lines, oil distribution and transmission lines, steam lines and/or piping that contains hazardous materials;
- Orange will be used to designate telephone lines, communications cables and cable television installations;
- Blue will be used to designate water lines and slurry pipelines;
- Green will designate waste water (sewer) lines;
- Pink will represent surveyor's marks.

Marks, in the form of lines or arrows, will be approximately 12 inches in length and spaced up to 50 feet apart. Marks will be placed over the center of the utility. The location company or utility will place its initials near the markings designating its utilities at least one time per excavation site.

Where gas lines are present, they must be marked showing line pressure, pipe diameter and material of construction (when known). The following markings will be used for gas line pressure and construction materials:

- TP=Transmission Pressure (>60 psi)
- DP=Distribution Pressure (< or = 60 psi)
- STL= Steel Pipe
- PL=Plastic Pipe

4. REFERENCE DOCUMENTS

RMS 2.2.3 HSE Requirements

RMS 2.2.3.2 Near-Miss and Incident Notification

Common Ground Alliance (CGA). Manual of Best Practices; Chapters 3 & 4. 2013.

Total SA; Safety at Work: Total's Golden Rules. 2010.

U.S. Army; Corps of Engineers Manual EM385-1-1, Safety and Health Requirements; 9/15/2008.

U.S. OSHA; Standard 1926.651; 1926.651(b) (2); 1926.651(b) (3).

U.S. OSHA; Letter of Interpretation 10/23/2003 Use of Hydro-vacuum or non-conductive hand tools to locate underground utilities: Section 1926.651(b) (2) and (b) (3).

Appendix M

Glove Comparison Chart

Subject RETIA USA - Glove Policy
Sent 03/03/2017 11:53 AM by TOTAL Notifications
To Gregory Parana; Ken Meyer; 2 Recipients & 1 Company
Priority Normal
Attachments

RETIA USA

RETIA USA LLC
1201 Louisiana Street, Suite 1800
Houston, TX 77002

March 3, 2017

Dear CDM Smith Inc. (400-157131),

Total has issued a new General Duty Gloves Policy (see HSE Procedures: General Duty Gloves: RPA-HSE #61HOH-1.5.2). According to this policy, General Duty Gloves will meet the following cut and abrasion performance standards:

- ANSI / ISEA 105 - 2016 level A3 and/or CE -388 – 2016 level C Cut protection
- ANSI Abrasion level 3

These should be considered minimum performance standards for General Duty Gloves used at RETIA USA sites.

Please review the applicable Site Specific Health and Safety Plan (HASP) and amend the plan, as required, to achieve these performance standards at a minimum for General Duty Gloves. We recognize the Personnel Protection Equipment (PPE) Selection procedure is highly site specific and more stringent requirements could apply. In such cases, the more stringent Site Specific requirements should be applied and documented in the HASP.

If you have specific questions concerning these General Duty Glove requirements or the implementation of this policy, please do not hesitate to contact RETIA USA's Safety Director Fred Wolf, CSP directly at (253) 229-1044.

RETIA USA

Appendix N

RETIA USA Excavation and Trenching Procedure

Excavation & Trenching Procedure

0	Document created	05/23/13
Reviews / Modifications		
Version n°	*Comment*	*Date*
1	Final for distribution	8/22/2013

Author	Verifier	Approver
Fred Wolf	Darrell Bailey	Danny Kite

1. PURPOSE

Consistent with Total's Golden Rule # 9 *Excavation Work*, this procedure describes the Trenching & Excavation Procedure to be followed at RETIA USA managed sites located in the United States of America.

2. RESPONSIBILITY

The RETIA Department Manager (R-DM) is responsible for administrating the RMS, and may delegate day to day responsibility to the RETIA Compliance Manager (R-CM) .

The Lead Contractor Project Manager (LC-PM) on site, RETIA Site Supervisor (R-SS), RETIA Project Coordinators (R-PC), RETIA Department Manager (R-DM) and RETIA Company President (R-CP) have responsibility for executing this procedure

3. SCOPE/APPLICABILITY

The RETIA Management System (RMS) applies to remediation sites managed by RETIA USA located in the United States of America.

The Excavation & Trenching Procedure applies to all open excavations made in the earth's surface, which includes trenches. According to OSHA construction safety and health standards 29 CFR 1926.650(b), a trench is referred to as a narrow excavation made below the surface of the ground in which the depth is greater than the width-the width not exceeding 16 feet (4.6 meters) . An excavation is any man-made cut, cavity, trench, or depression in the earth's surface formed by earth removal.

Prior to initiating any excavation & trenching activities, the R-PC will be responsible for complying with and accomplishing the requirements established in the RMS 2.3.3 *Utility or Structure Clearance and Isolation Procedure.*

4. DESCRIPTION

Procedure

The RETIA Project Coordinators (R-PC) will be responsible for the implementation of this standard. The R-PC will become completely familiar with 29 CFR 1926.650 Subpart P Excavations as well as all applicable state and local regulations and requirements. The main hazards encountered during excavation work are:

- Collapse
- Over running of vehicles
- Persons falling into the excavation
- Materials falling into the excavation
- Underground Services/Utilities
- Access and Egress
- Hazardous Atmospheres
- Undermining Adjacent Structures
- Flooding and water accumulation
- Occupational health exposures (due to the presence of contaminants)

The contractor is responsible for preplanning any excavation work to address and mitigate the hazards outlined above, Organization and planning are key factors in ensuring the health and safety of workers. The Contractor shall devise a Safe System of Work which shall include the following elements:

1. Throughlyl pre-planning of thethe work including the use of hazard analysis and permit-to-work systems if required;
2. Location and identification of services and or utilities according to procedures in RMS 2.3.3 Utility or *Structure Clearance. and Isolation Procedure* ;.
3. Adoption of io Safe Digging Practices as required;
4. The appointment of an Excavation Competent Person.

The R-PC or a qualified designee appointed by the R-PC will verify that the Contractor has appointed an *Excavation Competent Person* prior to the start of work. The Excavation Competent Person is someone, who through training and experience, has the knowledge and expertise to identify existing and predictable hazards that could potentially lead to unplanned incidents and who has the authority to take prompt corrective action to control exposures to such hazards.

The Excavation Competent Person will:

1. Understand the application of 29 CFR 1926 Subpart P to excavation related activity;

2. Take into consideration changing site factors and conditions that effect excavation safety;

3. Perform daily inspections prior to personnel entering the excavation each day and as needed throughout the shift and additional inspections following changes in site conditions that could affect excavation safety (i.e. rain storms). Inspection is especially critical on Mondays or following periods of site shutdown, where rain or other changing conditions occurring over the weekend have deteriorated soil conditions and or protective systems.

4. Prepare written documentation of such inspections.

5. Classify soil associated with the excavation.

6. Determine appropriate protective systems.

7. Design a safe acess and egress to all excavations as required.

8. Determine the need for excavation de-watering and monitor all de-watering activity;

9. Using the daily excavation checklist provided in this procedure, prepare the daily excavation inspection checklist and the inspection checklist for events that could impact the excavation and trenching. These inspection reports will be signed and dated and maintained in a specific excavation inspection log kept at the job site.

10. Understand and exercise their authority to stop work and to apply corrective actbions necessary to ensure proper excavation protective measures are maintained.

Protective Systems

Excavation Soil Classification

The U.S. Occupational Safety and Health Administration (OSHA) requires the classification of soils where works could be exposed to hazards associated with trenching and excavation related activities. OSHA uses four (4) soil classifications which include:

1. Solid Rock

2. Type A-cohesive soil, plastic soils with an unconfined compressive strength >1.5 tons/sq-ft;

3. Type B-cohesive soil, with unconfined compressive strength between 0.5 and 1.5 tons/sq-ft;

4. Type C-grannular or cohesive soil with compressive strength <0.5 tons/sq-ft.

The Competent Person will classify site soil according to these categories based upon at least one (1) visual and one (1) manual test in accordance with 29 CFR 1926 Subpart P Appendix A Soil Classification. The Competent Person will reevaluate the soil classification based on a change in site conditions.

Sloping and Benching

If the total depth of the excavation is less than 20 feet, the excavation can be performed using the OSHA soil classification and the following table of maximum slope angles. For sites with different soil conditions present, RETIA will use the slope requirements for the least stable soil present. Refer to 29 CFR 1926 Subpart P Appendix B Sloping and Benching for additional criteria for allowable slope and benching configurations.

Soil or Rock Type	Maximum Allowable Slope (H:V)
Stable Rock	Vertical (90 deg)
Type A	0.75:1 (53 deg)
Type B	1:1 (45 deg)
Type C	1.5:1 (34 deg)

If the total depth of the excavation is 20 feet or greater, the sloping or benching design will be performed by a registered professional engineer. If the excavation depth is less than twenty feet, the R-PC has the option of using the OSHA Soil Type and the tables of Maximum Allowable Slopes or having a registered professional engineer (who may require additional soil testing) develop a site specific design for a stable slope. A copy of this design will be kept at the project site and a copy will be maintained by the R-PC.

Timber Shoring of Trenches

RETIA USA will not permit the use of timber shoring in excavations or trenches.

Aluminum Shoring of Trenches or the Use of Trench Boxes

RETIA USA requires that the design of any aluminum shoring system installed in a trench deeper than 20 feet be performed by a registered professional engineer.

For trenches less than 20 feet, the aluminum shoring system will be designed and installed in accordance with 26 CFR 1926 Subpart P Appendix D Aluminum Hydraulic Shoring for Trenches.

Trench Shoring information prepared by the manufacturer which is specific to aluminum shoring system used will be maintained at the project site.

In all cases, the Aluminum shoring will extend at least 18 inches above the base of the slope associated with the trench.

Where trench boxes (shields) are utilized at depths equal to or less than 20 feet, they will be used in accordance with the manufacturer's tabulated data and all specifications, recommendations and limitations. Trench boxes will never be moved while occupied.

General Requirements

The R-PC or qualified designee will make certain that an Affected Zone is established around the excavation site. This zone will be determined on a site specific basis by a registered professional engineer and will function as an exclusion zone for heavy equipment and spoils that could result in excessive surcharges acting on the trench.

Excavated materials (i.e. soil piles) shall be placed at least 2 feet from the leasing edge of the excavation.

Barricades and or stop logs/blocks will be placed near to the excavation (but at least 5 ft/1.5 m away) to provide protection from a vehicle overrunning and falling into an excavation. This will also minimize the risk of "surcharging" (i.e. the excavation edge collapsing due to the weight of the vehicle. Barricades and Stop Logs should be appropriately anchored to prevent movement.

If the depth of the excavations greater than four (4) feet and there is a potential falling hazard, appropriate fall protection measures (guardrails, intermediate rail and toe board) will be used to prevent accidental falls into the trench. Hurricane fensing is not deemed appropriate.

Walkways over the excavation will be used and guard rails provided.

Hazardous atmospheres will be actively monitored using real time, direct reading instruments. If the atmosphere in the trench reaches 10% of the Lower Flammable Limit work in the trench or excavation will cease. Oxygen levels will also be monitored and work will be curtailed if oxygen deficient conditions are noted. Oxygen levels in trenches and excavations less than 21% are considered oxygen deficient by RETIA USA. While the work is curtailed, the reason for the oxygen reduction will be determined and aplan for safe work continuation will be formulated.

Employees are prohibited from working in excavations containing water unless a special support or shield and water removal is used to prevent cave-ins.

Where the excavation comes within ten (10) feet of a structure (such as building), a registered professional engineer will be called in to give advice and evaluate the structural stability of the both the trench and the object. Additional shoring may be required and if so, will be designed by a registered professional engineer.

Structural ramps used only by personnel will be designed by a competent person. Structural ramps used for equipment will be designed by a registered professional engineer.

A means of egress from the excavation or trench deeper than four (4) feet will be provided every twenty five (25) feet. If ladders are used for this purpose, at least three (3) rungs will extend above the ground surface.

Contractors shall maintain detailed, written records of all daily excavation inspections that should include the following information as a minimum:

- Name of person completing the inspection
- Location of Excavation
- Date and time of inspection
- Preceding Weather Conditions
- Verified Depth of Excavation
- Soil Type
- Protective System utilized including maximum allowable slope angle
- Surface Encumbrances
- Details of the locations of any underground utilities
- An assessment to demonstrate that the hazards outlined in Section 4.1 have been checked and controlled.

5. *REFERENCE DOCUMENTS*

Brower, R. Safety and Health for Engineers (2nd Edition); Wiley. 2006.

Total SA; Safety at Work: Total's Golden Rules. 2010.

U.S. Army; Corps of Engineers Manual EM385-1-1, Safety and Health Requirements; 9/15/2008.

U.S. OSHA; Standard 1926 Subpart P "Excavations"

6. *Excavation Daily Checklist Form*

Name of Excavation Competent Person: _____			**Date of Inspection: _____**
Excavation/Trench Location: _____			
Depth: _____	**Width: _____**		**Date Opened: _____**
Soil classification: ☐ **Stable Rock** ☐ **A** ☐ **B** ☐ **C**			
Indicate, by marking the test below, how the classification was made.			
Manual test(s)	Cohesive unfissured	Cohesive fissured	Granular
a) plasticity			
b) dry strength			
c) thumb penetration			
d) pocket penetrometer			
e) other _____			
Visual test(s) **(Do as many as possible)**	☐ **Cohesive Soil**		☐ **Granular Soil**
☐ **Spoil pile:**	☐ **Remains in clumps**		☐ **Breaks up easily**
☐ **Trench Side:**	☐ **Stands vertical for over 2 hours**		☐ **Sloughs into trench**
The excavation is properly (check one)			
☐ **Shored (indicate the type of shoring)**	☐ **Closed** ☐ **Open** ☐ **Wood** ☐ **Metal**		
☐ **Sloped/benched (indicate the slope)**	☐ **Vertical (stable rock)** ☐ **¾:1 (A)** ☐ **1:1 (B)** ☐ **1 ½:1 (C)**		
Excavation Checklist	Morning	Mid-Day	Afternoon
Time	_____	_____	_____
Weather	_____	_____	_____

Excavation Safety – Compliance Verification

06/03/2013

Date:	**Location:**
Project#:	**Project Title:**
Contractor/Sub:	**Competent Person:**

Excavation Safety Compliance Verification Question	Refer. 1926.	Y, N, or N/A	Recommendation
1. Is there an Excavation Competent Person onsite?	.650(b)		
2. Has the location of utility installations, (sewer, gas, electric, & water) been located prior to opening the excavation?	.651(b)		
3. If the excavation is deeper than 5 feet, but less than 20 feet, is there proper shielding (trench box), shoring system, or sloping/benching requirements? If more than 20 feet deep, has the cave in protection been designed by a P.E.?	.652(a)		
4. Did a Competent Person classify the soil with at least one visual and one manual test? Is a proper protective system in place based on this soil classification (Shielding – trench box; Shoring system – hydraulic, timber, screw jack; or Sloping/Benching (A=1V-3/4H) (B=1V-1H) (C=1V-1 1/2 H)?	.652(a) App. A		
5. In excavations 4 feet deep, is a safe means of egress (ladders, stairs, ramp) located within 25 feet of each worker in a trench?	.651(c)		
6. In excavations 4 feet deep, has air monitoring and ventilation (if necessary) been conducted to prevent exposure to harmful levels of atmospheric contaminants (i.e., oxygen deficiency, flammable gases, toxic chemicals, etc.)?	.651(g)		
7. Are support systems (shoring, bracing, & underpinning) provided to ensure the stability of adjoining structures and underground utilities?	.651(i)		
8. Is excavated materials placed at least 2 ft. from the edge?	.651(j)		
9. Are employees prohibited from working in excavations containing water unless a special support or shield and water removal is used to prevent cave-ins?	.651(h)		
10. Are employees exposed to vehicle traffic provided with, and required to wear, suitable high-visibility garments?	.651(d)		
11. Are employees prohibited from being underneath/near loads or within the swing radius of heavy equipment?	.651(e)		
12. Is a Daily Inspection of the excavation and adjacent areas completed by a Competent Person prior to start of work, as need throughout the shift, and after a rainstorm	.651(k)		

Excavation Safety
06/03/2013
Definitions and Notes

"Competent person" - one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authority to take prompt corrective measures to eliminate them.

Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a competent person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions. An inspection shall be conducted by the competent person prior to the start of work and as needed throughout the shift. Inspections shall also be made after every rainstorm or other hazard increasing occurrence.

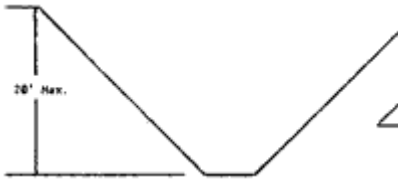
Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

Where oxygen deficiency or a hazardous atmosphere could reasonably be expected to exist, the atmosphere in the excavation shall be tested before employees enter excavations greater than four feet deep.

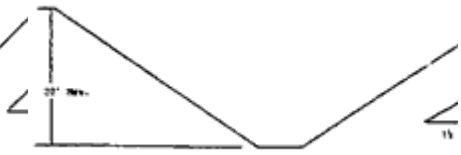
Design of support systems, shield systems, or other protective systems that are drawn from manufacturer's tabulated data shall be in accordance with all specifications, recommendations, and limitations issued or made by the manufacturer. Shield systems shall not be subjected to loads exceeding those which the system was designed to withstand. Shields shall be installed in a manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads.

Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C in accordance with the definitions. The classification of the deposits shall be made based on the results of at least one visual and at least one manual analysis. Deposit shall be reclassified as necessary to reflect the changed circumstances.

Excavations made in Type A soil



Excavations made in Type B Soil



Excavations made in Type C soil

I. **OVERVIEW: SOIL MECHANICS**.

A number of stresses and deformations can occur in an open cut or trench. For example, increases or decreases in moisture content can adversely affect the stability of a trench or excavation. The following diagrams show some of the more frequently identified causes of trench failure.

II.

A. TENSION CRACKS. Tension cracks usually form at a horizontal distance of 0.5 to 0.75 times the depth of the trench, measured from the top of the vertical face of the trench. See the accompanying drawing for additional details.

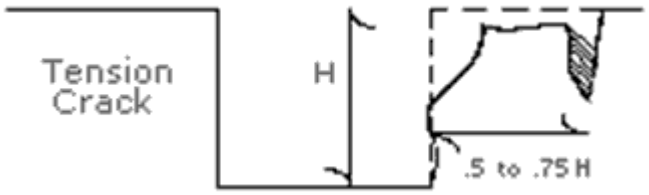


FIGURE 5:2-1. TENSION CRACK.

B. SLIDING or sluffing may occur as a result of tension cracks, as illustrated below.

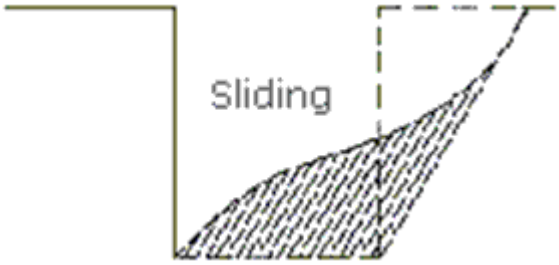


FIGURE 5:2-2. SLIDING.

C. TOPPLING. In addition to sliding, tension cracks can cause toppling. Toppling occurs when the trench's vertical face shears along the tension crack line and topples into the excavation.

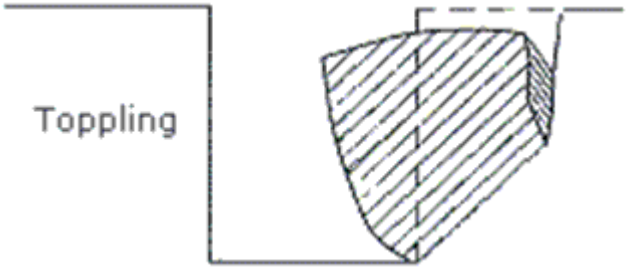


FIGURE 5:2-3. TOPPLING.

D. SUBSIDENCE AND BULGING. An unsupported excavation can create an unbalanced stress in the soil, which, in turn, causes subsidence at the surface and bulging of the vertical face of the trench. If uncorrected, this condition can cause face failure and entrapment of workers in the trench.

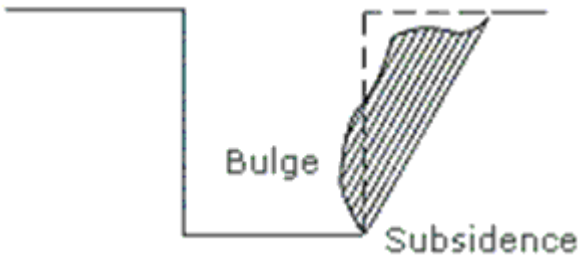


FIGURE 5:2-4. SUBSIDENCE AND BULGING.

E. HEAVING OR SQUEEZING. Bottom heaving or squeezing is caused by the downward pressure created by the weight of adjoining soil. This pressure causes a bulge in the bottom of the cut, as illustrated in the drawing above. Heaving and squeezing can occur even when shoring or shielding has been properly installed.

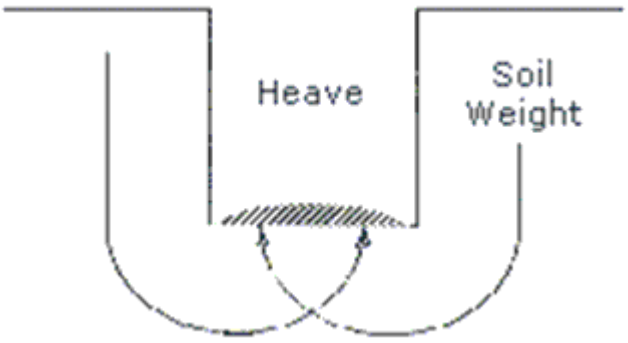
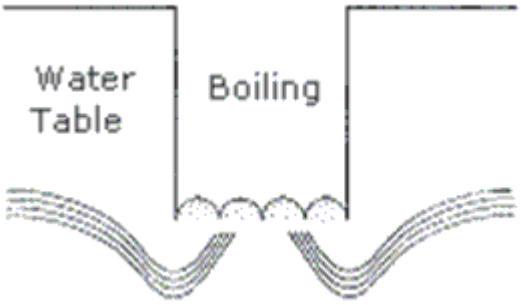


FIGURE 5:2-5. HEAVING OR SQUEEZING.

F. BOILING is evidenced by an upward water flow into the bottom of the cut. A high water table is one of the causes of boiling. Boiling produces a "quick" condition in the bottom of the cut, and can occur even when shoring or trench boxes are used.	 **FIGURE 5:2-6. BOILING.**
G. UNIT WEIGHT OF SOILS refers to the weight of one unit of a particular soil. The weight of soil varies with type and moisture content. One cubic foot of soil can weigh from 110 pounds to 140 pounds or more, and one cubic meter (35.3 cubic feet) of soil can weigh more than 3,000 pounds.	

III. **DETERMINATION OF SOIL TYPE.**

OSHA categorizes soil and rock deposits into four types, A through D, as follows:

A. **STABLE ROCK** is natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed. It is usually identified by a rock name such as granite or sandstone. Determining whether a deposit is of this type may be difficult unless it is known whether cracks exist and whether or not the cracks run into or away from the excavation.

B. **TYPE A SOILS** are cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (tsf) (144 kPa) or greater. Examples of Type A cohesive soils are often: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. (No soil is Type A if it is fissured, is subject to vibration of any type, has previously been disturbed, is part of a sloped, layered system where the layers dip into the excavation on a slope of 4 horizontal to 1 vertical (4H:1V) or greater, or has seeping water.

C. **TYPE B SOILS** are cohesive soils with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa). Examples of other Type B soils are: angular gravel; silt; silt loam; previously disturbed soils unless otherwise classified as Type C; soils that meet the unconfined compressive strength or cementation requirements of Type A soils but are fissured or subject to vibration; dry unstable rock; and layered systems sloping into the trench at a slope less than 4H:1V (only if the material would be classified as a Type B soil).

D. **TYPE C SOILS** are cohesive soils with an unconfined compressive strength of 0.5 tsf (48 kPa) or less. Other Type C soils include granular soils such as gravel, sand and loamy sand, submerged soil, soil from which water is freely seeping, and submerged rock that is not stable. Also included in this classification is material in a sloped, layered system where the layers dip into the excavation or have a slope of four horizontal to one vertical (4H:1V) or greater.

E. **LAYERED GEOLOGICAL STRATA**. Where soils are configured in layers, i.e., where a layered geologic structure exists, the soil must be classified on the basis of the soil classification of the weakest soil layer. Each layer may be classified individually if a more stable layer lies below a less stable layer, i.e., where a Type C soil rests on top of stable rock.

The designated competent person should be able to demonstrate the following:

Training, experience, and knowledge of:
- soil analysis;
- use of protective systems; and
- requirements of 29 CFR Part 1926 Subpart P.

Ability to detect:
- conditions that could result in cave-ins;
- failures in protective systems;
- hazardous atmospheres; and
- other hazards including those associated with confined spaces.

Authority to take prompt corrective measures to eliminate existing and predictable hazards and to stop work when required.

The **competent person** must conduct inspections and they should be documented.

- Daily and before the start of each shift and as dictated by the work being done;
- After every rainstorm or other event that could increase hazards, (thawing, etc.)
- When fissures, tension cracks, sloughing, undercutting, or other conditions occur;
- When there is a change in the size, location, or placement of the spoil pile; and
- When there is any indication of change or movement in adjacent structures.

Overview for Subpart P - Excavations

29 CFR 1926.652(a)(1)	(Protection in Excavations)
.651(k)(1)	(Inspections)
.651(j)(2)	(Loose Rock/Soil)
.651(c)(2)	(Means of Egress)
.651(d)	(Vehicular Traffic)
.651(k)(2)	(Inspections)
.651(h)(1)	(Water Accumulation)
.651(j)(1)	(Loose Rock/Soil)
.651(l)(2)*	(Walkways/Guardrails)
.651(e)	(Falling Loads)
.651(i)(3)	(Adjacent Structures)
.651(l)(1)*	(Walkways/Guardrails)
.652(b)	(Sloping/Benching Systems)
.651(i)(1)	(Adjacent Structures)
.652(c)	(Design/Protective Systems)
.652(g)(2)	(Shield Systems Requirements)
.652(g)(1)	(Shield Systems/General)
.651(b)(4)	(Underground Installations)
.651(g)(1)	(Hazardous Atmospheres)
.651(a)	(Surface Encumbrances)
.652(a)(2)	(Protective Systems)

TEST EQUIPMENT AND METHODS FOR EVALUATING SOIL TYPE.

Many kinds of equipment and methods are used to determine the type of soil prevailing in an area, as described below.

POCKET PENETROMETER. Penetrometers are direct-reading, spring-operated instruments used to determine the unconfined compressive strength of saturated cohesive soils. Once pushed into the soil, an indicator sleeve displays the reading. The instrument is calibrated in either tons per square foot (tsf) or kilograms per square centimeter (kPa). Penetrometers have error rates in the range of ± 20-40%.

Shearvane (Torvane). To determine the unconfined compressive strength of the soil with a shearvane, the blades of the vane are pressed into a level section of undisturbed soil, and the torsional knob is slowly turned until soil failure occurs. The direct instrument reading must be multiplied by 2 to provide results in tons per square foot (tsf) or kilograms per square centimeter (kPa).

Thumb Penetration Test. The thumb penetration procedure involves an attempt to press the thumb firmly into the soil in question. If the thumb makes an indentation in the soil only with great difficulty, the soil is probably Type A. If the thumb penetrates no further than the length of the thumb nail, it is probably Type B soil, and if the thumb penetrates the full length of the thumb, it is Type C soil. The thumb test is subjective and is therefore the least accurate of the three methods.

Dry Strength Test. Dry soil that crumbles freely or with moderate pressure into individual grains is granular. Dry soil that falls into clumps that subsequently break into smaller clumps (and the smaller clumps can be broken only with difficulty) is probably clay in combination with gravel, sand, or silt. If the soil breaks into clumps that do not break into smaller clumps (and the soil can be broken only with difficulty), the soil is considered unfissured unless there is visual indication of fissuring.

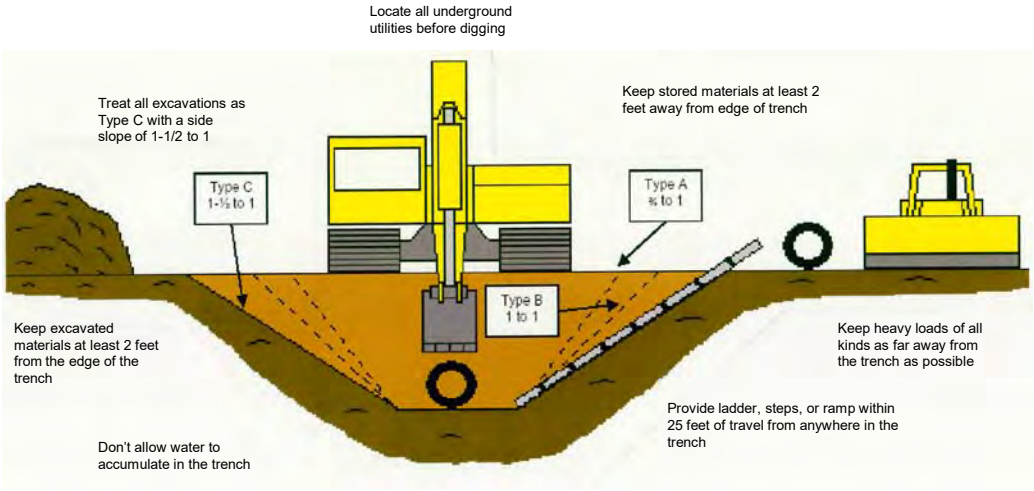
PLASTICITY OR WET THREAD TEST. This test is conducted by molding a moist sample of the soil into a ball and attempting to roll it into a thin thread approximately 1/8 inch (3 mm) in diameter (thick) by 2 inches (50 mm) in length. The soil sample is held by one end. If the sample does not break or tear, the soil is considered cohesive.

VISUAL TEST. A visual test is a qualitative evaluation of conditions around the site. In a visual test, the entire excavation site is observed, including the soil adjacent to the site and the soil being excavated. If the soil remains in clumps, it is cohesive; if it appears to be coarse-grained sand or gravel, it is considered granular. The evaluator also checks for any signs of vibration.

During a visual test, the evaluator should check for crack-line openings along the failure zone that would indicate tension cracks, look for existing utilities that indicate that the soil has previously been disturbed, and observe the open side of the excavation for indications of layered geologic structuring.

The evaluator should also look for signs of bulging, boiling, or sluffing, as well as for signs of surface water seeping from the sides of the excavation or from the water table. If there is standing water in the cut, the evaluator should check for "quick" conditions. In addition, the area adjacent to the excavation should be checked for signs of foundations or other intrusions into the failure zone, and the evaluator should check for surcharging and the spoil distance from the edge of the excavation.

Trench Safety In Review

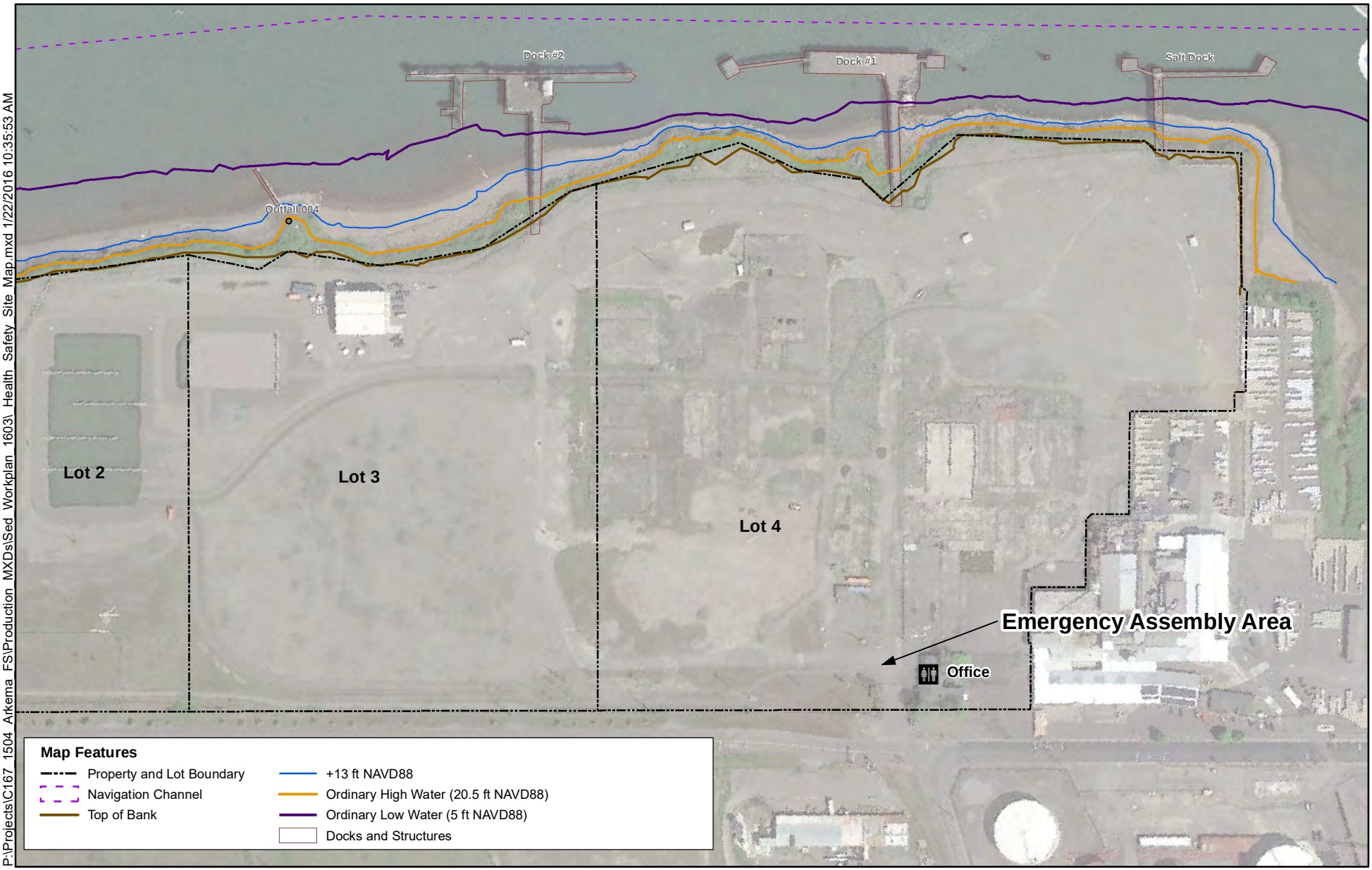


Appendix O

RESERVED FOR
Drowning Site Assessment

Appendix P

Site and Hospital Maps



P:\Projects\C167_1504_Arkema_FS\Production_MXDs\Sed_Workplan_1603_Health_Safety_Site_Map.mxd 1/22/2016 10:35:53 AM

integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Aerial: Google Earth, 2015
Area above +16 ft: 2007 DEA Topographic Survey

0 100 200 Feet

N

DRAFT

Pre-remedial Design Investigation Work Plan
Health and Safety Plan
Site Map

Directions from Arkema to Legacy Good Samaritan Hospital (4.5 mi – about 11 mins)

1.Head southeast on NW Front Ave toward NW Doane Ave 3.5 mi

2.Turn right at NW 17th Ave 0.2 mi

3.Turn left at NW Thurman St 262 ft

4.Turn right at NW 16th Ave 0.4 mi

5.Turn right at NW Lovejoy St 0.4 mi

6.Turn right at NW 22nd Ave 39 ft

Directions from Cathedral Park Boat Ramp to Legacy Emanual Hospital (4.5 mi – about 11 mins)

1.Head northeast on N Burlington Ave toward N Willamette Blvd 118 ft

2.Turn right at N Willamette Blvd 3.2 mi

3.Slight left at N Rosa Parks Way 0.8 mi

4.Turn right at N Interstate Ave 0.5 mi

5.Turn left at N Killingsworth St 0.7 mi

6.Turn right at N Vancouver Ave 1.3 mi

7.Turn right at N Stanton St 335 ft

8.N Stanton St turns slightly right and becomes N Gantenbein Ave 20 ft

Arkema Site

Willamette River

Legacy Good Samaritan Hospital

Legacy Emanual Hospital

PORTLAND

P:\Projects\C167 1504 Arkema FS\Production MXDs\Sed Workplan 1603\ Health Safety Hospital.mxd 1/25/2016 11:12:20 AM

integral consulting inc.

FEATURE SOURCES:
Property Boundaries and Transportation Features: Metro RLIS, 2014

0 3,000 6,000 Feet

N

DRAFT

Pre-remedial Design Investigation Work Plan
Health and Safety Plan
Hospital Route Map

Appendix Q

Regulatory Notice

IT'S THE LAW!

Know your rights

1-800-922-2689
osha.oregon.gov

You have a right to a safe and healthful workplace

- You have the right to notify your employer or Oregon OSHA about workplace hazards. You may ask Oregon OSHA to keep your name confidential.
- You have the right to request an Oregon OSHA inspection if you believe that there are unsafe or unhealthy conditions in your workplace. You or your representative may participate in the inspection.
- You have the right to report a work-related injury or illness, without being retaliated against.
- You can file a complaint with the Oregon Bureau of Labor and Industries within 90 days, or with federal OSHA within 30 days, of discrimination by your employer for making safety and health complaints or for exercising your rights under the Oregon Safe Employment Act.
- Anyone who wants to register a complaint about the administration of the Oregon Safe Employment Act can do so by contacting:

  U.S. Department of Labor
  OSHA Region X
  1111 Third Ave., Suite 715
  Seattle, WA 98101-3212
  206-553-5930

- You have a right to see Oregon OSHA citations issued to your employer. Your employer must post the citations at the workplace.
- Your employer must correct workplace hazards by the date indicated on the citation and must certify that these hazards have been reduced or eliminated.
- You have the right to copies of your medical records or records of your exposure to toxic and harmful substances or conditions. Additionally, you may request the workplace injury and illness log.
- You have the right to know about hazardous substances used in your workplace.

The Oregon Safe Employment Act of 1973 provides job safety and health protection for workers through the promotion of safe and healthful working conditions throughout the state. The Oregon Occupational Safety and Health Division (Oregon OSHA) of the Department of Consumer and Business Services has the primary responsibility for administering the act.

Oregon OSHA issues occupational safety and health standards, and its trained safety and health compliance officers conduct job-site inspections to ensure compliance with the Oregon Safe Employment Act.

Oregon OSHA has a staff of trained safety and health professionals available to work with businesses in all industries to improve workplace safety and health. **Consultations and training opportunities are available at no charge to Oregon businesses by calling any of the phone numbers listed.**

This free poster is available from Oregon OSHA

— It's the law! —

FOR MORE INFORMATION, copies of the Oregon Safe Employment Act, specific safety and health standards, advice or assistance, call:

Salem Central Office	**503-378-3272**
Bend	**541-388-6066**
Eugene	**541-686-7562**
Medford	**541-776-6030**
Pendleton	**541-276-9175**
Portland	**503-229-5910**
Salem	**503-378-3274**

Oregon OSHA

Display this poster where all your workers can see it!

Oregon Administrative Rule 437-001-257(2)(a).

440-1507 (3/20/COM)

Appendix R

Safety Data Sheets (Hexane and Sudan VI)

SAFETY DATA SHEET

Version 5.1
Revision Date 02/24/2014
Print Date 03/11/2014

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Hexane

Product Number : 296090
Brand : Sigma-Aldrich
Index-No. : 601-037-00-0
REACH No. : 01-2119480412-44-XXXX
CAS-No. : 110-54-3

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Flammable liquids (Category 2), H225
Skin irritation (Category 2), H315
Reproductive toxicity (Category 2), H361
Specific target organ toxicity - single exposure (Category 3), Central nervous system, H336
Specific target organ toxicity - repeated exposure, Oral (Category 2), Nervous system, H373
Aspiration hazard (Category 1), H304
Acute aquatic toxicity (Category 2), H401
Chronic aquatic toxicity (Category 2), H411

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word Danger

Hazard statement(s)
H225 Highly flammable liquid and vapour.
H304 May be fatal if swallowed and enters airways.
H315 Causes skin irritation.
H336 May cause drowsiness or dizziness.
H361 Suspected of damaging fertility or the unborn child.
H373 May cause damage to organs (Nervous system) through prolonged or repeated exposure if swallowed.

H411	Toxic to aquatic life with long lasting effects.

Precautionary statement(s)

P201	Obtain special instructions before use.
P202	Do not handle until all safety precautions have been read and understood.
P210	Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P233	Keep container tightly closed.
P240	Ground/bond container and receiving equipment.
P241	Use explosion-proof electrical/ ventilating/ lighting/ equipment.
P242	Use only non-sparking tools.
P243	Take precautionary measures against static discharge.
P260	Do not breathe dust/ fume/ gas/ mist/ vapours/ spray.
P264	Wash skin thoroughly after handling.
P271	Use only outdoors or in a well-ventilated area.
P273	Avoid release to the environment.
P280	Wear protective gloves/ protective clothing/ eye protection/ face protection.
P301 + P310	IF SWALLOWED: Immediately call a POISON CENTER or doctor/ physician.
P303 + P361 + P353	IF ON SKIN (or hair): Remove/ Take off immediately all contaminated clothing. Rinse skin with water/ shower.
P304 + P340	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P308 + P313	IF exposed or concerned: Get medical advice/ attention.
P321	Specific treatment (see supplemental first aid instructions on this label).
P331	Do NOT induce vomiting.
P332 + P313	If skin irritation occurs: Get medical advice/ attention.
P362	Take off contaminated clothing and wash before reuse.
P370 + P378	In case of fire: Use dry sand, dry chemical or alcohol-resistant foam for extinction.
P391	Collect spillage.
P403 + P233	Store in a well-ventilated place. Keep container tightly closed.
P403 + P235	Store in a well-ventilated place. Keep cool.
P405	Store locked up.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Synonyms	:	n-Hexane
Formula	:	C_6H_{14}
Molecular Weight	:	86.18 g/mol
CAS-No.	:	110-54-3
EC-No.	:	203-777-6
Index-No.	:	601-037-00-0
Registration number	:	01-2119480412-44-XXXX

Hazardous components

Component	Classification	Concentration
n-Hexane		
	Flam. Liq. 2; Skin Irrit. 2; Repr. 2; STOT SE 3; STOT RE 2; Asp. Tox. 1; Aquatic Acute 2; Aquatic Chronic 2; H225, H304, H315, H336, H361, H373, H411	-

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
no data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides

5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

5.4 Further information
Use water spray to cool unopened containers.

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Use personal protective equipment. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapours accumulating to form explosive concentrations. Vapours can accumulate in low areas.
For personal protection see section 8.

6.2 Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

6.3 Methods and materials for containment and cleaning up
Contain spillage, and then collect with an electrically protected vacuum cleaner or by wet-brushing and place in container for disposal according to local regulations (see section 13).

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Avoid contact with skin and eyes. Avoid inhalation of vapour or mist.
Flash back possible over considerable distance.Container explosion may occur under fire conditions.Use explosion-proof equipment.Keep away from sources of ignition - No smoking.Take measures to prevent the build up of electrostatic charge.

For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities

Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage.

7.3 Specific end use(s)

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
n-Hexane	110-54-3	TWA	50 ppm	USA. ACGIH Threshold Limit Values (TLV)
	Remarks	Central Nervous System impairment Eye irritation Peripheral neuropathy Substances for which there is a Biological Exposure Index or Indices (see BEI® section) Danger of cutaneous absorption		
		TWA	50 ppm 180 mg/m3	USA. NIOSH Recommended Exposure Limits
		TWA	500 ppm 1,800 mg/m3	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		The value in mg/m3 is approximate.		
		TWA	50 ppm 180 mg/m3	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000

Biological occupational exposure limits

Component	CAS-No.	Parameters	Value	Biological specimen	Basis
n-Hexane	110-54-3	2,5-Hexanedione	0.4 mg/l	Urine	ACGIH - Biological Exposure Indices (BEI)
	Remarks	End of shift at end of workweek			

8.2 Exposure controls

Appropriate engineering controls

Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection

Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.4 mm
Break through time: 480 min
Material tested:Camatril® (KCL 730 / Aldrich Z677442, Size M)

Splash contact
Material: Nitrile rubber

Minimum layer thickness: 0.2 mm
Break through time: 30 min
Material tested:Dermatril® P (KCL 743 / Aldrich Z677388, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Complete suit protecting against chemicals, Flame retardant antistatic protective clothing, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type AXBEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: liquid Colour: colourless
b)	Odour	no data available
c)	Odour Threshold	no data available
d)	pH	7.0
e)	Melting point/freezing point	Melting point/range: -95 °C (-139 °F)
f)	Initial boiling point and boiling range	69 °C (156 °F)
g)	Flash point	-26.0 °C (-14.8 °F) - closed cup
h)	Evapouration rate	15.8
i)	Flammability (solid, gas)	no data available
j)	Upper/lower flammability or explosive limits	Upper explosion limit: 7.7 %(V) Lower explosion limit: 1.2 %(V)
k)	Vapour pressure	341.3 hPa (256.0 mmHg) at 37.7 °C (99.9 °F) 176.0 hPa (132.0 mmHg) at 20.0 °C (68.0 °F)
l)	Vapour density	no data available
m)	Relative density	0.659 g/mL at 25 °C (77 °F)
n)	Water solubility	insoluble
o)	Partition coefficient: n-octanol/water	log Pow: 3.90 - 4.11
p)	Auto-ignition temperature	234.0 °C (453.2 °F)
q)	Decomposition	no data available

temperature

r)	Viscosity	no data available
s)	Explosive properties	no data available
t)	Oxidizing properties	no data available

9.2 Other safety information
no data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
no data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
Vapours may form explosive mixture with air.

10.4 Conditions to avoid
Exposure to moisture may affect product quality.
Heat, flames and sparks. Extremes of temperature and direct sunlight.

10.5 Incompatible materials
Oxidizing agents

10.6 Hazardous decomposition products
Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 Oral - rat - 25,000 mg/kg

LC50 Inhalation - rat - 4 h - 48000 ppm

Dermal: no data available

no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
Eyes - rabbit
Result: Mild eye irritation

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

Carcinogenicity - rat - Inhalation
Tumorigenic:Carcinogenic by RTECS criteria. Tumorigenic Effects: Testicular tumors.

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
no data available

Overexposure may cause reproductive disorder(s) based on tests with laboratory animals. Suspected human reproductive toxicant Suspected of damaging fertility.

Specific target organ toxicity - single exposure
May cause drowsiness or dizziness.

Specific target organ toxicity - repeated exposure
Ingestion - May cause damage to organs through prolonged or repeated exposure. - Nervous system

Aspiration hazard
May be fatal if swallowed and enters airways.

Additional Information
RTECS: MN9275000

Prolonged or repeated contact with skin may cause:, defatting, Dermatitis, Contact with eyes can cause:, Redness, Blurred vision, Provokes tears., Effects due to ingestion may include:, Gastrointestinal discomfort, Central nervous system depression, Lung irritation, chest pain, pulmonary edema, giddiness, slowed reaction time, slurred speech, Headache, Dizziness, Drowsiness, Unconsciousness

Testes. - Irregularities - Based on Human Evidence
Testes. - Irregularities - Based on Human Evidence

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Toxicity to fish	LC50 - Pimephales promelas (fathead minnow) - 2.5 mg/l - 96.0 h
Toxicity to daphnia and other aquatic invertebrates	EC50 - Daphnia magna (Water flea) - 3,878.00 mg/l - 48 h
Toxicity to algae	EC50 - Chlorella vulgaris (Fresh water algae) - 12,840.00 mg/l - 3 h
	EC50 - SKELETOMA - 0.30 mg/l - 8 h

12.2 Persistence and degradability
no data available

12.3 Bioaccumulative potential
no data available

12.4 Mobility in soil
no data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects
An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.
Toxic to aquatic life.

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN number: 1208 Class: 3 Packing group: II
Proper shipping name: Hexanes
Reportable Quantity (RQ): 5000 lbs
Marine pollutant: No
Poison Inhalation Hazard: No

IMDG
UN number: 1208 Class: 3 Packing group: II EMS-No: F-E, S-D
Proper shipping name: HEXANES
Marine pollutant: No

IATA
UN number: 1208 Class: 3 Packing group: II
Proper shipping name: Hexanes

15. REGULATORY INFORMATION

REACH No. : 01-2119480412-44-XXXX

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
The following components are subject to reporting levels established by SARA Title III, Section 313:

	CAS-No.	Revision Date
n-Hexane	110-54-3	2007-07-01

SARA 311/312 Hazards
Fire Hazard, Acute Health Hazard, Chronic Health Hazard

Massachusetts Right To Know Components

	CAS-No.	Revision Date
n-Hexane	110-54-3	2007-07-01

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
n-Hexane	110-54-3	2007-07-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
n-Hexane	110-54-3	2007-07-01

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Aquatic Acute	Acute aquatic toxicity
Aquatic Chronic	Chronic aquatic toxicity
Asp. Tox.	Aspiration hazard
Flam. Liq.	Flammable liquids
H225	Highly flammable liquid and vapour.
H304	May be fatal if swallowed and enters airways.
H315	Causes skin irritation.
H336	May cause drowsiness or dizziness.
H361	Suspected of damaging fertility or the unborn child.
H373	May cause damage to organs through prolonged or repeated exposure if swallowed.
H401	Toxic to aquatic life.
H411	Toxic to aquatic life with long lasting effects.

Repr.	Reproductive toxicity

HMIS Rating

Health hazard:	2
Chronic Health Hazard:	*
Flammability:	3
Physical Hazard	0

NFPA Rating

Health hazard:	2
Fire Hazard:	3
Reactivity Hazard:	0

Further information

Copyright 2014 Sigma-Aldrich Co. LLC. License granted to make unlimited paper copies for internal use only.
The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 5.1 Revision Date: 02/24/2014 Print Date: 03/11/2014

SAFETY DATA SHEET

Creation Date 22-Jul-1999 **Revision Date** 17-Jan-2018 **Revision Number** 3

1. Identification

Product Name **Sudan IV**

Cat No. : **S667-25**

CAS-No 85-83-6
Synonyms Oil Red IV; Scarlet Red; Fast Oil Red B

Recommended Use Laboratory chemicals.
Uses advised against Not for food, drug, pesticide or biocidal product use

Details of the supplier of the safety data sheet

Company
Fisher Scientific
One Reagent Lane
Fair Lawn, NJ 07410
Tel: (201) 796-7100

Emergency Telephone Number
CHEMTREC®, Inside the USA: 800-424-9300
CHEMTREC®, Outside the USA: 001-703-527-3887

2. Hazard(s) identification

Classification
This chemical is considered hazardous by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

Skin Corrosion/irritation	Category 2
Serious Eye Damage/Eye Irritation	Category 2
Specific target organ toxicity (single exposure)	Category 3
Target Organs - Respiratory system.	

Label Elements

Signal Word
Warning

Hazard Statements
Causes skin irritation
Causes serious eye irritation
May cause respiratory irritation

Precautionary Statements
Prevention
Wash face, hands and any exposed skin thoroughly after handling
Wear protective gloves/protective clothing/eye protection/face protection
Avoid breathing dust/fume/gas/mist/vapors/spray
Use only outdoors or in a well-ventilated area
Inhalation
IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing
Call a POISON CENTER or doctor/physician if you feel unwell
Skin
IF ON SKIN: Wash with plenty of soap and water
If skin irritation occurs: Get medical advice/attention
Take off contaminated clothing and wash before reuse
Eyes
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
If eye irritation persists: Get medical advice/attention
Storage
Store in a well-ventilated place. Keep container tightly closed
Store locked up
Disposal
Dispose of contents/container to an approved waste disposal plant
Hazards not otherwise classified (HNOC)
None identified

3. Composition/Information on Ingredients

Component	CAS-No	Weight %
2-Naphthalenol, 1-[[2-methyl-4-[(2-methylphenyl)azo]phenyl]azo]-	85-83-6	~ 100

4. First-aid measures

Eye Contact Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Get medical attention.

Skin Contact Wash off immediately with plenty of water for at least 15 minutes. Obtain medical attention.

Inhalation Move to fresh air. If breathing is difficult, give oxygen. Obtain medical attention.

Ingestion Do not induce vomiting. Obtain medical attention.

Most important symptoms and effects No information available.

Notes to Physician Treat symptomatically

5. Fire-fighting measures

Suitable Extinguishing Media Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Unsuitable Extinguishing Media No information available

Flash Point Not applicable
Method - No information available

Autoignition Temperature
Explosion Limits
Upper No data available

Lower	No data available
Sensitivity to Mechanical Impact	No information available
Sensitivity to Static Discharge	No information available

Specific Hazards Arising from the Chemical
Keep product and empty container away from heat and sources of ignition.

Hazardous Combustion Products
Carbon monoxide (CO) Carbon dioxide (CO_2) Nitrogen oxides (NOx)
Protective Equipment and Precautions for Firefighters
As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear. Thermal decomposition can lead to release of irritating gases and vapors.

NFPA

Health	Flammability	Instability	Physical hazards
2	0	0	N/A

6. Accidental release measures

Personal Precautions	Ensure adequate ventilation. Use personal protective equipment. Avoid dust formation.
Environmental Precautions	Should not be released into the environment. See Section 12 for additional ecological information.
Methods for Containment and Clean Up	Sweep up or vacuum up spillage and collect in suitable container for disposal. Avoid dust formation.

7. Handling and storage

Handling	Wear personal protective equipment. Ensure adequate ventilation. Do not get in eyes, on skin, or on clothing. Avoid ingestion and inhalation. Avoid dust formation. Wash hands before breaks and immediately after handling the product.
Storage	Keep containers tightly closed in a dry, cool and well-ventilated place.

8. Exposure controls / personal protection

Exposure Guidelines	This product does not contain any hazardous materials with occupational exposure limitsestablished by the region specific regulatory bodies.
Engineering Measures	Ensure that eyewash stations and safety showers are close to the workstation location. Ensure adequate ventilation, especially in confined areas.

Personal Protective Equipment

Eye/face Protection	Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.
Skin and body protection	Wear appropriate protective gloves and clothing to prevent skin exposure.
Respiratory Protection	Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Use a NIOSH/MSHA or European Standard EN 149 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced.
Hygiene Measures	Handle in accordance with good industrial hygiene and safety practice.

9. Physical and chemical properties

Physical State	Powder Solid

Appearance	Red brown
Odor	Odorless
Odor Threshold	No information available
pH	No information available
Melting Point/Range	181.1 °C / 358 °F
Boiling Point/Range	260 °C / 500 °F
Flash Point	Not applicable
Evaporation Rate	Not applicable
Flammability (solid,gas)	No information available
Flammability or explosive limits	
Upper	No data available
Lower	No data available
Vapor Pressure	negligible
Vapor Density	Not applicable
Specific Gravity	No information available
Solubility	Insoluble in water
Partition coefficient; n-octanol/water	No data available
Autoignition Temperature	
Decomposition Temperature	No information available
Viscosity	Not applicable
Molecular Formula	C24H20N4O
Molecular Weight	380.1662

10. Stability and reactivity

Reactive Hazard None known, based on information available

Stability Stable under normal conditions.

Conditions to Avoid Incompatible products. Excess heat. Avoid dust formation.

Incompatible Materials Strong oxidizing agents

Hazardous Decomposition Products Carbon monoxide (CO), Carbon dioxide (CO_2), Nitrogen oxides (NOx)

Hazardous Polymerization Hazardous polymerization does not occur.

Hazardous Reactions None under normal processing.

11. Toxicological information

Acute Toxicity

Product Information No acute toxicity information is available for this product

Component Information

Toxicologically Synergistic Products No information available

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Irritation No information available

Sensitization No information available

Carcinogenicity The table below indicates whether each agency has listed any ingredient as a carcinogen.

Component	CAS-No	IARC	NTP	ACGIH	OSHA	Mexico
2-Naphthalenol, 1-[[2-methyl-4-[(2-methylphenyl)azo]phenyl]azo]-	85-83-6	Not listed	Not listed	Not listed	Not listed	Not listed

Mutagenic Effects No information available

Reproductive Effects No information available.

Developmental Effects No information available.

Teratogenicity No information available.

STOT - single exposure Respiratory system
STOT - repeated exposure None known

Aspiration hazard No information available

Symptoms / effects,both acute and delayed No information available

Endocrine Disruptor Information No information available

Other Adverse Effects The toxicological properties have not been fully investigated.

12. Ecological information

Ecotoxicity
Do not empty into drains.

Persistence and Degradability Insoluble in water

Bioaccumulation/ Accumulation No information available.

Mobility Is not likely mobile in the environment due its low water solubility.

13. Disposal considerations

Waste Disposal Methods Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. Chemical waste generators must also consult local, regional, and national hazardous waste regulations to ensure complete and accurate classification.

14. Transport information

DOT Not regulated
TDG Not regulated
IATA Not regulated
IMDG/IMO Not regulated

15. Regulatory information

International Inventories

Component	TSCA	DSL	NDSL	EINECS	ELINCS	NLP	PICCS	ENCS	AICS	IECSC	KECL
2-Naphthalenol, 1-[[2-methyl-4-[(2-methylphenyl)azo]phenyl]azo]-	X	X	-	201-635-8	-		X	X	X	X	X

Legend:
X - Listed
E - Indicates a substance that is the subject of a Section 5(e) Consent order under TSCA.
F - Indicates a substance that is the subject of a Section 5(f) Rule under TSCA.
N - Indicates a polymeric substance containing no free-radical initiator in its inventory name but is considered to cover the designated polymer made with any free-radical initiator regardless of the amount used.
P - Indicates a commenced PMN substance
R - Indicates a substance that is the subject of a Section 6 risk management rule under TSCA.
S - Indicates a substance that is identified in a proposed or final Significant New Use Rule
T - Indicates a substance that is the subject of a Section 4 test rule under TSCA.
XU - Indicates a substance exempt from reporting under the Inventory Update Rule, i.e. Partial Updating of the TSCA Inventory Data Base Production and Site Reports (40 CFR 710(B).

Y1 - Indicates an exempt polymer that has a number-average molecular weight of 1,000 or greater.
Y2 - Indicates an exempt polymer that is a polyester and is made only from reactants included in a specified list of low concern reactants that comprises one of the eligibility criteria for the exemption rule.

U.S. Federal Regulations

TSCA 12(b) Not applicable

SARA 313 Not applicable

SARA 311/312 Hazard Categories See section 2 for more information

CWA (Clean Water Act) Not applicable

Clean Air Act Not applicable

OSHA Occupational Safety and Health Administration
Not applicable

CERCLA Not applicable

California Proposition 65 This product does not contain any Proposition 65 chemicals

U.S. State Right-to-Know Regulations Not applicable

U.S. Department of Transportation

Reportable Quantity (RQ):	N
DOT Marine Pollutant	N
DOT Severe Marine Pollutant	N

U.S. Department of Homeland Security
This product does not contain any DHS chemicals.

Other International Regulations

Mexico - Grade No information available

16. Other information

Prepared By
Regulatory Affairs
Thermo Fisher Scientific
Email: EMSDS.RA@thermofisher.com

Creation Date 22-Jul-1999
Revision Date 17-Jan-2018
Print Date 17-Jan-2018
Revision Summary This document has been updated to comply with the US OSHA HazCom 2012 Standard replacing the current legislation under 29 CFR 1910.1200 to align with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

Disclaimer
The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text

End of SDS

Appendix S

Safety Guidelines (Cold Stress, Heat Stress, Overwater Safety)

SAFETY GUIDELINE SG-26

COLD STRESS AND ADVERSE WEATHER CONDITIONS

Adverse weather conditions are an important consideration in planning and conducting site operations and field activities. Extreme weather can cause physical discomfort, loss of efficiency, and personal injury. Adverse weather conditions include heat (discussed in safety guideline SG-25), cold, and snow and electrical storms. The sections below provide information regarding work in cold environments and electrical storms.

COLD WEATHER

Performing field activities in cold climates may cause severe injury to the surface of the body or may result in profound generalized cooling (hypothermia) that can result in death. Work in cold climates may also increase physical hazards, such as slips/trips and vehicle accidents.

Frostbite is caused by the actual freezing of tissue and is usually caused by exposing skin to extremely cold temperatures. Frost nip or incipient frostbite is characterized by sudden blanching or whitening of the skin. With superficial frostbite, the skin has a waxy or white appearance and is firm to the touch, but tissue beneath is resilient. Deep frostbite is an extremely serious injury, characterized by tissues that are cold, pale, and solid.

Hypothermia is the gradual lowering of the body temperature, which may result in loss of coordination, confusion, sleep, and death. Unlike frostbite, hypothermia may occur at temperatures above freezing. Symptoms are usually exhibited in five stages:

- Shivering
- Apathy, listlessness, sleepiness, and (sometimes) rapid cooling of the body to less than 95°F
- Glassy stare, slow pulse, slow respiratory rate, and unconsciousness
- Freezing of extremities
- Death.

Three factors influence the development of a cold injury: ambient temperature, wind velocity, and moisture. Wind chill is used to describe the chilling effect of moving air in combination with low temperatures. For example, an ambient temperature of 10°F with a wind of 15 mph has the equivalent chilling effect of still air at -18°F. Additionally, water conducts heat 240 times faster than air. Thus the body cools much faster when wearing damp or wet clothing.

Other cold-related hazards include slips and trips on snow-covered or frozen surfaces, falling through ice into lakes or ponds, and motor vehicle accidents. Cold weather also can hamper field operations by freezing decontamination solutions, and restricting the use of monitoring instruments (cold causes condensation to form on the lamps of photoionization detectors and can significantly reduce battery life).

Field personnel can implement many practices to prevent cold weather–related injuries or illnesses. Appropriate measures must be included in the site-specific health and safety plan. Precautionary measures include the following:

- Avoid work in adverse weather conditions.
- Dress warmly and stay dry, using rain gear and wool or synthetic insulated clothing (do not wear cotton).
- Provide warm liquids and shelter for breaks.
- Stay off frozen ponds or lakes.
- Exercise caution when walking on frozen or snow-covered surfaces.
- Obtain hot water for decontamination solutions.
- Provide portable heaters for decontamination.
- Provide shelter from wind or snow for field sampling activities.
- Select appropriate, well-maintained vehicles for winter driving (i.e., four-wheel-drive trucks with high clearance) and provide tire chains or other approved traction devices.
- Obtain appropriate emergency supplies when working in remote areas, including extra clothes, radio or cellular telephone, blankets, emergency shelter, food, and other survival supplies, as dictated by local terrain and climate.

ELECTRICAL STORMS

Lightening can pose a hazard during outdoor operations, especially for personnel handling metal equipment or working near drill rigs or other elevated equipment. To protect against this hazard, field personnel should observe local weather conditions and suspend field activities during electrical storms. Other precautions are as follows:

- Provide lightning protection on structures.
- Do not handle flammable liquids or gases during an electrical storm.
- If traveling by vehicle, stay inside the vehicle during an electrical storm.
- Do not use electrical equipment or telephones during electrical storms.

SAFETY GUIDELINE SG-25

HEAT STRESS

Heat stress is a general term that includes heat cramps, heat exhaustion, and heat stroke. Heat exhaustion and heat stroke can pose a serious threat to the health of field personnel conducting hazardous material investigations at industrial and other facilities. This threat is increased for field personnel wearing personal protective equipment (PPE), as the impermeable clothing does not allow sweat to evaporate and cool the body. Other important factors include degrees of acclimation to work, general physical fitness, water intake, and work/rest regimens.

Depending on ambient conditions, work in the sun (radiant heat load), the work being performed, and other factors, heat stress may affect field personnel at temperatures as low as 70°F (adjusted for humidity and radiant heat) and can occur rapidly, with field personnel suffering acute symptoms in less than 15 minutes. Even relatively minor symptoms of heat stress can result in impaired functional ability, threatening the safety of the field person and his or her companions. Thus, heat stress can present a greater health risk to field personnel than chemical hazards or recognized physical hazards.

The sections below provide information and guidelines for monitoring and preventing heat stress.

HEAT-RELATED ILLNESSES

A common factor in heat-related illnesses is the failure of the field personnel to recognize the symptoms of heat stress. All personnel should become familiar with the symptoms of heat stress and appropriate first-aid precautionary measures.

Table 1 provides information on the types of heat-related disorders and procedures for treating them. Heat stress can result in minor symptoms such as heat rash, heat cramps, discomfort, and drowsiness. Prolonged heat stress can result in more severe effects, such as heat exhaustion and heat stroke. Heat rash is a relatively minor form of early heat stress that results from prolonged contact with wet clothing. Heat rash can be prevented by allowing the skin to dry completely during rest periods and by showering as soon as possible at the end of the work day. Heat cramps and drowsiness symptoms may result in impaired functional ability, which in turn may threaten the safety of the individual and coworkers.

Heat cramps, heat syncope (fainting spell), heat exhaustion, and heat stroke all result from excessive loss of body fluids and electrolytes and impaired ability to cool the body through

sweating. The symptom of heat cramps is spasms in the abdomen or limbs. Heat syncope is a pooling of blood in the lower extremities, which may result in fainting when standing up suddenly. Heat exhaustion, caused by more severe dehydration, has the following symptoms: pale, clammy skin; profuse sweating; weakness; headache; and nausea. Heat stroke (sometimes called "sunstroke") is a life-threatening condition that occurs when the body's temperature-regulating system no longer functions properly. Heat stroke requires immediate lowering of body temperature and medical attention. Symptoms of heat stroke include hot, dry skin; a high fever (often 106°F or more); dizziness; nausea; rapid pulse; and unconsciousness. Brain damage and death may follow if the body temperature is not reduced.

Table 1. Heat-Related Disorders and Treatments

Disorder	Cause	Signs	Treatment
Heat rash	Heavy sweating; drinking large volumes of water without replacing salt loss	Profuse tiny raised vesicles; prickly skin	Remove from source of heat; allow skin to dry completely during rest periods; shower as soon as possible after work day
Heat syncope	Lack of acclimatization; pooling of blood in the legs	Fainting while standing, immobile in heat	Remove to cooler area
Heat cramps	Heavy sweating; drinking large volumes of water without replacing salt loss	Painful spasms of muscles used during work; cool, moist skin	Provide fluids that replace salts and protein; allow 1–3 days of rest, depending on the severity of the attack
Heat exhaustion	Sustained exertion in heat; lack of acclimatization; failure to replace water and/or salt	Fatigue; nausea; headache; moist and clammy skin; pale complexion; delirium; diarrhea; cramps	Remove to cooler area; provide cool water and salted fruit or protein drinks
Heat stroke	Sustained exertion in heat; excessive exposure to heat; lack of physical fitness; alcoholism; drug abuse; dehydration; cardiovascular disease	Headache; rapid pulse; dizziness; nausea; confusion; convulsions; flushed, dry skin; high body temperature; loss of consciousness; coma	Call emergency medical services (often 911) immediately; place the worker in a cool, shady area; remove his or her clothing, then sprinkle his or her entire body with cool water; also cool by fanning; treat for shock

Field personnel must learn to recognize that dizziness, nausea, headaches, skin rashes, muscle cramps, and pale or clammy skin are symptoms of heat stress and act promptly when suffering these symptoms. Field personnel may not realize the risk they face by ignoring these symptoms and staying in the work area until overcome by heat stress or other impairments related to heat. Critical factors in the prevention of heat stress include a proper work regimen and the intake of adequate replacement fluids and electrolytes.

FACTORS INFLUENCING HEAT STRESS

Many factors determine an individual's susceptibility to heat stress. Environmental factors include the ambient temperature, humidity, and presence or absence of cooling breezes or shade. The nature of the work being performed—including the level of physical activity, the degree of permeability of protective equipment, the number of layers of protective equipment, and the time of day that the work is being performed—affects the level of heat stress.

Some individuals are predisposed towards suffering heat stress. Factors that could increase a field person's susceptibility to heat stress include previous heat-related conditions, degree of physical fitness, lack of acclimatization, age, dehydration, obesity, alcohol or drug use, infection, sunburn, diarrhea, and chronic disease.

Field personnel who have acclimated to working in hot climates or in PPE will be less likely to suffer heat stress. Acclimated individuals typically have lower heart rates and body temperatures than non-acclimated field personnel. Acclimated field personnel also sweat sooner and more profusely than those not acclimated to high temperatures or the use of PPE (acclimated individuals may sweat more profusely when wearing PPE than non-acclimated field personnel, thus increasing their risk of dehydration).

The National Institute for Occupational Safety and Health (NIOSH) recommends a progressive 6-day regimen to allow field personnel to acclimate to work in a hot environment, especially when wearing PPE (this program begins with 50 percent exposure, then lengthens the staying time by 10 percent each subsequent day). An individual's capacity to work in hot environments generally decreases with age. According to NIOSH, however, an older person in peak physical condition may have a greater work capacity than a less fit, younger individual. Thus, physical fitness is a more significant factor than age when determining an individual's work capacity. Weight is usually a significant factor when determining the ability of an individual to work in a heated environment, because overweight people have lower surface area to mass ratio and thus cannot dissipate heat as well as slimmer people. Weight is not as significant a factor when wearing PPE, as the impermeable garments impede the dissipation of body heat through evaporation of sweat regardless of the individual's weight.

MONITORING FOR HEAT STRESS

To ensure the safety of field personnel wearing impermeable or semipermeable encapsulating PPE, NIOSH recommends that heat stress monitoring be implemented at temperatures about 70°F, using an "adjusted temperature." The adjusted temperature is calculated by determining the ambient temperature (using a standard thermometer, shielded from heat) and adding the total of 13 × the percentage of sunshine (complete overcast = 0 percent sunshine, and no cloud cover = 100 percent sunshine). For example, for an ambient temperature of 80°F and 80 percent sunshine, the adjusted temperature would be 90.4°F (80+(13×0.80) = 90.4). The effect of heat stress on the body may be monitored using the techniques described below. Recommended

intervals for physiological monitoring when wearing permeable or impermeable work clothes are shown in Table 2.

HEART RATE

To monitor the effect of heat stress using the heart rate method, field personnel must measure their heart rate over a 30-second period at the beginning of each rest break. The pulse should be taken at the radial (wrist) artery, not the carotid (neck) artery. When monitoring heart rate, the following guidelines apply:

- If the individual's heart rate does not exceed 110 beats/minute, proceed as before
- If the individual's heart rate exceeds 110 beats/minute at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same
- If the individual's heart rate exceeds 110 beats/minute at the beginning of the next rest period, shorten the next work cycle by another one-third
- Integral recommends the use of heart rate monitoring as the minimum heat stress monitoring technique.

Table 2. Suggested Frequency of Physiological Monitoring for Fit and Acclimatized Field Personnel[a]

Adjusted Air Temperature[b]	Normal Work Ensemble[c]	Impermeable Ensemble[d]
90°F or above (32.2°C)	After each 45 minutes of work	After each 15 minutes of work
87.5–90°F (30.8–32.2°C)	After each 60 minutes of work	After each 30 minutes of work
82.5–87.5°F (28.1–30.8°C)	After each 90 minutes of work	After each 60 minutes of work
77.5–82.5°F (25.3–28.1°C)	After each 120 minutes of work	After each 90 minutes of work
72.5–77.5°F (22.5–25.3°C)	After each 150 minutes of work	After each 120 minutes of work

Source: NIOSH. 1985. Occupational safety and health guidance manual for hazardous waste site activities. Prepared by the National Institute for Occupational Safety and Health, Occupational Safety and Health Administration, U.S. Coast Guard, and U.S. Environmental Protection Agency, Washington, DC.

Notes:

[a] For work level of 250 kilocalories/hour (moderate work activity).

[b] Calculate the adjusted air temperature (ta adj) by using this equation: ta adj °F + (13 x % sunshine). Measure air temperature (ta) with a standard, mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate percent sunshine by judging what percent of time the sun is not covered by clouds that are thick enough to produce a shadow (100 percent sunshine = no cloud cover and sharp, distinct shadows; 0 percent sunshine = no shadows).

[c] A normal work ensemble consists of cotton coveralls or other cotton clothing with long sleeves and pants.

[d] An impermeable ensemble consists of polyvinyl chloride-coated Tyvek® or Saranex® coveralls.

Oral Temperature

To monitor the effect of heat stress on the field person using the oral temperature method, the individual should use a clinical thermometer (3 minutes under the tongue) at the end of each work period, but before taking a drink. When monitoring oral temperature, the following guidelines apply:

- If the oral temperature does not exceed 99.6°F, no action is needed
- If the oral temperature exceeds 99.6°F at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same
- If the oral temperature exceeds 99.6°F at the beginning of the next rest period, shorten the following work period by one-third
- If the oral temperature exceeds 100.6°F at the beginning of any rest period, the field person should not be permitted to wear impermeable equipment.

Body Water Loss

To monitor the effect of heat stress on field personnel by measuring body water loss, the field personnel must weigh themselves with a scale accurate to within 0.25 pounds at the beginning and end of each work day. Their weight for the beginning and the end of the work shift should be taken while wearing similar clothing or, for the greatest accuracy, when nude. Fluctuations in weight (between the beginning of the shift and the end of the shift) indicate the gain or loss of body fluids, thus revealing if fluid replenishment has been effective. Body weight loss in a work day should not exceed 1.5 percent of total body weight. Where such weight losses occur, more attention should be given to fluid replacement during subsequent work shifts.

Electronic Monitors

Electronic monitors that constantly monitor a field person's heart rate and core temperature have recently been developed. These devices utilize sensors that are held in place on the field person's chest with an elastic band and are programmed to account for the field person's age and type of protective equipment. The field person's heart rate and core temperature are monitored. Lights illuminate on a small pad (worn outside of the PPE) to indicate one of the following conditions: the field person may continue as before; the field person has only a limited amount of work time left; or the field person should exit the work area immediately. These devices also include audible alarms and can be set to download heat stress data to a printer at the end of the shift.

Other electronic monitors are designed to measure adjusted (ambient) temperatures and can be programmed to account for the level of individual activity and type of protective equipment. These devices can calculate stay times (the amount of time field personnel in the area may remain in that area at the current activity levels) and can also log conditions encountered.

These devices do not actually monitor the effects of heat stress on field personnel but may be used to implement heat stress prevention measures.

Heat Stress Prevention

Several means are available to decrease or prevent the effects of heat stress.

An effective means of preventing heat stress is to schedule work in the cool parts of the day—early mornings, evenings, or at night. If the heat source is mechanical (e.g., caused by a power plant or production equipment), it may be possible to schedule the work during hours when the facility is inoperative.

Engineering methods may be used to cool field personnel regardless of the time of day. These methods frequently involve the use of cool vests (ice packs worn under PPE in a special vest), forehead and neck cooling wraps, circulating air (often associated with powered air-purifying respirators that utilize hoods rather than sealed facepieces), compressed air vortex cooling systems, or in extreme cases, circulating liquids through specially designed suits. Other engineering controls to prevent heat stress include erecting a shelter to protect field personnel from direct sunlight or circulating air through the workplace. In some instances, deluge showers can be constructed within the exclusion zone or in the decontamination area that allow field personnel wearing fully encapsulating PPE to stand under a shower of cold water. The deluge shower is an efficient means of providing relief to the field person without requiring the field person to proceed through decontamination and exit from the work area. The water would need to be containerized for proper disposal.

A critical element in an effective heat stress prevention program is to ensure that field personnel maintain a normal level of fluids within their bodies. To prevent heat-related illness, the field person's intake of fluids must approximate the amount of fluid lost (e.g., the field person must drink 8 ounces of water for every 8-ounce decrease in body weight). The sensation of thirst is not a reliable indicator of fluid loss. When heavy sweating occurs, it is essential that field personnel increase their fluid intake. The following guidelines may be useful:

- Provide fluid replenishment beverages at the work site, cooled to 50–60°F (appropriate beverages include water and diluted fruit juices or Gatorade®).
- Have field personnel drink 16 ounces of fluid prior to working in a hot environment.
- Have field personnel drink 8 to 16 ounces of liquids every 15 to 20 minutes, or at each rest break. NIOSH recommends that field personnel consume a total of 1 to 1.5 gallons of fluids a day, although a greater quantity may be required.

Scheduling rest periods to break up work periods is essential to prevent heat-related illnesses. It is imperative that rest periods be taken in an environment cooler than the work area from which respite is sought (e.g., has shade, fans, water, etc.). It is difficult to establish a rigid schedule that spells out the staying time and rest breaks based on temperature alone because

other factors, such as the level of physical activity and the type of protective equipment, play a significant role in determining an individual's susceptibility to heat stress. The recommended course of action is to use the guidelines for physiological monitoring provided in Table 2 to schedule the initial work period, then vary the length of the break and the next work period based on the physiological responses of individual field personnel to the work load. If field personnel are engaged in strenuous activities, are not acclimated to the work environment, or are not in peak physical condition, the work interval should be shortened significantly, and monitoring continued.

Individual Responsibilities

In preventing heat stress, it is essential that field personnel monitor their own symptoms and promptly take steps to remedy any signs of heat stress. Field personnel should be aware of the human tendency to discount symptoms of heat stress. Such steps include notifying coworkers of their condition and taking whatever measures may be necessary to alleviate the symptoms by taking a break, increasing the intake of fluids, instituting environmental controls (such as the use of cool vests or circulating air), assuming less strenuous duties, or implementing appropriate first-aid procedures as indicated in Table 1. No field monitoring program can substitute for the individual's sense of his or her own health and physical limits.

SAFETY GUIDELINE SG-16

OVERWATER SAFETY

Integral field projects may require the collection of biological, sediment, and water samples from vessels. In addition to the physical and chemical hazards associated with all field sampling, there are special hazards associated with work on board sampling vessels. Safety guideline SG-16 presents policies and procedures for ensuring the safety of Integral field personnel while engaged in overwater activities.

At a minimum, the Integral overwater safety policy provides for training, appropriate equipment, hazard recognition, and establishment of emergency procedures. These procedures address inland or protected waters only. Additional procedures must be developed for working on vessels offshore.

TRAINING

Appropriate training is essential to prevent accidents and ensure the proper completion of field duties. The following training requirements apply to all Integral fieldwork conducted on the water:

- All Integral and subcontractor personnel must participate in project-specific safety meetings.
- If the project is a potential hazardous materials site, all personnel must complete the 40-hour hazardous waste operations and emergency response (HAZWOPER) health and safety training, and at least one person must have Occupational Safety and Health Administration (OSHA) supervisor training.
- All Integral field personnel must have completed training in first aid and cardiopulmonary resuscitation.
- Vessel operators must demonstrate proficiency in the operation of that type of vessel and knowledge of overwater safety and navigation rules, or may be required to complete training in these subjects according to state law.

SAFETY EQUIPMENT

To prevent accidents and ensure adequate preparation for emergencies that may arise, the following safety equipment must be provided for all overwater operations:

- U.S. Coast Guard (USCG)–approved personal flotation devices (PFDs)—There must be one PFD for every person on board the vessel, plus a throwable device on board vessels greater than 16 ft in length.
- Fire extinguisher—Requirements vary, depending on the vessel's length and if the vessel has enclosed or inboard engines.
- First-aid kit—Kits must be provided for all Integral fieldwork.
- Marine radio with weather channel—A VHF radio with weather channel is required for commercial vessels and by Integral for fieldwork on most inland waters.
- Cellular telephone—If a two-way radio is not available, then a cellular telephone must be on board.
- Horn or bell—USCG regulations require that a signaling device be on board all vessels longer than 36 ft and require that all vessels, regardless of length, be capable of making audible signals during certain events (i.e., approaching or overtaking other vessels). Integral requires a horn or bell on all vessels, regardless of length.
- Navigation lights—The requirements for navigation lights vary based on the length and type of vessel. All vessels operated at night must have the appropriate navigation lights.
- Oars or paddles—Small power boats must be equipped with alternate means of propulsion.
- Anchor and suitable line—In most cases, vessels should be equipped with two anchor types and sufficient anchor line for expected water depths plus rode and bottom conditions.
- Reach pole or shepherd's hook—On larger vessels (i.e., greater than 36 ft in length), a reach pole or shepherd's hook should be available to rescue anyone who falls overboard.
- Other rescue gear—On larger vessels, a block and tackle or other means must be available to pull a person from the water.

HAZARDS AND PREVENTION

There are numerous physical hazards associated with working on board a vessel. Potential hazards and appropriate precautions are listed below:

- Slips/trips/falls—The combination of a moving vessel and wet or slippery decks increases the potential for slips, trips, or falls. Onboard personnel can prevent these by increasing their awareness of the surroundings, keeping one hand free for handholds and support, keeping the deck and working areas clear of unnecessary obstacles or hazards, and wearing nonskid boots or shoes.

- Drowning—Even the best swimmer can drown if caught unprepared, tired, or weighed down with bulky clothing and boots. Drowning can be prevented by taking precautions against falling overboard (avoid reaching over the side; beware of slips, trips, and falls; avoid on-deck work in heavy seas) and by wearing a USCG-approved PFD. PFDs should be worn underneath chemical protective equipment such as Tyvek® coveralls (thus allowing the wearer to remove the coveralls without first removing the PFD and minimizing potential contamination) and should be properly secured or buckled.
- Crushing/falling objects—The use of hoists to lift coring tools and other equipment could result in crushing or other injuries to field personnel. These injuries can be avoided by using properly adjusted and maintained hoists, allowing only experienced personnel to operate the hoist, keeping all personnel out of the way during lifting and hoisting, and wearing hardhats to protect against head injuries or bumps.
- Gear deployment and retrieval—The deployment and retrieval of sampling gear presents a hazard because of the weight of the gear, its suspension over the deck, and the risk of entanglement or accidental and premature release or closure. Setting the triggering mechanism must always be performed when the equipment is resting on a stable surface. During sample retrieval, at least one crew member is required to watch for the appearance of the sampling gear and alert the winch operator (e.g., yell "sight"). Failure to observe the sampling gear and stop the winch could lead to cable breakage, loss of sampling gear, and possible injury from either the falling gear or the end of the broken cable. All nonessential personnel should stay clear of the work area during the retrieval and deployment of sampling gear. All personnel should be knowledgeable in the proper hand signals for guiding the winch operator.
- Cables—After repeated use, stainless steel cables may fray or break. Sampling personnel must never take hold of the moving cable unless they are wearing work gloves. Periodically during the sampling event, the site safety officer (SSO) should inspect the cable for wear, especially where the wire or cable is attached to the sampling equipment. If a cable is frayed, an onsite evaluation should be made to determine if the damaged section needs to be cut off or the entire cable replaced.
- Climate—Depending on weather conditions, field personnel may suffer from hypothermia, dehydration, or heat stress. Climate-related illnesses and injuries can be prevented by dressing appropriately for the expected weather and by having additional clothing on board should personnel get wet or the weather change suddenly. When working in cold, wet weather, appropriate clothing may include raingear, wool, and modern synthetics. Cotton clothing should only be worn during warm, dry weather. In addition, fluid replenishment beverages (to protect against heat stress and dehydration) or warm beverages (to protect against hypothermia) should be available during fieldwork. In extreme climates, survival suits, use-tested prior to the project, may be required.

- Unsecured gear—Wherever possible, all on-deck sampling and safety gear should be secured to a deck, rail, or bulkhead to prevent loss from unexpected movement caused by wind or waves.
- Hatches—All personnel should be alerted to the presence of an open hatch; hatches should not be left open unnecessarily.
- Chemical and sample storage—To prevent fire, health hazards, or sample contamination, all field chemicals such as solvents and formalin should be stored in secured boxes or appropriately ventilated cabinetry on deck—not in the cabin, hold, or near samples. Solvents must be recapped immediately after use.

SAMPLING VESSEL OPERATIONS

Physical hazards associated with the deployment and retrieval of sampling equipment from a sampling vessel result from the equipment's weight and the method of deployment. Only trained personnel may deploy and retrieve sampling gear. Under circumstances of potentially dangerous waves or winds, the vessel pilot and field team leader must employ best professional judgment to ensure safe field operations.

To avoid injuries from heavy equipment, personnel must wear steel-toed boots when on the work deck or loading/unloading heavy equipment from the vessel. Hard hats must be worn by personnel on the work deck, because of the proximity of overhead gear. Sample handling equipment, containers, deck lines, hydraulic cables, and water hoses not in immediate use must be kept clear of walkways and work areas until needed. Each time sampling operations at a given location have been completed, excess sediment on the deck should be washed off onto the sampling location or, if specified in the field sampling plan (depending the anticipated level of contamination), containerized in U.S. Department of Transportation–approved 55-gallon drums. These procedures are in place to 1) prevent personnel from slipping, 2) minimize personnel exposure to potentially contaminated sediment, and 3) limit cross-contamination between sampling locations.

USCG-approved PFDs must be provided for and worn by all personnel working on the deck, or as directed by the Integral SSO or vessel operator. The vessel must also be equipped with throwable life rings, fire extinguishers, and warning horns. All crew members will be briefed on the location of this equipment prior to initiation of the sampling event.

SMALL CRAFT OPERATION

An increased level of protection may be required on small boats (i.e., length 20 ft or less), depending on boat size and location in the river. Small boat procedures will include all the requirements listed above. In addition, all personnel on board are required to wear USCG-approved PFDs at all times. Any Integral staff or subcontractors operating small watercraft

must have completed a USCG Auxiliary *Boating Safely* course and have a demonstrated knowledge of the safe handling of these craft.

U.S. COAST GUARD NOTIFICATION

If required for the body of water that will be sampled, the USCG will be notified of the schedule and scope of the overwater sampling work. If the USCG deems a notice to other mariners to be necessary, then information will be provided by Integral to the USCG to make barge and other river traffic aware of the sampling activities.

EMERGENCY PROCEDURES

In case of a boating-related injury or fatality, Integral field personnel must perform the following actions:

- Notify emergency medical or rescue personnel immediately (the USCG emergency frequency is VHF channel 16).
- Be knowledgeable of when and how to use flares to signal Mayday or SOS.
- Notify the SSO, the appropriate Integral project manager, and the corporate health and safety manager (CHSM) immediately. The project manager and CHSM will coordinate notifying OSHA and the USCG, as appropriate.

In case of boating-related property damage, Integral field personnel must:

- Notify police or other legal jurisdictions (as appropriate).
- Notify the SSO, the appropriate Integral project manager, and the CHSM within 4 hours of the incident. The project manager and the CHSM will coordinate notifying the USCG.
- Notify the Integral contracts and risk manager to initiate insurance claims.

Appendix T

Field Safety Tailgate Briefing Form

January 2018

FIELD SAFETY TAILGATE BRIEFING FORM

Corporate Health and Safety Manager:
Matthew Behum
(410) 573-1982 ext. 512

Date: _____ Project name: _____ Project number: _____

Meeting conductor: _____ Site safety officer: _____ Project manager: _____

Items discussed (check all that apply):

- ☐ HSP review and location
- ☐ Lines of authority
- ☐ Chemical hazards and exposure routes
- ☐ Flammable hazards
- ☐ Lifting techniques
- ☐ Buddy system
- ☐ Self and coworker monitoring
- ☐ Biological/plant/animal hazards
- ☐ Slips, trips, and falls
- ☐ Heat and cold stress
- ☐ Overhead hazards
- ☐ Vessel safety protocols
- ☐ Proper use of PPE
- ☐ Safety equipment location
- ☐ Proper safety equipment use
- ☐ Fire extinguisher location
- ☐ Eye wash station location
- ☐ Emergency procedures and evacuation route
- ☐ Directions to hospital
- ☐ Emergency decontamination procedures
- ☐ Site communication
- ☐ Work zones
- ☐ Vehicle safety and driving/road conditions
- ☐ Other: _____

Daily work scope: _____

Site-specific hazards: _____

Weather conditions: _____

Field staff health and safety concerns: _____

Attendees	
Printed Name	Signature

Appendix U

COVID-19 Field Management Plan

COVID-19 Field Program Management Plan

The emergence of the SARS-CoV-2 virus in late 2019, and subsequent COVID-19 respiratory illness pandemic, requires separate consideration and advanced planning. It is important that the latest guidance from the U.S. Centers for Disease Control and Prevention (CDC) is adhered to at all times during the work. Safe work practices that will underpin activities and responsibilities in the field include, at a minimum, screening employees at the start of the day for fever, maintaining physical distancing of 6 ft, wearing face masks where close contact is required, and robust hand hygiene. In each step of the sampling program, including mobilization, fieldwork, and demobilization, we must consider how best to ensure that field staff, including subcontractors, are physically distant from one another. With that in mind, we ask project managers and field team leaders to be prepared to develop new sampling protocols and altered logistics that may involve the following:

- Sequenced work practices
- Estimations of how far ahead certain steps in the sequenced process should be before the next one is initiated
- Additional logistics to secure laboratories and other subcontractors with capacity issues or delays due to COVID-19
- Additional logistics to obtain supplies and deliver samples to couriers or the laboratory
- Schedule delays due to sampling and logistics modifications that may increase budgets along with additional communications with the client to discuss these needs and expectations
- Increased communications with the field team to talk through and potentially modify sampling plans in real-time.

During this pandemic, advanced planning is key.

Topics included in this document are:

- **COVID-19 Field Program Decision Framework**. This section describes a decision framework used by project managers and key Operations staff to assess the plans and safe execution of each field event.
- **COVID-19 Site and Preventive Measures Plans**. This section describes protective measures Integral's field teams will use to minimize the spread of COVID-19.

- **COVID-19 Confirmed Case Response Plan**. This section describes potential COVID-19 exposure scenarios among field team members and how Integral will respond under each scenario.

By implementing the guidelines described in this health and safety plan appendix, the project can proceed with limited risks to workers and the public related to COVID-19. This introductory section provides background information on the COVID-19 virus that is important for all site workers to understand.

Patients with COVID-19 can develop respiratory distress, fever, and other flu-like symptoms, but they are not always symptomatic. According to the CDC, human infections with COVID-19 are present throughout the world, including in the United States and more specifically, Portland, Oregon. On March 8, 2020, Governor Kate Brown of Oregon declared a State of Emergency related to the COVID-19 pandemic. On March 13, 2020, the President of the United States declared the COVID-19 pandemic a national emergency. These declarations remain in place at this time.

COVID-19 appears to spread easily in a community ("community spread") and people may have been infected with the virus without knowing when or how they were exposed. Currently, there is an effort to better understand disease transmissibility, infectivity, and severity associated with COVID-19. According to the CDC:

- Transmission most likely occurs during close (within 6 ft) contact with an infected person.
- Transmission is thought to occur mainly via droplets of respiratory secretions produced when an infected person coughs or sneezes, similar to how influenza spreads.
- Respiratory droplets from an infected person that contact others could transmit COVID-19.
- There is evidence that asymptomatic carriers of COVID-19 can actively transmit it to others.
- COVID-19 can be transmitted by contacting contaminated surfaces.

Symptoms may appear 2 to 14 days after exposure based on the incubation period. Typical symptoms of COVID-19 include:

- Fever
- Cough
- Shortness of breath
- Loss of sense of taste or smell.

In addition to these symptoms, other indicators of a potential COVID-19 infection include[1]:

- Trouble breathing
- Persistent pain or pressure in the chest
- Confusion
- Bluish lips or face.

COVID-19 Field Program Decision Framework

At the onset of the COVID-19 outbreak, Integral established a COVID-19 Response Team that includes members of the Board, the corporate Contracts and Risk manager, the corporate Health and Safety officer, the Human Resources director, the IT manager, and the Operations director. The COVID-19 Response Team is responsible for:

- The efficient transition of staff resources who support non-essential services from an office to at-home work environment
- The education of staff in federal, state, and local acts and orders during the pandemic
- The development of corporate policies related to the COVID-19 response
- The effective communication of corporate policies and information to staff.

A critical component of Integral's services is to conduct essential fieldwork for our clients and community in a time of emergency while making certain our teams are safe in the field. To complete this process, Integral has developed a decision framework to assess the safe completion of scheduled or emergency fieldwork. The COVID-19 Response Team consistently evaluates each field project using these steps:

1. Obtain client approval for performing the fieldwork
2. Review scope of services, contractual requirements, client expectations, subcontractors, sampling environment, sampling equipment and logistics, laboratory and supplies logistics, and travel logistics with the principal in charge, project manager, and field staff
3. Review the requirements with field staff and obtain their approval for involvement in the field
4. Review federal, state, and local emergency orders to assess essential services, travel restrictions, and closures

[1] This list is not inclusive. Please consult your medical provider for any other symptoms that are severe or concerning.

5. Obtain client documentation confirming our status as an essential service in the state or city where the field services are to be conducted. Documentation is to include date, point of contact, and contact information so that if challenged by law enforcement, the fieldwork can be confirmed without our employees being quarantined or incarcerated. If an accident were to occur during a field event and result in a claim against our insurance, our coverage may be compromised if it is determined that we were working contrary to government orders. Insurance does not cover losses incurred while violating the law.
6. Review compliance of field operations and logistics with up-to-date CDC and Occupational Safety and Health Administration (OSHA) guidance specific to the COVID-19 response (i.e., physical distancing, hand-washing, cough and sneeze etiquette)
7. Review project-specific health and safety plan for any additions related to emergency sampling and COVID-19 (i.e., per this Field Management Plan)
8. Ensure all work is documented and appropriate staff are informed.

It is critical that each step is completed and evaluated in concert with the project manager and field lead. At the conclusion of this review process, a decision is made to either proceed with or suspend, delay, or cancel the fieldwork.

People at high-risk of severe illness from COVID-19 should not participate in activities on the field project. In addition, those who live with a high-risk person should consider whether the risks posed by participating in the field project work are acceptable.

COVID-19 Site and Preventive Measure Plans

Integral and its subcontractors will take proper precautions to minimize to every extent possible the transmission of the SARS-CoV-2 virus (COVID-19) during site investigation activities. These activities may include site visits, construction oversight, sediment and soil sampling, groundwater monitoring, and the deployment and retrieval of in-water remote sensing instrumentation. This Field Program Management Plan may be used as an addendum to the existing project-specific Health and Safety Plan and shall remain in effect until superseded by further updates.

The COVID-19 outbreak is an ongoing and continually changing health crisis that requires daily reviews of practices and work restrictions to ensure ongoing protectiveness. Guidelines presented herein are consistent with the preventive recommendations provided by the CDC (www.cdc.gov/coronavirus/2019-ncov/infection-control/control-recommendations.html) and the COVID-19 planning guidance provided by OSHA (www.osha.gov/Publications/OSHA3990.pdf). Supplemental or additional facts and

information can be obtained through the Oregon Health Authority (https://govstatus.egov.com/OR-OHA-COVID-19).

Each field effort will require discussions between the project manager and client to address specific requirements associated with local orders and directives that could impact travel and health and safety. The following lists general CDC recommendations followed by steps Integral and its subcontractors will take to reduce the transmission of COVID-19.

Worker Training

According to the OSHA COVID-19 resource page (https://www.osha.gov/SLTC/covid-19/controlprevention.html#health), training is recommended for all workers with reasonably anticipated occupational exposure to COVID-19. This training will be performed for project workers and includes information on potential sources of exposure to the virus, the hazards associated with that exposure, and appropriate workplace protocols in place to prevent or reduce the likelihood of exposure. Training will also include information about how to isolate individuals with suspected or confirmed COVID-19, and where to report possible cases.

Workers required to use personal protective equipment (PPE) must be trained. This training includes the following:

- When to use PPE
- What PPE is necessary
- How to properly put use PPE
- How to properly dispose of or decontaminate and maintain PPE
- The limitations of PPE.

Traveling to Site—Rental Car Use

Staff on business travel will not be permitted to use public transportation until otherwise notified. In most instances, staff will require rental car use for offsite commuting. In this case, Integral recommends physical distancing during travel (i.e., more than one person in a typical passenger car is not allowed).

Staff requiring rental cars for any sort of business travel, including fieldwork, are to take the following precautions when taking possession of the vehicle for the first time, and at the start of each day while renting the vehicle:

- Use a disinfecting wipe to wipe down main contact areas, including:
  - Door handles (inside and outside)
  - Steering wheel

  - Dashboard
  - Clock and entertainment surface, including knobs
  - Gear shifting knob
  - Blinker and windshield wiper knob
  - Window control switch or lever
  - Rear view mirror and mirror control knobs
  - Center console
  - Odometer acrylic screen
  - Glove compartment external door
- Refrain from wearing the same unwashed clothes the following day or subsequent days after using a rental vehicle
- Sanitize hands immediately after refueling and after returning the rental vehicle.

Before Entering Site

Some site owners may require that field staff undergo body temperature screening prior to entering the site. If it is required and an individual chooses not to participate, the individual should discuss the decision with the project manager, field lead, or site safety officer. Client has the right to deny access to the facility if a temperature scan is refused.

Other actions to be taken before entering a site include the following:

- Learn the community exposure and travel history of all employees and visitors and current conditions in Portland, Oregon, to understand potential exposure. If an individual has traveled internationally or has had exposure to infected individuals within the U.S., the individual will need to self-quarantine for a minimum of 14 days. A positive COVID-19 test will also prevent staff from entering the field.
- If a staff member is feeling well but has a sick family member at home, the staff member should notify the project manager and follow CDC-recommended care (https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-prevent-spread.html#precautions).
- If a staff member shows any signs of a respiratory ailment (cough, sore throat, fever), he or she is required to stay home and not report to work. Symptoms of COVID-19 include fever (>100.0 °F), cough, and shortness of breath as described on the CDC website (https://www.cdc.gov/coronavirus/2019-ncov/community/guidance-business-response.html). It is recommended that the individual contact a health care provider for medical advice. If COVID-19 is suspected or confirmed, staff must stay home for a minimum of 14 days.

Minimizing Chance of Exposure on the Site

- Information needed to minimize exposure and prevent the spread of COVID-19 will be included in each day's health and safety meeting. Field crew meetings should be conducted outside, if possible.
- Workers will follow site-specific health and safety plan requirements for the use of PPE. PPE is not to be shared.
- If symptoms consistent with COVID-19 are noticeable during the sampling day, the employee or subcontractor should excuse him- or herself from further work, leave the site immediately, and follow CDC guidance (https://www.cdc.gov/coronavirus/2019-ncov/if-you-are-sick/steps-when-sick.html).
- Workers will wash hands often with soap and water for at least 20 seconds. If soap and water are not available, hand sanitizer with at least 60 percent alcohol will be made available in multiple locations, as needed. Frequent hand-washing is recommended throughout the day (https://www.cdc.gov/handwashing/).
- Workers are to avoid touching eyes, nose, and mouth with unwashed hands.
- Workers will wear a face covering or surgical mask when working around others (within 6 ft).
- Workers will use gloved hands when contacting surfaces or when transferring equipment between personnel is required.
- Workers who cough or sneeze should cover mouth and nose with a tissue or use the inside of one's elbow.
- Frequently touched objects and surfaces, such as workstations, keyboards, telephones, handrails, and doorknobs, will be cleaned and disinfected. The frequency and scope of the cleaning program for project facilities (office trailers, bathrooms, other buildings, and work areas) will be reviewed and increased as necessary. Cleaning products used will be those recommended by EPA and deemed as effective against the SARS-CoV-2 virus (https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2).
- Workers will avoid using other employees' phones, clipboards, pens, or other work tools and equipment, when possible. If necessary, workers will clean and disinfect them before and after use.

Managing Visitor Access and Movement in Sampling Area

- Only staff directly involved in sample collection or equipment deployment will be permitted within the sampling zone.
- All visitors present outside the collection or deployment area will maintain at least a 6-ft distance from fellow visitors or sampling staff, even after operations are

complete. Positions in the field facility will be assigned and marked to provide adequate distance when not working.

- Sequential work practices with appropriate physical distancing are to be considered and implemented wherever possible.
- Larger (but fewer) deliveries and courier pickups are to be set up, and products should be obtained through curbside pick-up or delivery.
- Group meetings are to be minimized whenever possible. Meetings that are conducted are limited to <10 people.

Boat-Specific Protocols

- PPE including face coverings or surgical masks, face shields, gloves, and goggles will be used if 6 ft of space cannot be maintained.
- The number of people on the boat and in enclosed boat spaces (cabin) will be limited.
- Positions on the deck of the boat will be assigned and marked to provide adequate distance when not working.

Implementing Environmental Control

- Appropriate disinfectant wipes and cleaners and hand sanitizer will be made available at each job site.
- Sampling staff will clean the sampling zone and surrounding environment to ensure no sampling waste or other trash is left behind. After trash is bagged, staff will sanitize hands and exit the sampled property.

COVID-19 Confirmed Case Response Plan

This section describes the management actions to be taken by field staff under different potential COVID-19 exposure scenarios. Prompt identification and isolation of potentially infectious individuals is critical in the protection of workers and visitors at the worksite. Any individual who presents with symptoms of COVID-19 is to contact his or her personal healthcare provider. Decisions about COVID-19 confirmatory testing are at the discretion of state and local health departments or clinicians. As indicated on the CDC website, a negative test result does not rule out that an individual will not become sick later. A diagnosis of COVID-19 may not involve testing. Carriers of the virus may also be asymptomatic. As a result, this section does not differentiate between people who may or may not have symptoms.

Exposure Scenarios and Specific Actions

Person-to-person transmission of COVID-19 can occur via primary, secondary, and tertiary exposure pathways:

- Primary exposure—Employee tested positive for the virus.
- Secondary exposure—Employee who within the last 14 days had direct contact with someone outside of the field team who has been diagnosed with COVID-19.
- Tertiary exposure—Employee had direct contact with someone outside of the field team who has been quarantined as a result of close contact within the last 14 days with someone who has been diagnosed with or is being tested for COVID-19.

In the event there is a confirmed case of an employee becoming infected with COVID-19 (primary exposure), the field lead and site safety officer will take the following immediate actions:

- Instruct the employee, if still at the site, to enter home isolation immediately.
- Notify Integral's COVID-19 Response Team immediately.
- Notify those who may have been exposed to the virus based on close prolonged contact with the diagnosed individual, while maintaining confidentiality as required by the Americans with Disabilities Act (ADA).
- Restrict access to areas where the employee worked and mark them as off limits to all site personnel. Areas will be disinfected following CDC guidelines.
- Ask field staff who were in close contact with the individual to self-quarantine for 14 days (see management actions for Secondary Exposure). This scenario may delay the field event.

In the event of secondary exposure, the employee will be sent home immediately to enter a 14-day self-quarantine where the individual will self-monitor. Self-monitoring means the individual will take temperature readings twice daily to monitor for fever and remain alert to cough or difficulty breathing.

- The field lead or site safety officer will notify Integral's COVID-19 Response Team immediately.
- The field team will continue cleaning common touch areas with recommended disinfectants.
- If the employee is confirmed positive, this becomes a primary exposure scenario. Staff who were in close contact will be notified, and procedures for primary exposure will be followed.

In the event of tertiary exposure, communication with the field team is recommended. The individual will be asked to self-monitor.

- The field lead or site safety officer will notify Integral's COVID-19 Response Team immediately.
- The field team will continue cleaning common touch areas with recommended disinfectants.
- If the acquaintance is confirmed to be infected, this becomes a secondary exposure scenario. Steps for secondary exposure will be followed going forward.

All employees need to be vigilant regarding potential exposure and transmission of COVID-19. Curbing this outbreak is considered a team effort as much as the field event is itself.

Discontinuation of Home Isolation

For individuals with symptoms who are confirmed or suspected of having COVID-19, home isolation may be discontinued under the following conditions:

- At least 3 days (72 hours) have passed since recovery, defined as resolution of fever without the use of fever-reducing medications and improvement in respiratory symptoms (e.g., cough, shortness of breath)

  AND

- At least 7 days have passed since the onset of symptoms.

Individuals with laboratory-confirmed COVID-19 and no symptoms may discontinue home isolation when at least 7 days have passed since the outcome of their positive test result and have had no subsequent illness (www.cdc.gov/coronavirus/2019-ncov/if-you-are-sick/care-for-someone.html#when).

COVID-19 Field Program Management Plan Acknowledgement

Project Number: _____

Project Name: _____

My signature below certifies that I have read and understand the policies and procedures specified in this COVID-19 Field Management Plan.

Date	Name	Signature	Company

Appendix D

Emergency Response Plan

Appendix D.
Emergency Response Plan

This Emergency Response Plan was developed for the pre-design investigation (PDI) to fill data gaps in and adjacent to the Arkema Project Area. The PDI elements include the following:

- Surface and subsurface sediment sampling
- Riverbank soil sampling
- Porewater sampling
- Groundwater flux study
- Investigation-derived waste management.

Details on the scope of work for each of the PDI elements are presented in the PDI Work Plan, and Appendix A (Field Sampling Plan) and Appendix C (Health and Safety Plan) to the PDI Work Plan.

Emergency Incident Contact

The person responsible for responding in the event of an emergency incident is the Arkema Project Area Supervising Contractor, Eron Dodak (work: 503-943-3614; cell: 503-407-2933; email: edodak@intgegral-corp.com).

Meeting with Local Community

Prior to initiating PDI fieldwork, a meeting will be held with local, state, and federal agencies involved in the cleanup, as well as local hospitals and emergency response providers. The meeting will be led by the Arkema Project Area Supervising Contractor, Eron Dodak of Integral Consulting Inc. (Integral), and the Community Involvement Coordinator, April Hasson of JLA Public Involvement.

The date for the meeting will be set within 2 weeks after U.S. Environmental Protection Agency (EPA) approval of the PDI Work Plan for the Arkema Project Area. The meeting will include a description of the fieldwork elements, proposed schedule for each element, an overview of the Emergency Response Plan, and a question and answer session.

Spill Prevention, Control, and Countermeasures (SPCC) Plan

Although no oil or materials will be sampled or transported that might fall under 40 C.F.R. Part 112, *Oil Pollution Prevention,* smaller quantities of fuels, oils, and greases will be used on the sampling vessels. A spill response kit will be stored on each vessel to clean up any leaks or spills of petroleum products. Release reporting, if necessary, will follow the requirements in the following section.

Field staff will generate sampling waste during operations, chiefly in the form of drums of potentially contaminated sediment, soil, and decontamination water. Because some of the riverbank soils may contain trace amounts of asbestos-containing materials, the soil cuttings will be immediately placed in drums to prevent airborne dispersion of any potential asbestos-containing materials.

Careful attention will be placed on site control during sampling, decontamination and cleanup as outlined in Integral's Safety Guideline (SG-07), *Site Control,* presented as Attachment 1 to this Emergency Response Plan. During sampling and post-sampling decontamination, dedicated exclusion, contamination reduction, and support zones will be established as outlined in the Arkema Project Area Health and Safety Plan (Appendix C).

If sediment or soil is spilled from a drum on the barge deck, riverbank area, or upland portion of the site, it will be collected with shovels and returned to the drum. Decontamination procedures will take place on polypropylene sheeting, and any decontamination water collected on the sheets will be decanted into the waste drum. Waste will be disposed of in accordance with federal, state, and local regulations.

Release Reporting

Release Reporting will be conducted in accordance with Section 3.11(b) of the Arkema Project Area Statement of Work (SOW) in the Administrative Settlement Agreement and Order on Consent (ASAOC) for the River Mile 7 West Project Area. Upon the occurrence of any event during performance of the Arkema Project Area remedial design work requiring reporting pursuant to Section 103 of CERCLA, 42 U.S.C. § 9603, or Section 304 of the Emergency Planning and Community Right-to-Know Act, 42 U.S.C. § 11004, the Arkema Project Area Supervising Contractor will immediately notify the following by phone:

- National Response Center (800-424-8802)
- Authorized EPA officer (Hunter Young, EPA Project Coordinator, 503-326-5020), the EPA Alternate Project Coordinator (if the EPA Project Coordinator is unavailable), or the EPA Emergency Response Unit, Region 10 (if neither the EPA Project Coordinator nor EPA Alternate Project Coordinator is available).

For any event requiring Release Reporting, Arkema will 1) within 14 days after the onset of the event, submit a report to EPA describing the actions or events that occurred and the measures taken, and to be taken, in response thereto; and 2) within 30 days after the conclusion of the event, submit a report to EPA describing all actions taken in response to the event.

Emergency Response and Reporting

Emergency Response and Reporting will be conducted in accordance with Section 3.11(a) of the Arkema Project Area SOW in the ASAOC for the River Mile 7 West Project Area. If any event occurs during performance of the Arkema Project Area remedial design work that causes a release of Waste Material on, at, or from the Arkema Project Area and that either constitutes an emergency situation or that may present an immediate threat to public health or welfare or the environment, the Arkema Project Area Supervising Contractor will do the following:

- (1) Immediately take all appropriate action to prevent, abate, or minimize such release or threat of release.
- (2) Immediately notify the authorized EPA officer. The authorized EPA officer is the EPA Project Coordinator (Hunter Young, 503-326-5020), the EPA Alternate Project Coordinator (if the EPA Project Coordinator is unavailable), or the EPA Emergency Response Unit, Region 10 (if neither the EPA Project Coordinator nor EPA Alternate Project Coordinator is available).
- (3) Take such actions in consultation with the authorized EPA officer and in accordance with all applicable provisions of the Health and Safety Plan, the Emergency Response Plan, and any other deliverable approved by EPA under the Arkema Project Area SOW.

For any event requiring Emergency Response and Reporting, Arkema will 1) within 14 days after the onset of the event, submit a report to EPA describing the actions or events that occurred and the measures taken, and to be taken, in response thereto; and 2) within 30 days after the conclusion of the event, submit a report to EPA describing all actions taken in response to the event.

Appendix E

Figures from Previous Reports

This figure shows the different physical features that define the SubSMA types. See text for a description of each physical feature.

Segment 4
Segment 3
Segment 3
Segment 2
RM-5
RM-6
RM-7
8
10
11
12
13
14
15
16
17D
9U
9D

LEGEND

Areas of Potential Concern (August 2011)
Portland Harbor Site
Federal Navigation Channel
Docks and Structures

Physical Features

Existing Remediation Cap
Potential Future Maintenance Dredge
Navigation Channel
Open Water
Limited Access Structures
Behind Structures with No Access
Under Heavy Structures
Behind Structure - Upland Removal
Existing Remediation Cap
Light Structures
Wave Zone
Potential Disposal Sites CAD/CDF
Segment Boundary
River miles

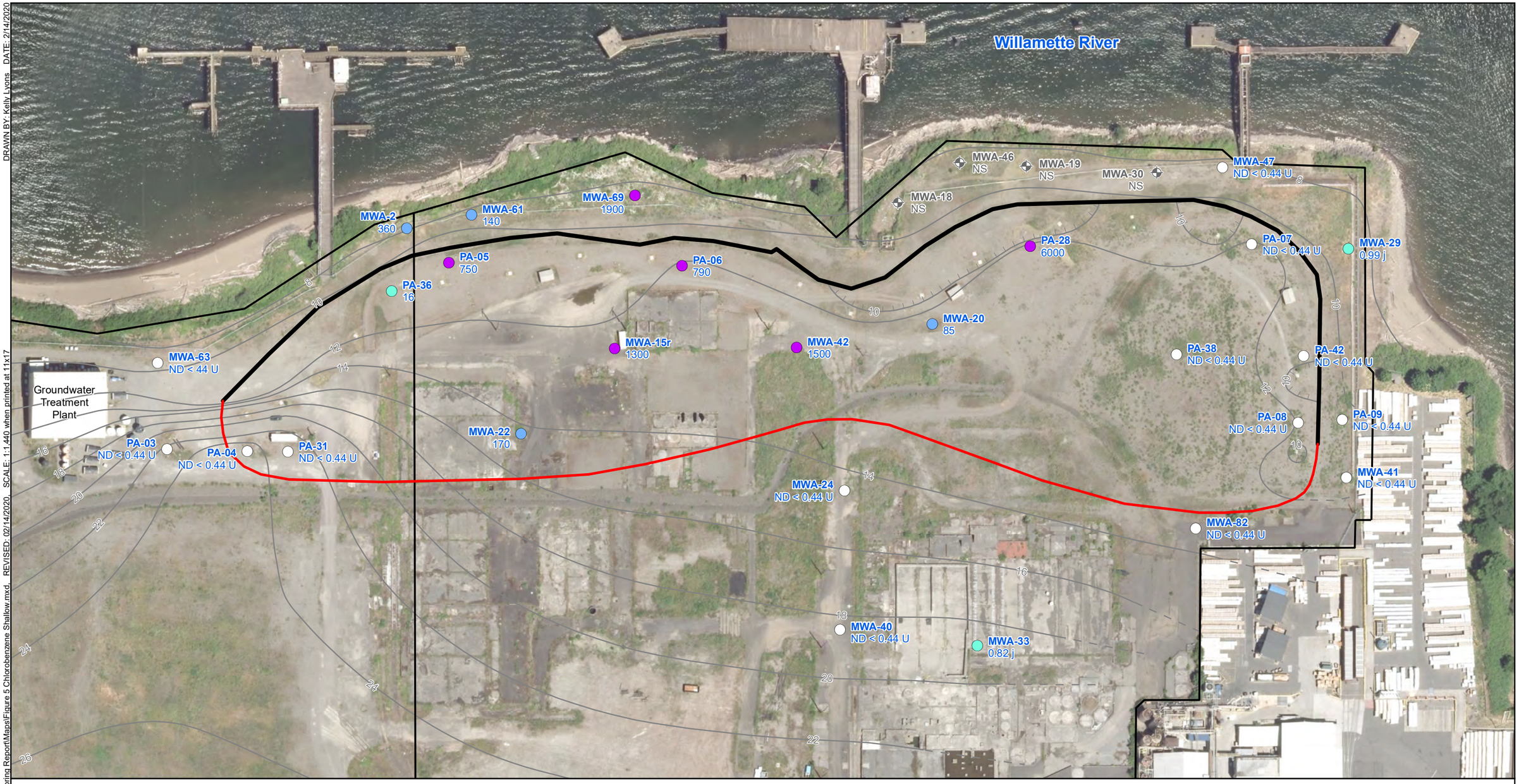
Feet
0 450 900 1,350 1,800

ANCHOR QEA
LWG LOWER WILLAMETTE GROUP

DO NOT QUOTE OR CITE
This document is currently under review by US EPA
and its federal, state, and tribal partners, and is subject
to change in whole or in part

Figure 5.4-1c
Portland Harbor RI/FS
Draft Feasibility Study
Summary of SubSMA Areas and Types (shown for largest SMA Alternative F)
Segment 3: AOPCs 9D - 14

Q:\Jobs\101142-01_AG_LWG\Maps\FS\FS_Draft2012\Section 5\FIG5_4_1_SummaryofSubSMAareasAndTypes.mxd jkilver 3/14/2012 2:49:15 PM



Legend

- >= 640 - < 6,400 µg/L
- >= 64 - < 640 µg/L
- < 64 µg/L
- Not Detected
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries
- Shallow Zone Groundwater Contours (ft NAVD88) October 2019

Notes:
Samples collected Oct 22-Nov 7, 2019.
All results in micrograms per liter (µg/L).
Screening criteria for chlorobenzene = 64 µg/L.
ND: Not detected.
NS: Not sampled.
See Table 3 for definition of qualifiers.

N

0 120 240
Feet

Figure 5
Chlorobenzene Groundwater Concentrations
Shallow Zone
Quarter 4, 2019
Groundwater Monitoring Report
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

Source: City of Portland Aerial Imagery, flown Summer 2017; NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl

M:\Projects\Arkema_Portland\Groundwater Monitoring Report\Maps\Figure 5 Chlorobenzene Shallow.mxd, REVISED: 02/14/2020, SCALE: 1:1,440 when printed at 11x17 DRAWN BY: Kelly Lyons DATE: 2/14/2020

DRAWN BY: Kelly Lyons DATE: 2/14/2020
M:\Projects\Arkema_Portland\Groundwater Monitoring Report\Maps\Figure 6 Chlorobenzene Intermediate.mxd REVISED: 02/14/2020 SCALE: 1:1,440 when printed at 11x17

Willamette River

MWA-49i
ND < 0.44 U

MWA-34i
67

MWA-32i
ND < 0.44 U

PA-29i
0.75 j

MWA-51i
170 J-

MWA-66i
38000 J+

MWA-64i
2300

MWA-8i
1400

PA-13i
0.65 j

PA-14i
ND < 0.44 U

MWA-53i
ND < 0.44 U

PA-11i
1000

PA-12i
610

PA-37I
15000

PA-39I
ND < 0.44 U

MWA-54i
570 J-

Groundwater Treatment Plant

PA-17IR
0.57 j

PA-10i
ND < 0.44 U

PA-32I
ND < 0.44 U

PA-15i
ND < 0.44 U

PA-16i
ND < 0.44 U

PA-44I
ND < 0.44 U

MWA-81i
ND < 0.44 U

MWA-70i
ND < 0.44 U

8 10 12 14 16 18 20 22 24

Legend

- > 6,400 µg/L
- >= 640 - < 6,400 µg/L
- >= 64 - < 640 µg/L
- < 64 µg/L
- Not Detected
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries
- Intermediate Zone Groundwater Contours (ft NAVD88) October 2019

Notes:
Samples collected Oct 22-Nov 7, 2019.
All results in micrograms per liter (µg/L).
Screening criteria for chlorobenzene = 64 µg/L.
ND: Not detected.
See Table 3 for definition of qualifiers.

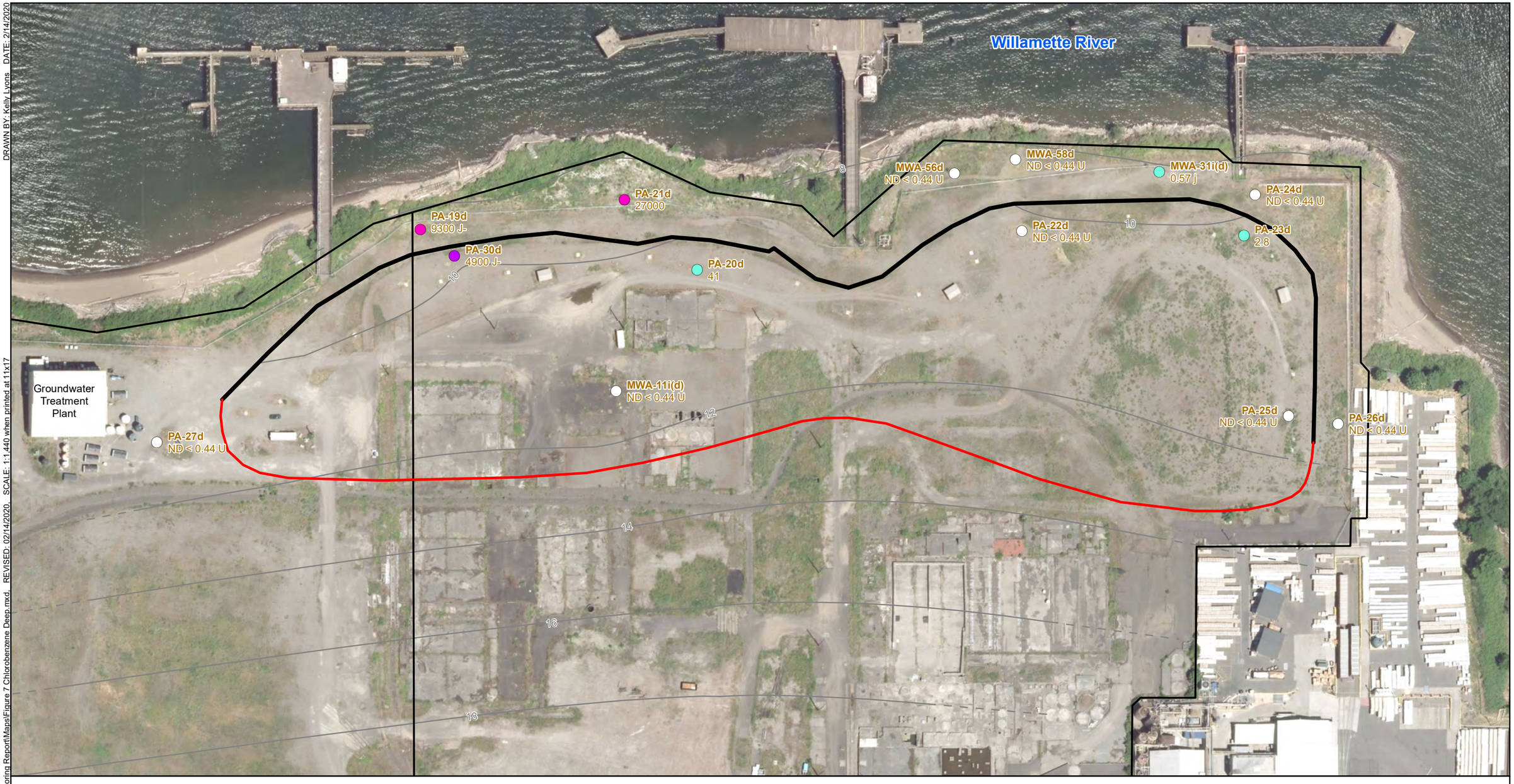
N

0 120 240
Feet

Figure 6
Chlorobenzene Groundwater Concentrations
Intermediate Zone
Quarter 4, 2019
Groundwater Monitoring Report
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com

Source: City of Portland Aerial Imagery, flown Summer 2017; NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- > 6,400 µg/L
- >= 640 - < 6,400 µg/L
- >= 64 - < 640 µg/L
- < 64 µg/L
- Not Detected
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries
- Deep Zone Groundwater Contours (ft NAVD88) October 2019

Notes:
Samples collected Oct 22-Nov 7, 2019.
All results in micrograms per liter (µg/L).
Screening criteria for chlorobenzene = 64 µg/L.
ND: Not detected.
See Table 3 for definition of qualifiers.

N

0 120 240
Feet

Figure 7
Chlorobenzene Groundwater Concentrations
Deep Zone
Quarter 4, 2019
Groundwater Monitoring Report
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com

Source: City of Portland Aerial Imagery, flown Summer 2017; NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl

M:\Projects\Arkema_Portland\Groundwater Monitoring Report\Maps\Figure 7 Chlorobenzene Deep.mxd REVISED: 02/14/2020 SCALE: 1:1,440 when printed at 11x17 DRAWN BY: Kelly Lyons DATE: 2/14/2020

DRAWN BY: Jake Sullivan DATE: 5/14/2020
SCALE: 1:1,440 when printed at 11x17 REVISED: 05/14/2020
M:\Projects\Arkema_Portland\Groundwater Monitoring Report\Maps\2020 Q1\Figure 5_Chlorobenzene Shallow.mxd

Willamette River

MWA-46 ND < 0.44 U
MWA-19 ND < 2.0 U
MWA-30 ND < 0.44 U
MWA-47 0.13 j
MWA-69 120
MWA-61 200
MWA-2 1.9 j
MWA-18 0.50
PA-28 3100
PA-07 0.24
MWA-29 ND < 0.20 U
PA-05 2400
PA-06 1200
PA-36 4.4
MWA-20 470
MWA-15r 5000
MWA-42 730
MWA-63 ND < 0.44 U
PA-38 0.24
PA-42 0.14 j
Groundwater Treatment Plant
MWA-22 42 J-
PA-08 0.53
PA-09 0.16 j
PA-04 0.14 j
PA-03 0.29
PA-31 0.15 j
MWA-41 0.16 j
MWA-24 0.20 J-
MWA-82 0.24
MWA-40 0.38
MWA-33 ND < 0.44 U

14 16 18 20 22 24 26 28 30

Legend

- > 6,400 ug/L
- >= 640 - 6,400 ug/L
- >= 64 - < 640 ug/L
- < 64 ug/L
- Not Detected
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries
- Shallow Zone Groundwater Contours (ft NAVD88) February 2020

Notes:
Samples Collected Feb 11-26 2020
All results in micrograms per liter (ug/L)
Screening Criteria for Chlorobenzene = 64 ug/L
See Table 4 for definition of qualifiers
ND: Non-Detect

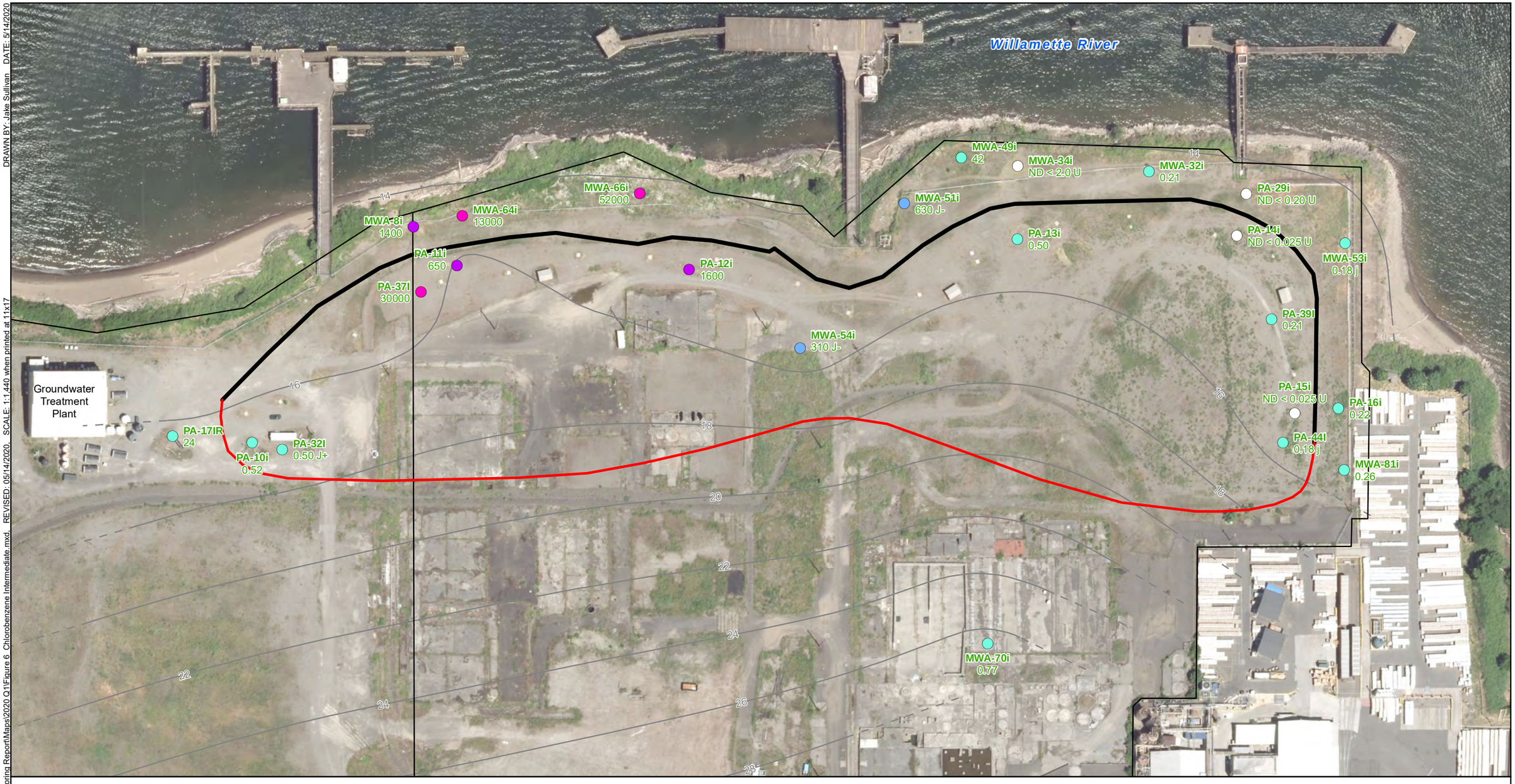
N

0 120 240
Feet

Figure 5
Chlorobenzene Groundwater Concentrations
Shallow Zone
Quarter 1, 2020
Groundwater Monitoring Report
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com

Source: City of Portland Aerial Imagery, flown Summer 2017; NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- > 6,400 ug/L
- >= 640 - 6,400 ug/L
- >= 64 - < 640 ug/L
- < 64 ug/L
- Not Detected
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries
- Intermediate Zone Groundwater Contours (ft NAVD88) February 2020

Notes:
Samples Collected Feb 11-26 2020
All results in micrograms per liter (ug/L)
Screening Criteria for Chlorobenzene = 64 ug/L
See Table 4 for definition of qualifiers
ND: Non-Detect

N

0 120 240
Feet

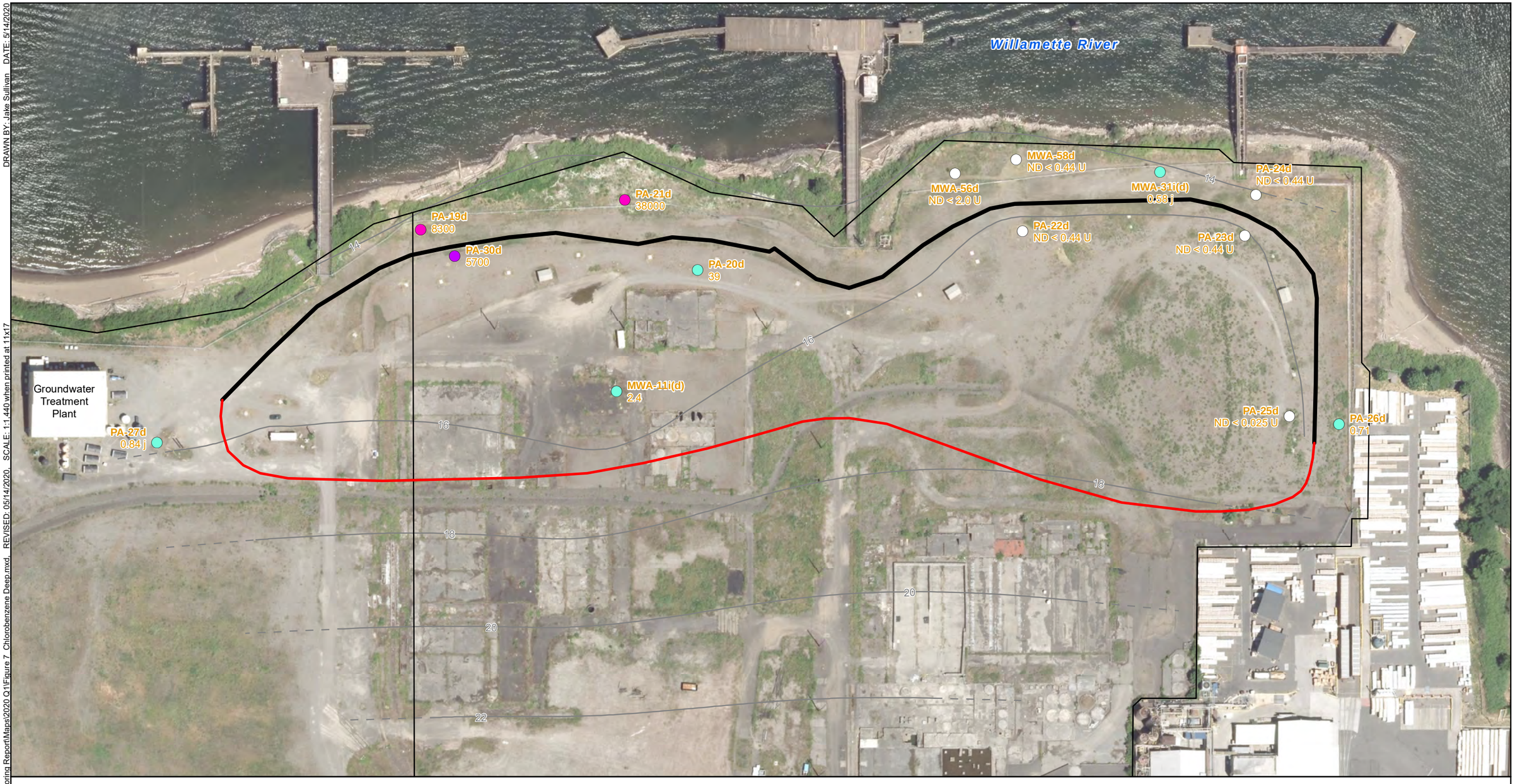
Figure 6
Chlorobenzene Groundwater Concentrations
Intermediate Zone
Quarter 1, 2020
Groundwater Monitoring Report
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

Source: City of Portland Aerial Imagery, flown Summer 2017; NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl

M:\Projects\Arkema_Portland\Groundwater Monitoring Report\Maps\2020 Q1\Figure 6_Chlorobenzene Intermediate.mxd, REVISED: 05/14/2020, SCALE: 1:1,440 when printed at 11x17 DRAWN BY: Jake Sullivan DATE: 5/14/2020

DRAWN BY: Jake Sullivan DATE: 5/14/2020
M:\Projects\Arkema Portland\Groundwater Monitoring Report\Maps\2020 Q1\Figure 7 Chlorobenzene Deep.mxd REVISED: 05/14/2020 SCALE: 1:1,440 when printed at 11x17



Legend

- > 6,400 ug/L
- >= 640 - 6,400 ug/L
- >= 64 - < 640 ug/L
- < 64 ug/L
- Not Detected
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries
- Deep Zone Groundwater Contours (ft NAVD88) February 2020

Notes:
Samples Collected Feb 11-26 2020
All results in micrograms per liter (ug/L)
Screening Criteria for Chlorobenzene = 64 ug/L
See Table 4 for definition of qualifiers
ND: Non-Detect

N

0 120 240
Feet

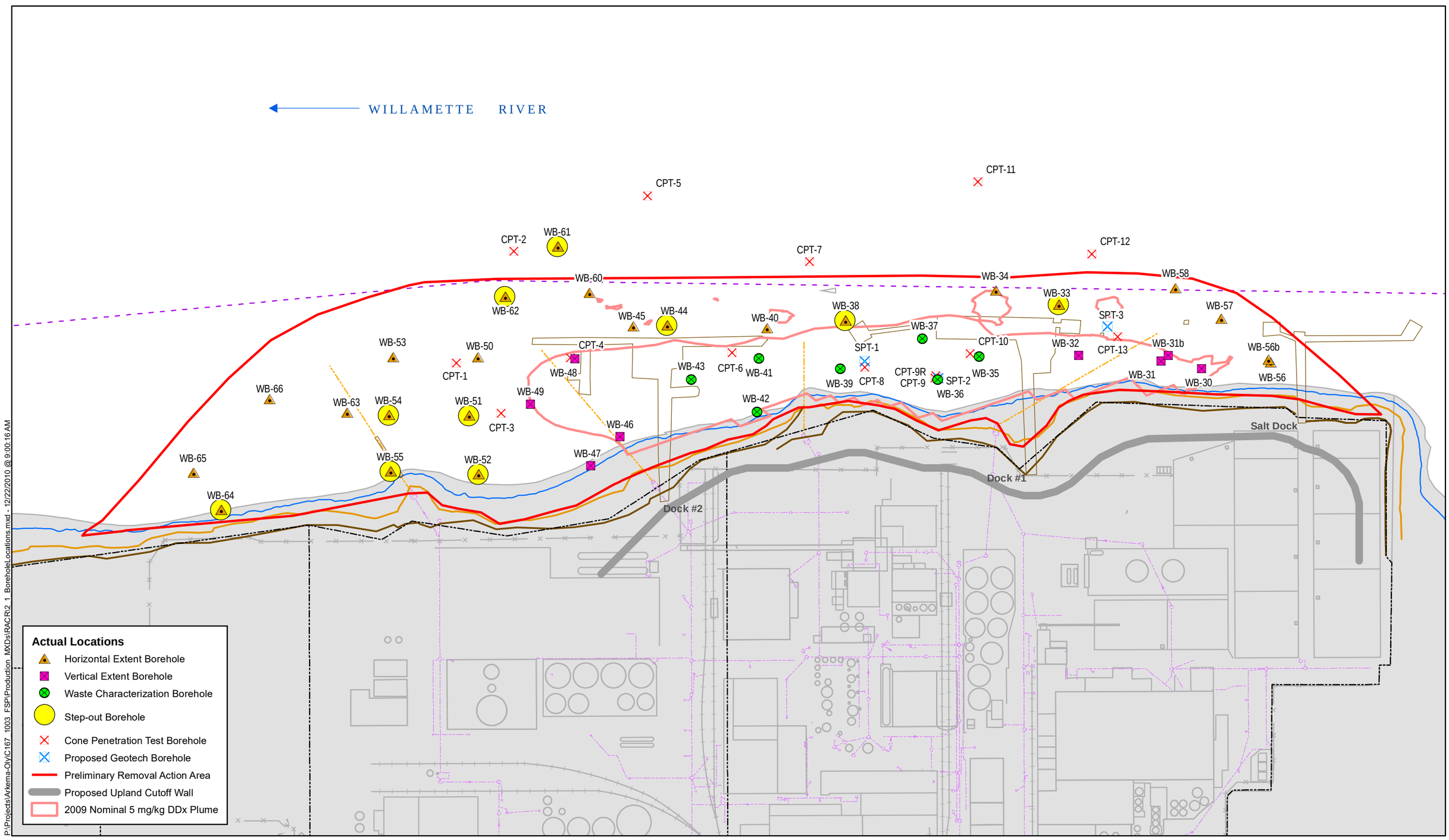
Figure 7
Chlorobenzene Groundwater Concentrations
Deep Zone
Quarter 1, 2020
Groundwater Monitoring Report
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com

Source: City of Portland Aerial Imagery, flown Summer 2017; NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl

Appendix F

Geotechnical Data from the Arkema Project Area



P:\Projects\Arkema-Oly\C167_1003_FSP\Production_MXDs\RACR\2_1_BoreholeLocations.mxd - 12/22/2010 @ 9:00:16 AM

integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB: DEA Survey
Navigation Channel: US Army Corps of Engineers
NOTE: All plumes use 15 anisotropy.

0 100 200 Feet

N

Map Features

- Property and Lot Boundary
- Docks and Structures
- Navigation Channel
- Existing Sewer Line
- Storm Drain
- River Edge +13 ft NAVD
- Ordinary High Water
- Top of Bank

Figure 2-1
2009 EE/CA Borehole Locations
Arkema Early Action
Removal Action Area Characterization Report

SOIL DESCRIPTION

Soil descriptions on the exploration logs are based on visual observations and laboratory testing on selected samples. The samples were visually classified in general accordance with ASTM D 2488.

Soil descriptions generally consist of the following:
Color, MAJOR CONSTITUENT, minor constituents, moisture, density/consistency, additional observations

MINOR CONSTITUENTS

Description	Estimated Percentage
Trace	Less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%

MOISTURE

Dry	Little perceptible moisture
Damp	Below optimum moisture for compaction
Moist	Likely near optimum moisture content
Wet	Likely wet of optimum moisture content
Saturated	Probably below water table or in perched groundwater

DENSITY/CONSISTENCY

Soil density/consistency descriptions on boring logs are primarily based on Standard Penetration Resistance. Density/consistency descriptions on exploration logs are provided in parentheses if they are based on visual observations rather than correlations with Standard Penetration Resistance (N-values) and other test results.

Granular Soils Density	Standard Penetration Resistance (N) in Blows/Foot	Cohesive Soils Consistency	Standard Penetration Resistance(N) in Blows/Foot	Approximate Undrained Strength in TSF
Very loose	0 to 4	Very soft	0 to 2	<0.125
Loose	4 to 10	Soft	2 to 4	0.125 to 0.25
Medium dense	10 to 30	Medium stiff	4 to 8	0.25 to 0.5
Dense	30 to 50	Stiff	8 to 15	0.5 to 1.0
Very dense	>50	Very stiff	15 to 30	1.0 to 2.0
		Hard	>30	>2.0

ROCK DESCRIPTION

Rock descriptions on the exploration logs are based on visual observations and generally consist of the following: Color, ROCK TYPE, field strength, structure, decomposition, disintegration, fracture density, fracture type, fracture infilling, fracture uneveness, moisture condition, additional observations.

TEST SYMBOLS

MC	Moisture Content	UC	Unconfined Compression
GS	Grain Size	TX	Triaxial Compressive Strength
AL	Atterberg Limits	DS	Direct Shear
SG	Specific Gravity	PL	Point Load Index
DT	Density Test	K	Permeability
OG	Organic Content	PP	Pocket Penetrometer in tons/ft^2
CN	Consolidation	TV	Torvane in tons/ft^2
UU	Unconsolidated Undrained Triaxial	PID	Photoionization Detector Reading
CU	Consolidated Undrained Triaxial	CA	Chemical Analysis

SAMPLE TYPE SYMBOLS

- Split Spoon
- Shelby Tube
- Cuttings
- Core Run
- P — Tube pushed, not driven

ARKEMA EARLY ACTION
PORTLAND, OREGON
REMOVAL ACTION AREA CHARACTERIZATION REPORT

KEY TO EXPLORATION LOGS

ARCADIS

CITY: SYRACUSE GROUP: ENVCAD DB: R. BASSETT, P. LISTER PM: C. BECKER TR: R. KILKENNY LYR:ON=*;OFF=REF
G:\ENVCAD\SYRACUSE\ACTIVE\MN000609\0001100007\DWG\00609N01.dwg LAYOUT: B-1SAVED: 11/4/2010 8:10 AM ACADVER: 18.0S (LMS TECH)PAGESETUP: ---PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 11/4/2010 8:10 AM BY: LISTER, PAUL
XREFS: IMAGES: PROJECTNAME: ---

Boring Log *SPT-1*

Arkema EE/CA Geotechnical Field Investigation, Portland, Oregon

N702,428.1 ft E7,627,925.3 ft NAD 83, Oregon North, International Feet

Approximate Mudline Elevation: -1.1 feet NAVD88 Water Depth: 6.4 to 8.7 ft (during drilling)

Depth (ft.)	Sample No.	Sample Type	SPT Results	Approx. Recovery (in.)	Lab Tests	TCR (%)	SCR (%)	RQD (%)	Lithology	Description
0										Dark gray to dark greenish gray ORGANIC SILT AND SILT (high plasticity),trace to little Sand, occasional rootlets and wood fragments, very soft, wet, sheen observed occasionally.
5	ARK-SPT-1-4-5.5		WOH	6	MC					
	ARK-SPT-1-5.5-7		WOH	9	MC, GS, AL					
	ARK-SPT-1-7-8.5		WOH	18	MC					
	ARK-SPT-1-8.5-10		WOH	18	MC, OG					
10	ARK-SPT-1-10-11.5		WOH	18	MC					Decrease in moisture/slightly stiffer consistency noted at approximately 10.8 ft.
	ARK-SPT-1-11.5-13		WOH	18	MC					
	ARK-SPT-1-13-15		P	24	GS, AL, SG, CU, CN, K					Bottom of casing at 13.1 feet. (Casing sank to this depth under its own weight)
15	ARK-SPT-1-15-17		P	24	GS, AL, UU					
	ARK-SPT-1-17-18.5		WOH	18	MC					
	ARK-SPT-1-18.5-20.5		P	25	GS, AL, UU, CN					
20	ARK-SPT-1-20.5-22		N=16	12	MC					Dark geenish gray, fine to medium SAND, little Silt, medium dense, wet
	ARK-SPT-1-22-22.5		N=50/6"	6						Gray, iron-oxide stained, vesicular BASALT, moderately hard to hard, intensely fractured/brecciated to moderately fractured, moderately to highly weathered, smooth-sided to rough fractures, wet. No recovery from 25.0 to 27.0 ft.
	ARK-SPT-1-22.5-27					60	20	0		
25										
	ARK-SPT-1-27-32				PL, UC	90	83	50		Dark gray with zones of reddish staining, vesicular BASALT, moderately hard to hard, close to very close fractures with iron-stained calcite fill (<0.01 in) in some cases, wet. No recovery from 31.5 to 32.0 ft.
30										
	ARK-SPT-1-32-37				PL, UC	100	100	83		Gray/green, vesicular BASALT, moderately hard to hard, close to moderately close fractures, <0.01 in calcite joint filling with chlorite, jagged to smooth fractures with small dilatency, wet calcite and chlorite vesicle fillings.
35										
	ARK-SPT-1-37-42				PL, UC	100	90	84		Greenish gray, phenocrystic BASALT, slightly weathered, hard, moderately close fractures, smooth with calcite fracture fill, jagged/brecciated at 41.5', vesicular from 40.5' to 41.0', wet.
40										Bottom of boring at 42 feet. Completed 10/17/2009

1. Refer to Figure B-1, Key to Exploration Logs, for explanation of symbols and definitions.
2. The stratum lines represent the approximate boundaries between soil units. Actual changes may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the subsurface conditions.
4. ATD = at time of drilling; WOH = weight of hammer; TCR= total core recovery; SCR= solid core recovery; RQD= rock quality designation

ARCADIS

G:\COMMON\Data\Projects\Arkema\LSS Arkema Portland\Notes and Data\Electronic Boring Logs\Design Files

Boring Log *SPT-2*

Arkema EE/CA Geotechnical Field Investigation, Portland, Oregon

N702,305.5 ft E 7,627,989.5 ft NAD 83 Oregon North, International Feet

Approximate Mudline Elevation: +2.3 feet NAVD88 Water Depth: 6.7 to 8.4 ft (during drilling)

Depth (ft.)	Sample No.	Sample Type	SPT Results	Approx. Recovery (in)	Lab Tests	Lithology	Description
0	ARK-SPT-2-2-3.5		WOH	4	MC		Dark greenish gray to brown ORGANIC SILT, trace fine rootlets, wet, very soft, slight sheen, light chemical/medicinal odor.
	ARK-SPT-2-3.5-5		WOH	12	MC, GS, AL		
5	ARK-SPT-2-5-6		N = 3	18	MC		
	ARK-SPT-2-6-6.5				MC		Brown very fine SAND, some Silt, wet, very loose, slight sheen, strong chemical/medicinal odor.
	ARK-SPT-2-6.5-7				MC		
	ARK-SPT-2-7-7.5		N = 1	12	MC, GS		
	ARK-SPT-2-8-9.5		WOH	NR			Dark gray to brown fine (above 10ft) to medium to coarse SAND, trace to few Silt, occasional layer of clay and silt (above10.5ft), wet, very loose, moderate to strong chemical odor.
10	ARK-SPT-2-9.5-10				MC		
	ARK-SPT-2-10-10.5		WOH	12	MC		
	ARK-SPT-2-11-12.5		WOH	9	MC		
	ARK-SPT-2-12.5-14		WOH	12	MC, GS		
	ARK-SPT-2-14-15		WOH	15	MC		
15	ARK-SPT-2-15-15.5				MC		Brown ORGANIC SILT, trace to some Sand, occasional wood fragments, wet, very soft.
	ARK-SPT-2-15.5-17.5		P	24			
	ARK-SPT-2-17.5-19		WOH	NR			
	ARK-SPT-2-19-20.5		WOH	15	MC		
20	ARK-SPT-2-20.5-22.5		P	22	GS, AL, OGM SG, CU, K,		
	ARK-SPT-2-22.5-24.5		P	24	CN		Dark gray to brown, fine to medium SAND, some Silt, trace wood fibers and roots, wet, very loose, moderate chemical odor.
25	ARK-SPT-2-24.5-26		WOH	6	MC		
	ARK-SPT-2-26-26.5				MC, GS		
	ARK-SPT-2-26.5-27.5		N = 3	12	MC		Dark gray to brown, fine to medium SAND, trace wood fragments, occasional silt layer, wet, very loose, slight sheen.
	ARK-SPT-2-27.5-29			NR			
30	ARK-SPT-2-30-30.25				MC		
	ARK-SPT-2-30.25-31.5		N = 4	9	MC		
	ARK-SPT-2-32.5-34		N = 4	12	MC		
35	ARK-SPT-2-35-36		N = 38	18	MC		Brown very fine SAND, some Silt, wet, medium dense.
	ARK-SPT-2-36-36.5		N = 17				Brown to Black, fine to medium rounded GRAVEL (clasts of subangular detrital gneiss and clasts of angular deeply weathered basalt)
	ARK-SPT-2-38-39		N = 50/6"	4			
40							Bottom of boring at 39.0 feet bgs (SPT refusal). Completeted on 10/18/09

1. Refer to Figure B-1, Key to Exploration Logs, for explanation of symbols and definitions.
2. The stratum lines represent the approximate boundaries between soil units. Actual changes may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the subsurface conditions.
4. ATD = at time of drilling; WOH = weight of hammer.

ARCADIS

G:\COMMON\Data\Projects\Arkema\LSS Arkema Portland\Notes and Data\Geotechnical Data\Electronic Boring Logs\Design Files

Boring Log *SPT-3*

Arkema EE/CA Geotechnical Field Investigation, Portland, Oregon

N702,126.1 ft E7,628,258.0 ft NAD 83, Oregon North, International Feet

Approximate Mudline Elevation: -10.6 feet NAVD88 Water Depth: 17.1 to 20.6 ft (during drilling)

Depth (ft.)	Sample No.	Sample Type	SPT Results	Approx. Recovery (in)	Lab Tests	Lithology	Description
0							Dark gray ORGANIC SILT, trace to some Sand, occasional trace Gravel, wood fragments, rootlets, and slight sheen, wet, very soft.
5	ARK-SPT-2-5-6.5		WOH	18	MC, GS, AL, OG		
	ARK-SPT-2-6.5-8		WOH	18	MC		
	ARK-SPT-2-8-9.5		WOH	16	MC		
10	ARK-SPT-9.5-11.5		P	22.5	GS, AL, SG, UU, CU CN		
	ARK-SPT-2-11.5-13		WOH	18	MC		
	ARK-SPT-2-13-15		P	23	GS, AL, CU, K		
15	ARK-SPT-2-15-17		P	6			Dark grey/brown SAND, some Silt/SILT, some Sand, occasional wood fragments, wet, very loose to loose.
	ARK-SPT-2-17-19		P	NR			
20	ARK-SPT-2-19-20.5		WOH	3	MC		
	ARK-SPT-2-20.5-22		WOH	6	MC, GS		
	ARK-SPT-2-22-22.25		N = 5	3	MC		
	ARK-SPT-2-22.25-23.5			15	MC		
	ARK-SPT-2-23.5-25		N = 66	12	MC		Dark gray Gravel (derived from basalt), trace wood fragments, wet, very dense.
25	ARK-SPT-2-25-26		N = 84/6"	6			Rock flour.
							Bottom of boring at 26.5 feet bgs (SPT refusal). Completed on

1. Refer to Figure B-1, Key to Exploration Logs, for explanation of symbols and definitions.
2. The stratum lines represent the approximate boundaries between soil units. Actual changes may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the subsurface conditions.
4. ATD = at time of drilling; WOH = weight of hammer.

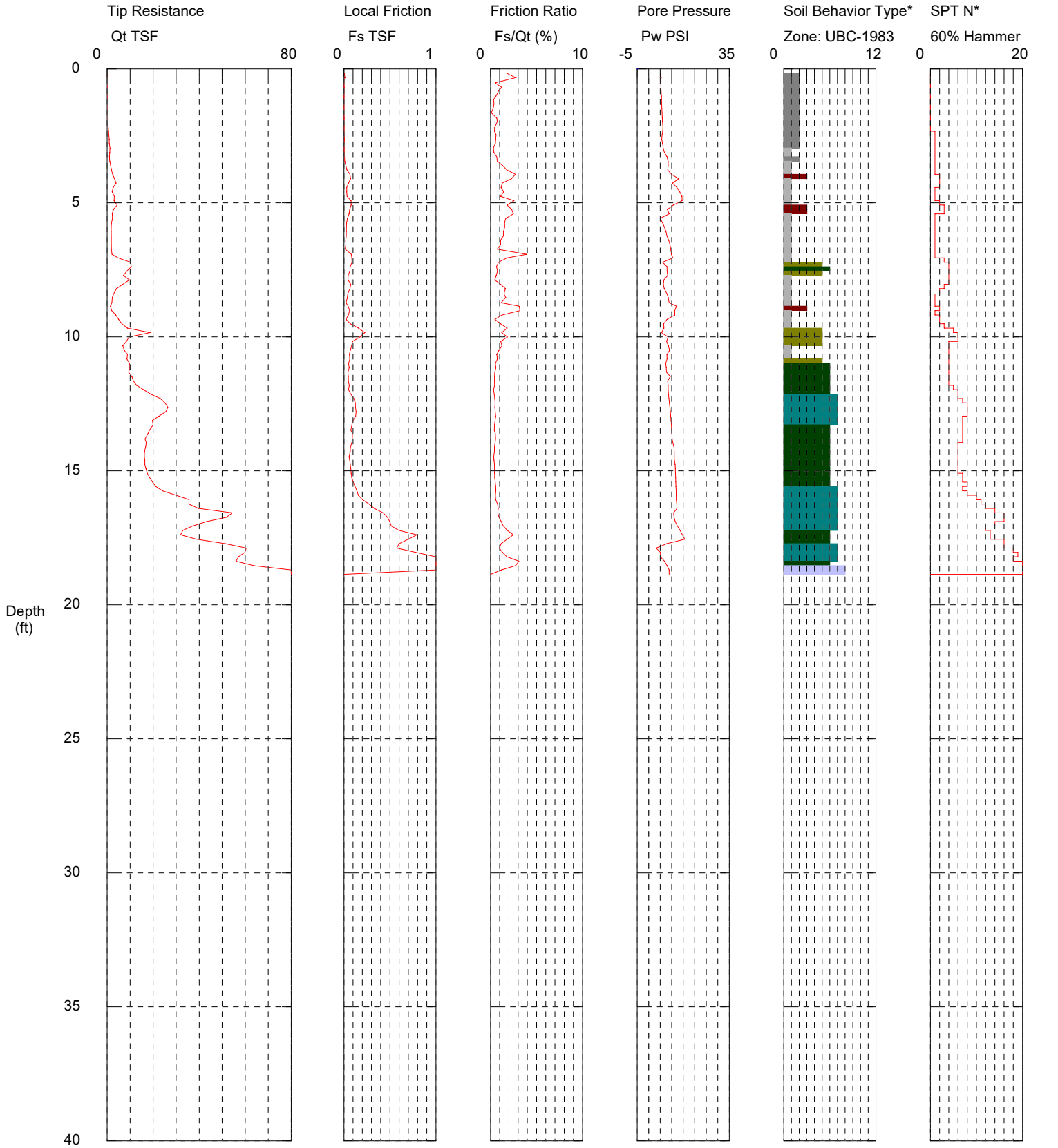
ARCADIS

G:\COMMON\Data\Projects\Arkema\LSS Arkema Portland\Notes and Data\Electronic Boring Logs\Design Files 10-05-10

CPT-1

Operator: K.Brown
Sounding: CPT-1
Cone Used: DSG1079

CPT Date/Time: 10/20/2009 2:21:50 PM
Location: Arkema, Portland, OR
Job Number: MN000609.0001.00007 (Arcadis)



Maximum Depth = 18.86 feet

Depth Increment = 0.164 feet

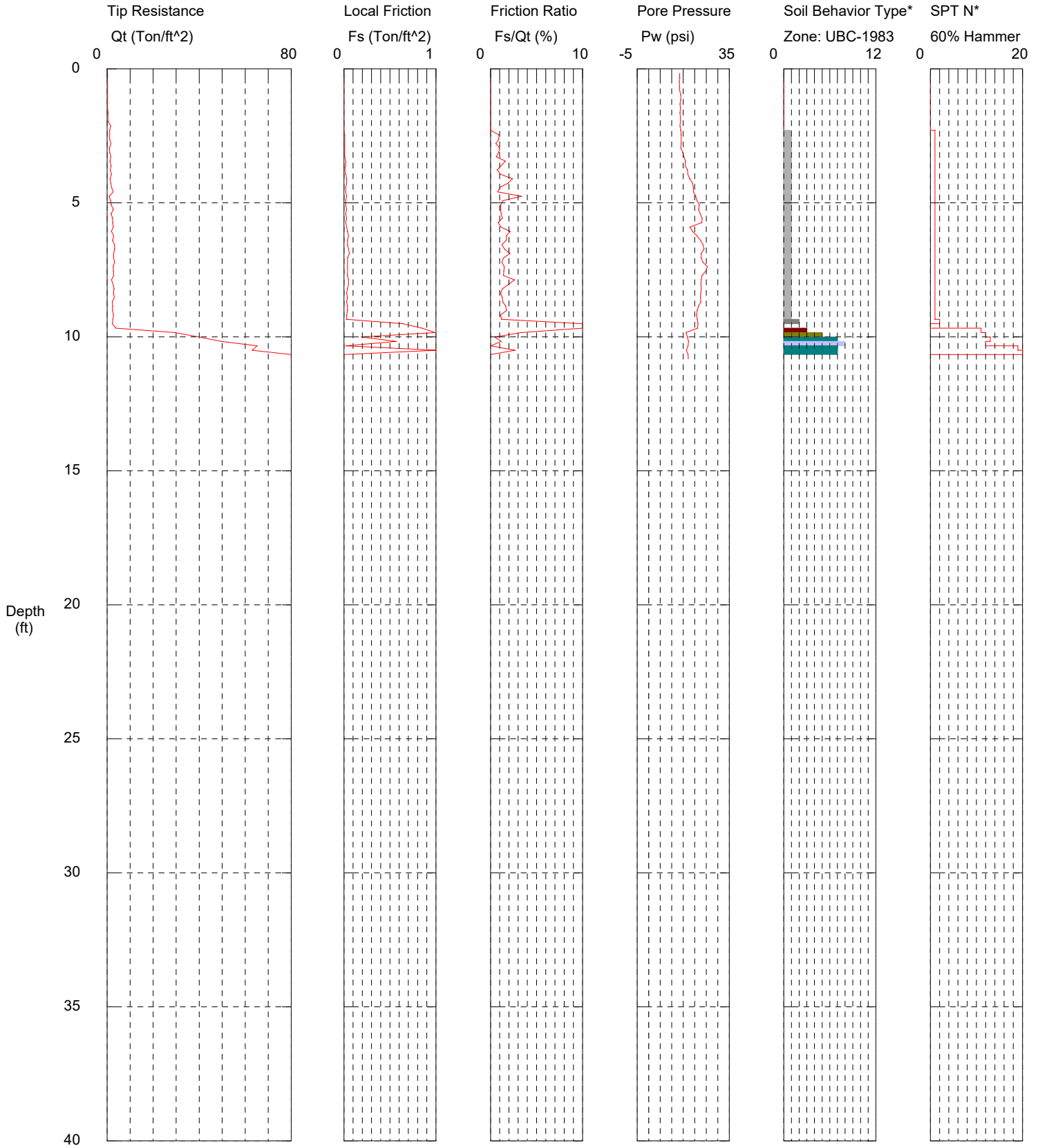
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

CPT-2

Operator: S.Vandehey
Sounding: CPT-2
Cone Used: 4CH

CPT Date/Time: 10-15-09 14:57
Location: Arkema, Portland, OR
Job Number: MN000609.0001.00007 (Arcadis)



Maximum Depth = 10.83 feet

Depth Increment = 0.164 feet

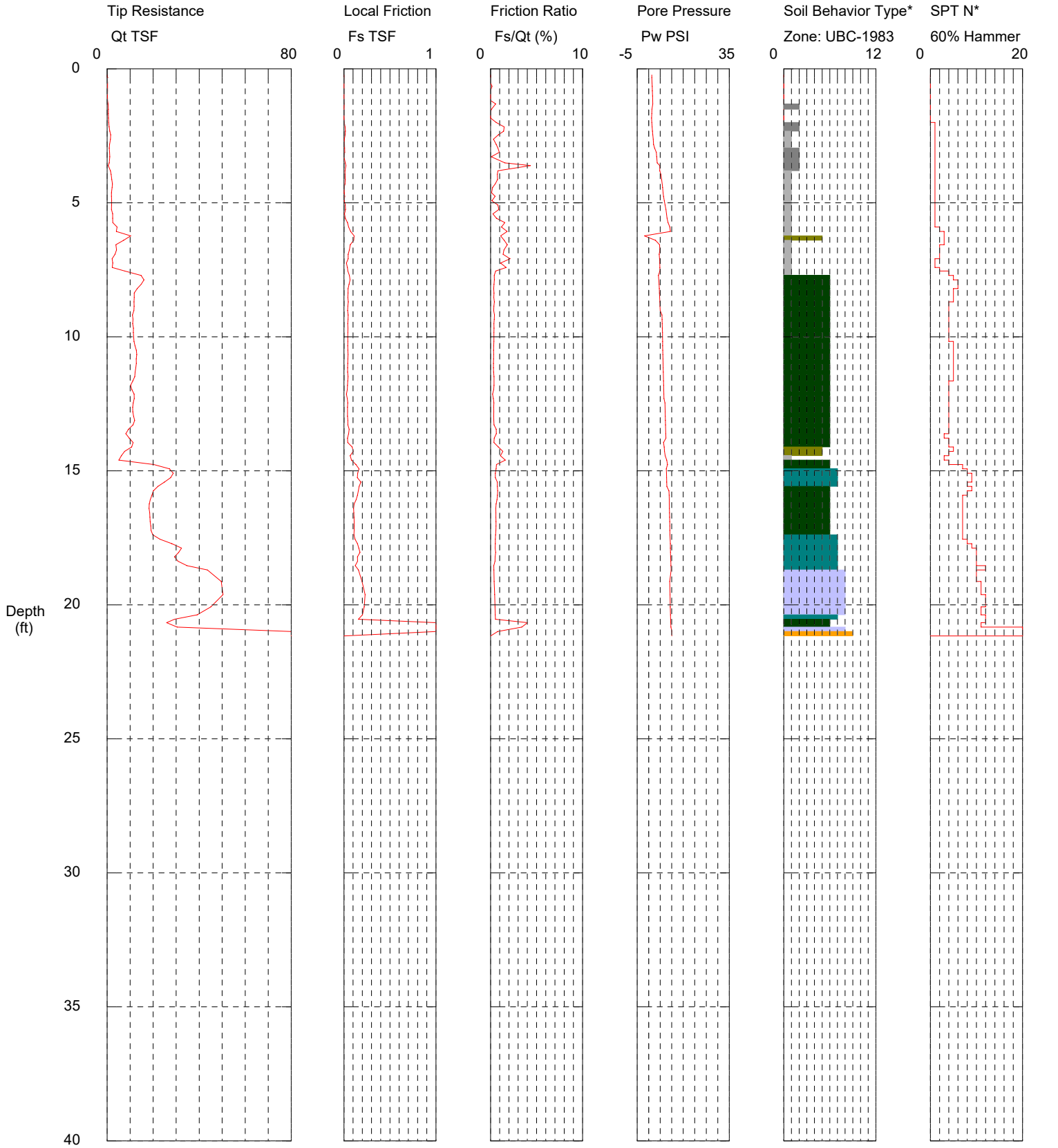
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

CPT-3

Operator: K. Brown
Sounding: CPT-3
Cone Used: DSG1079

CPT Date/Time: 10/20/2009 4:34:52 PM
Location: Arkema, Portland, OR
Job Number: MN000609.0001.00007 (Arcadis)



Maximum Depth = 21.16 feet

Depth Increment = 0.098 feet

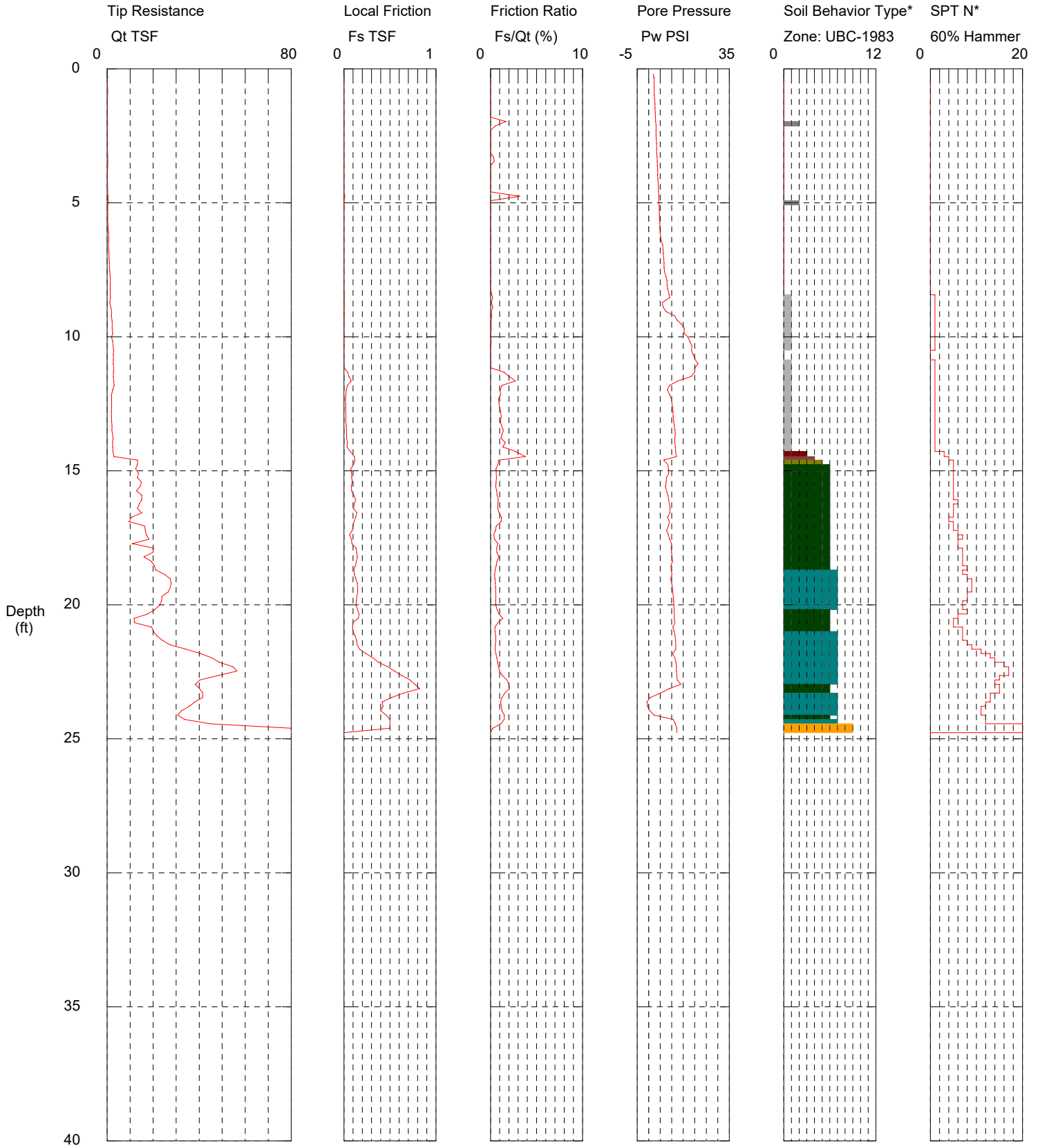
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

CPT-4

Operator: K. Brown
Sounding: CPT-4
Cone Used: DSG1079

CPT Date/Time: 10/20/2009 3:14:48 PM
Location: Arkema, Portland, OR
Job Number: MN000609.0001.00007 (Arcadis)



Maximum Depth = 24.77 feet

Depth Increment = 0.131 feet

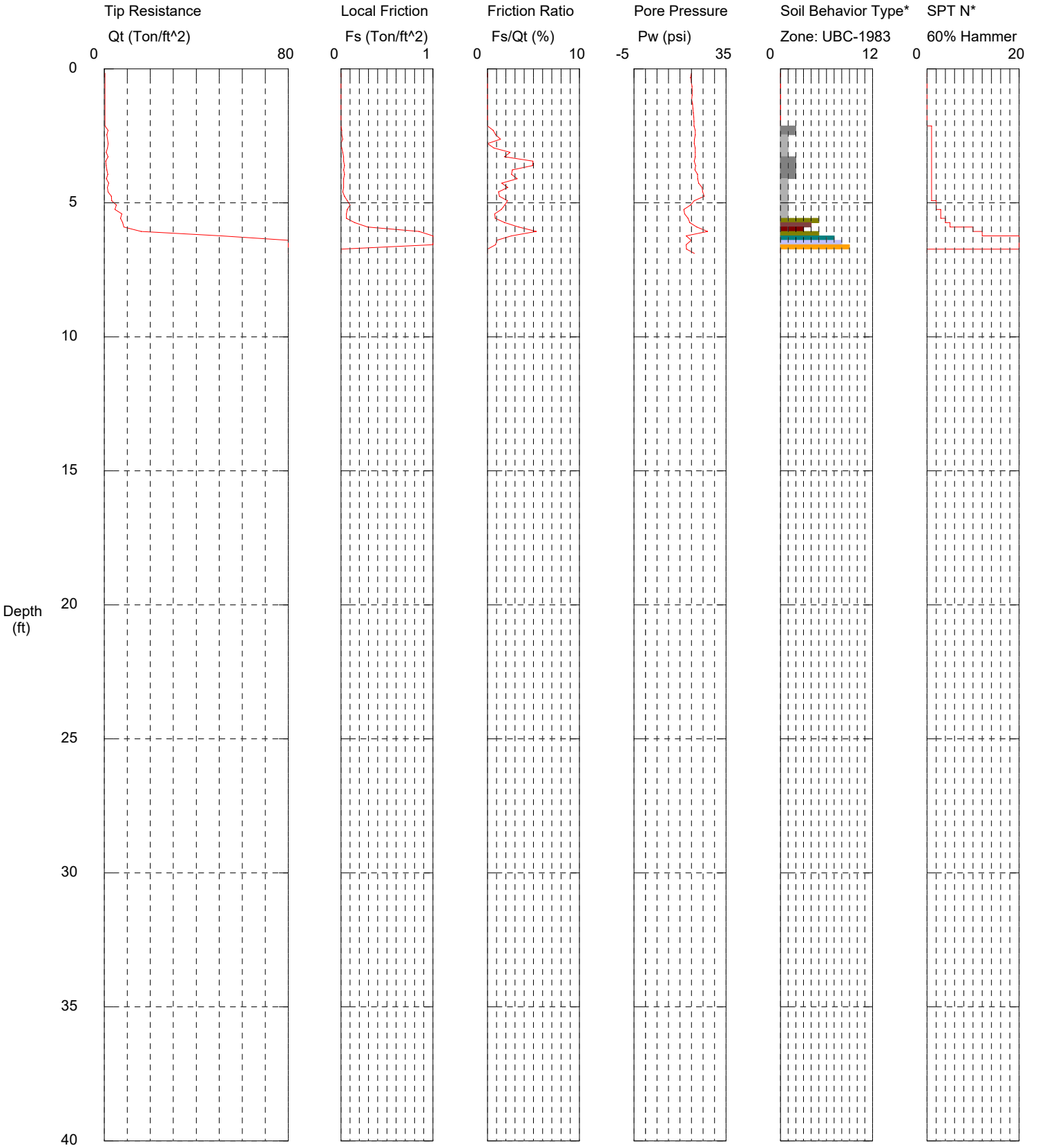
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

CPT-5

Operator: S.Vandehey
Sounding: CPT-5
Cone Used: 4CH

CPT Date/Time: 10-15-09 12:27
Location: Arkema, Portland, OR
Job Number: MN000609.0001.00007 (Arcadis)



Maximum Depth = 6.89 feet

Depth Increment = 0.164 feet

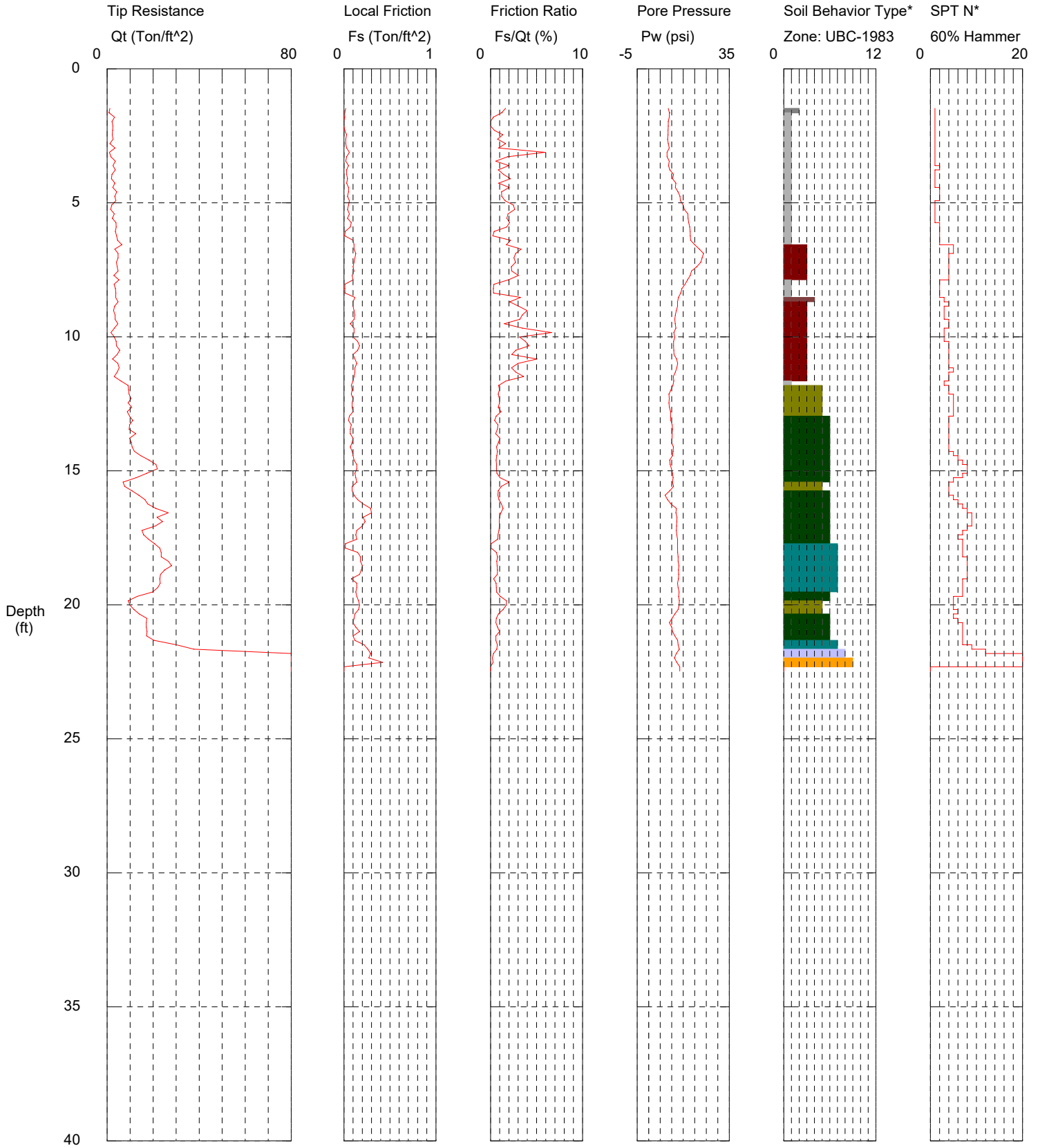
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

CPT-6

Operator: S.Vandehey
Sounding: CPT-6
Cone Used: 4CH

CPT Date/Time: 10-14-09 14:14
Location: Arkema, Portland, OR
Job Number: MN000609.0001.00007 (Arcadis)



Maximum Depth = 22.47 feet

Depth Increment = 0.164 feet

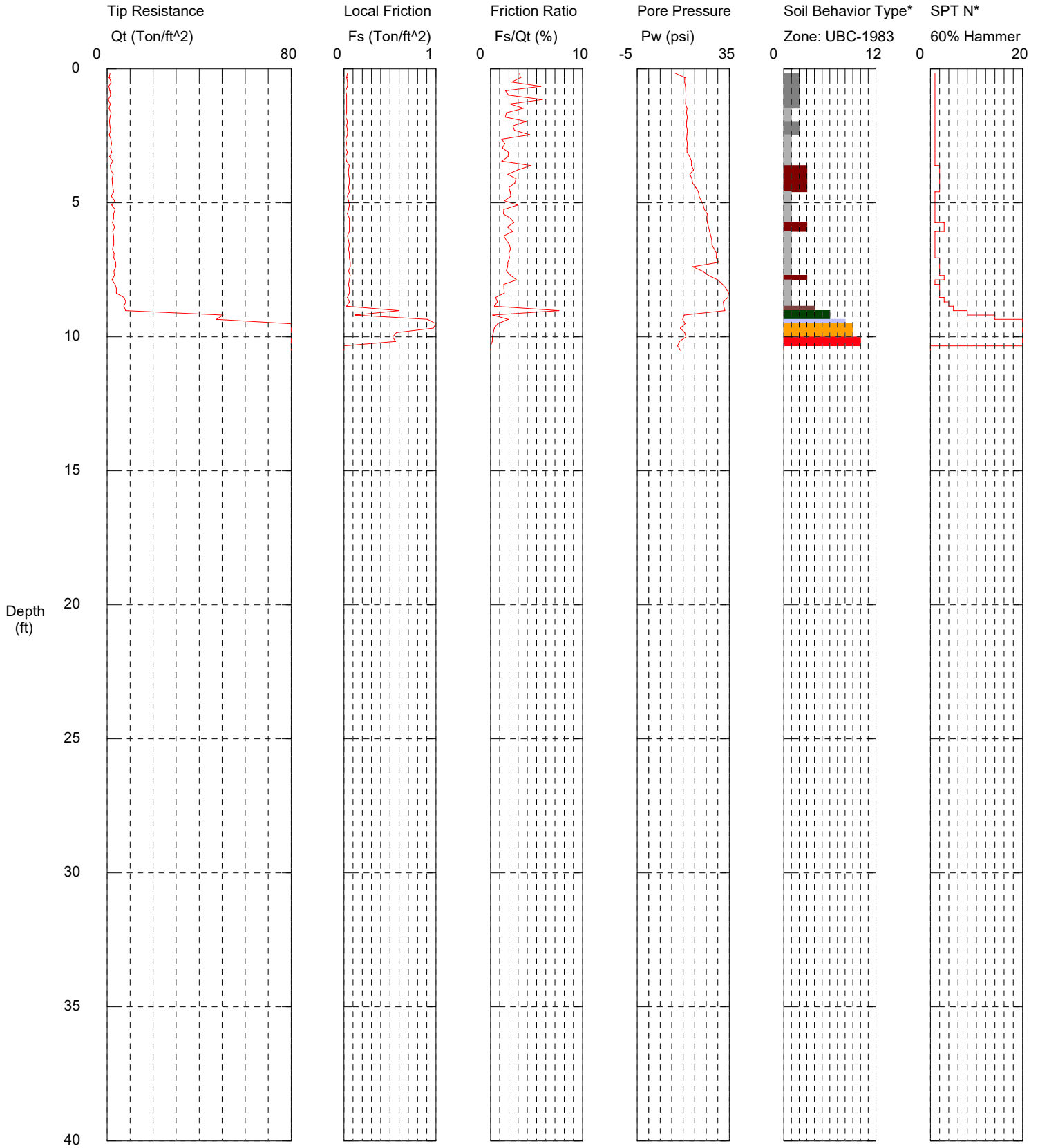
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

CPT-7

Operator: S.Vandehey
Sounding: CPT-7
Cone Used: 4CH

CPT Date/Time: 10-13-09 08:54
Location: Arkema, Portland, OR
Job Number: MN000609.0001.00007 (Arcadis)



Maximum Depth = 10.50 feet

Depth Increment = 0.164 feet

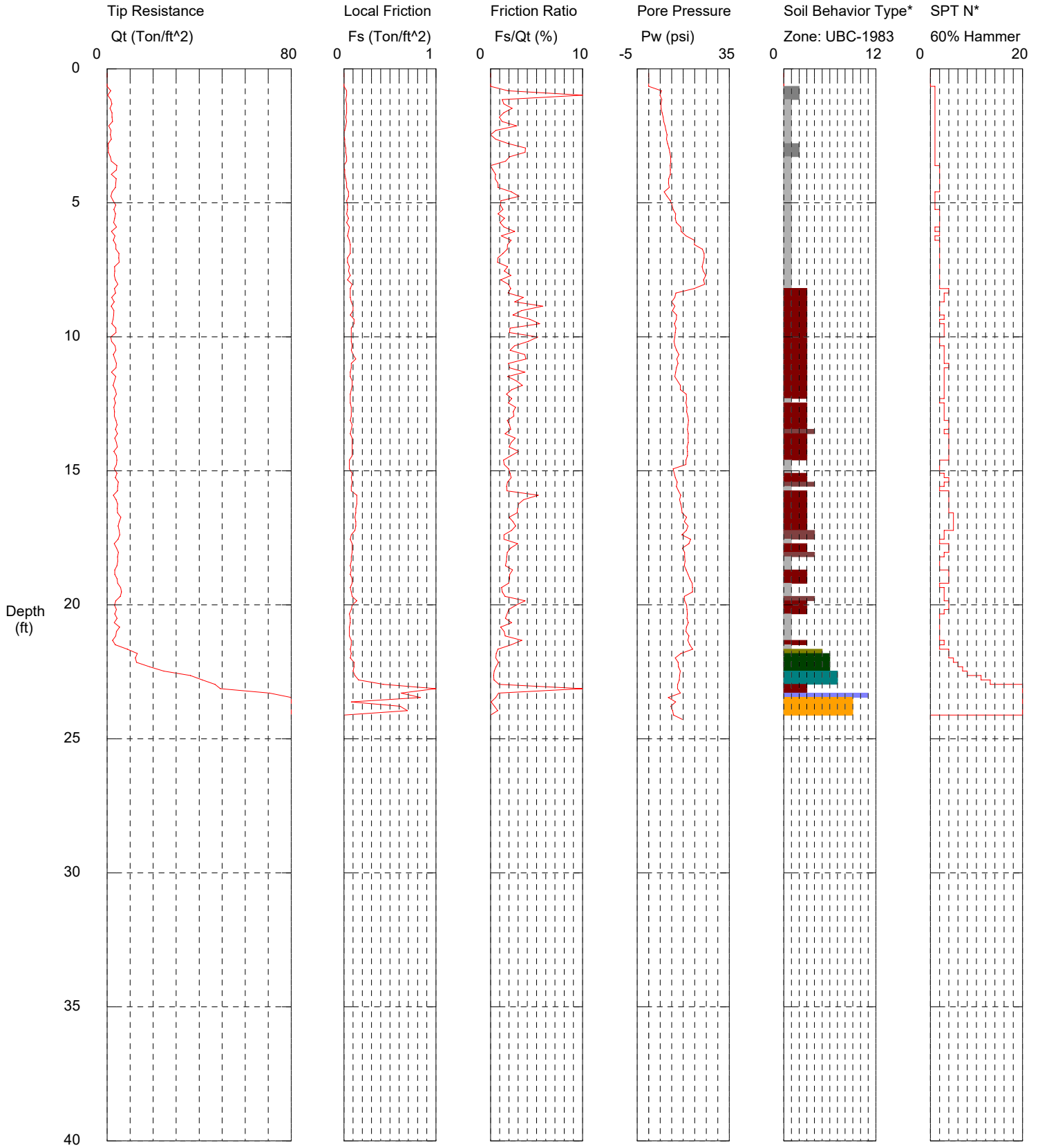
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

CPT-8

Operator: S.Vandehey
Sounding: CPT-8
Cone Used: 4CH

CPT Date/Time: 10-14-09 10:53
Location: Arkema, Portland, OR
Job Number: MN000609.0001.00007 (Arcadis)



Maximum Depth = 24.28 feet

Depth Increment = 0.164 feet

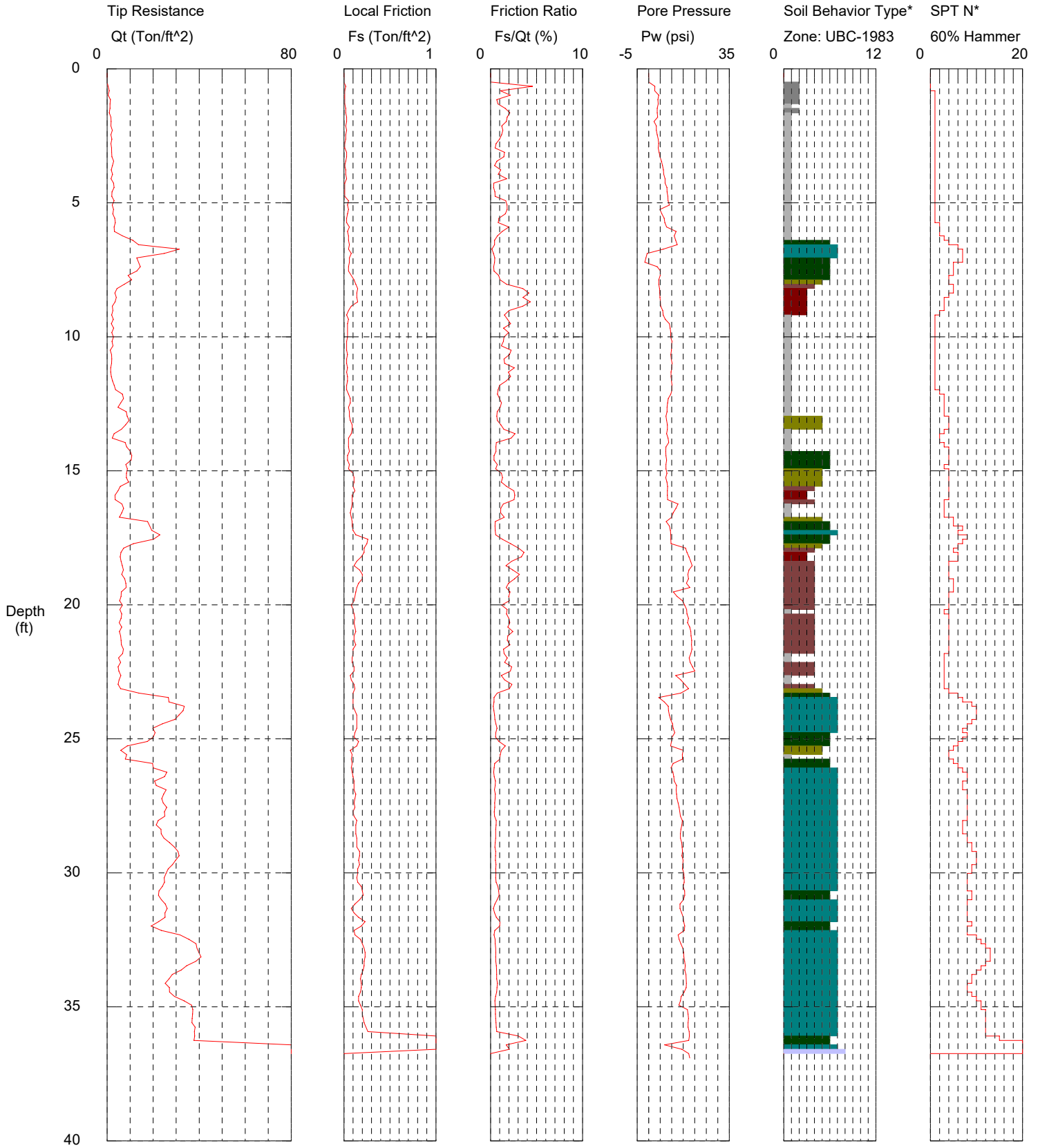
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

CPT-9

Operator: S.Vandehey
Sounding: CPT-9
Cone Used: 4CH

CPT Date/Time: 10-14-09 10:05
Location: Arkema, Portland, OR
Job Number: MN000609.0001.00007 (Arcadis)



Maximum Depth = 36.91 feet

Depth Increment = 0.164 feet

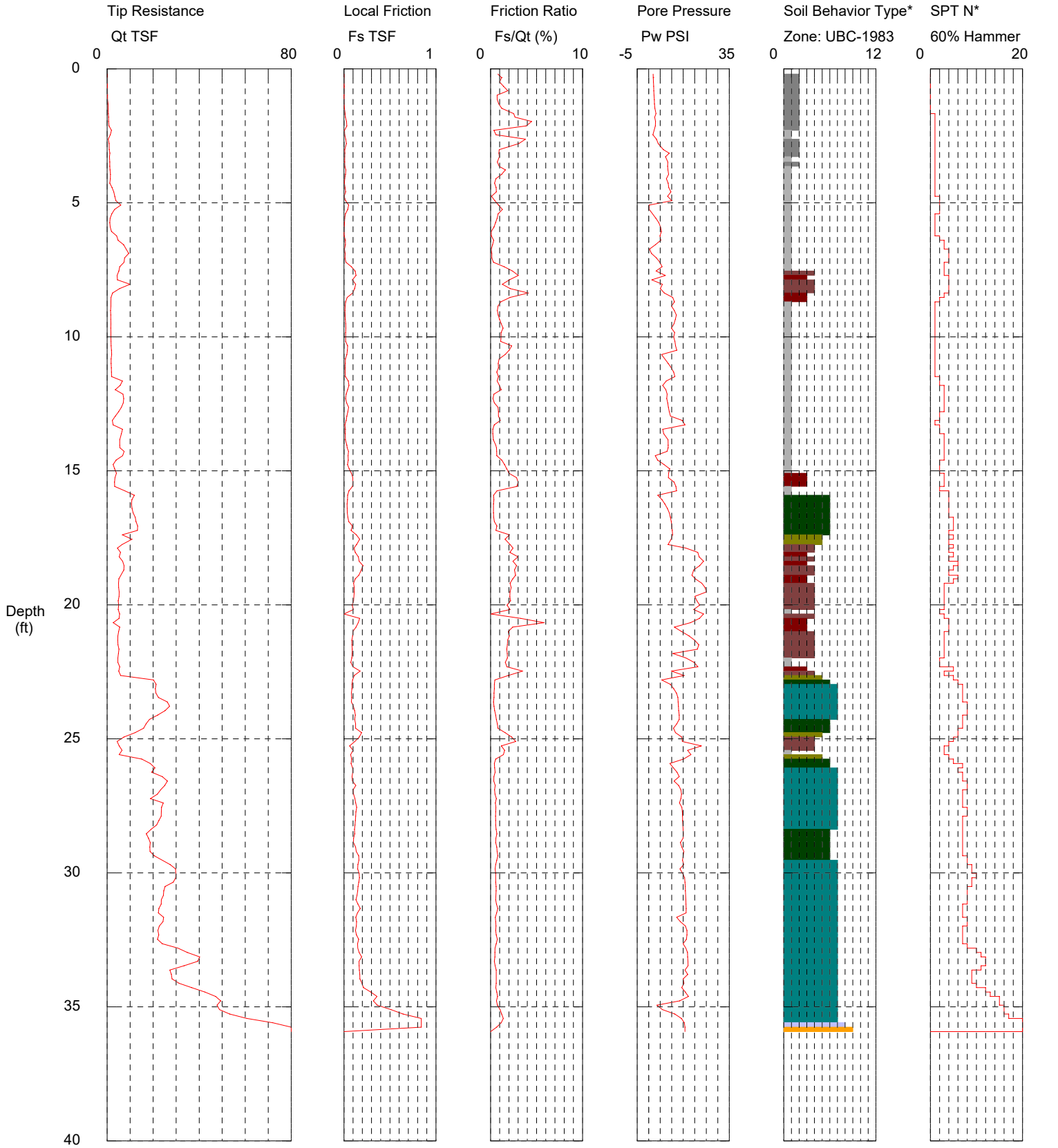
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

CPT-9R

Operator: K. Brown
Sounding: CPT-9R
Cone Used: DSG1079

CPT Date/Time: 10/20/2009 3:23:59 PM
Location: Arkema, Portland, OR
Job Number: MN000609.0001.00007 (Arcadis)



Maximum Depth = 35.93 feet

Depth Increment = 0.131 feet

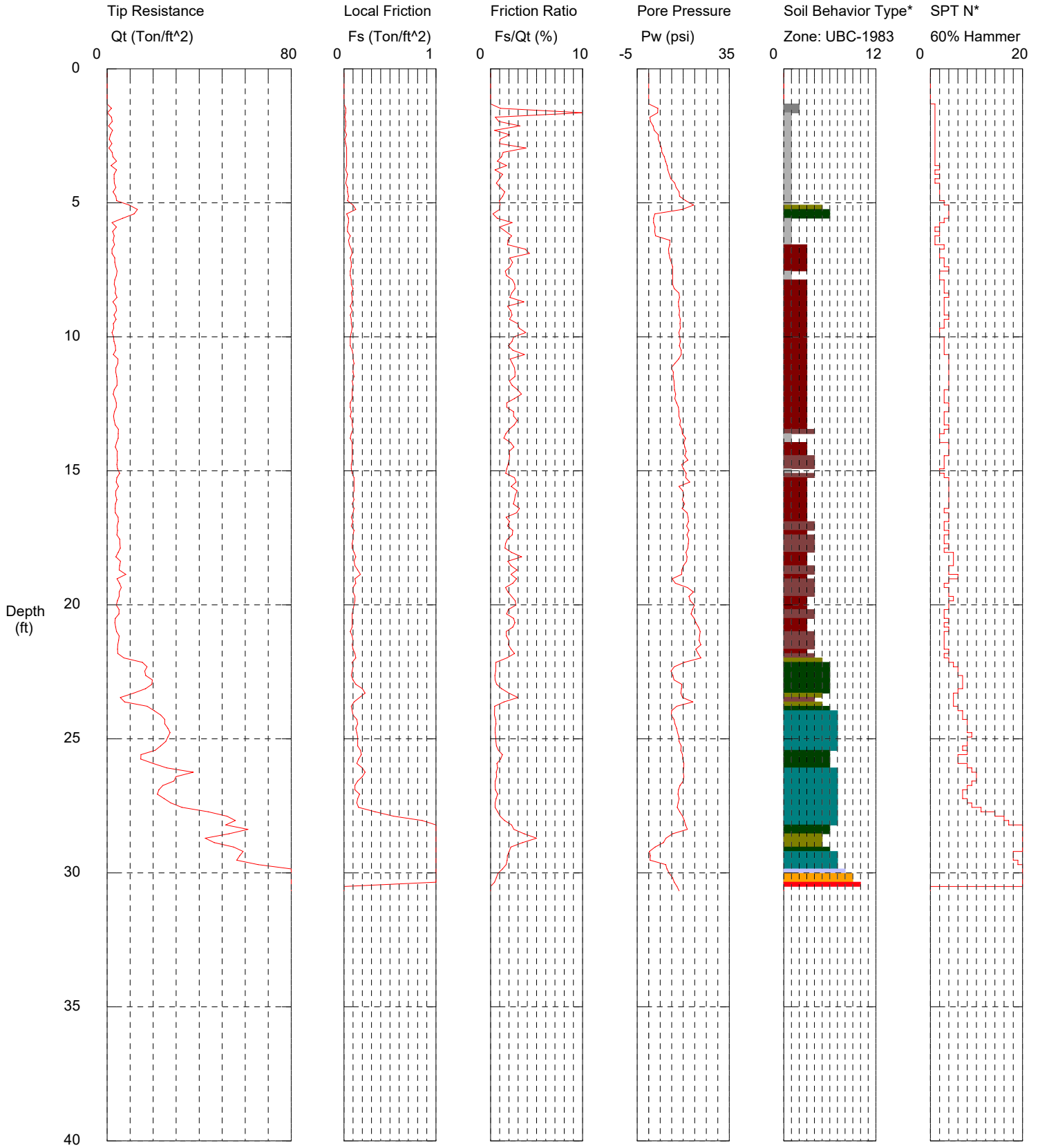
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

CPT-10

Operator: S.Vandehey
Sounding: CPT-10
Cone Used: 4CH

CPT Date/Time: 10-14-09 12:00
Location: Arkema, Portland, OR
Job Number: MN000609.0001.00007 (Arcadis)



Maximum Depth = 30.68 feet

Depth Increment = 0.164 feet

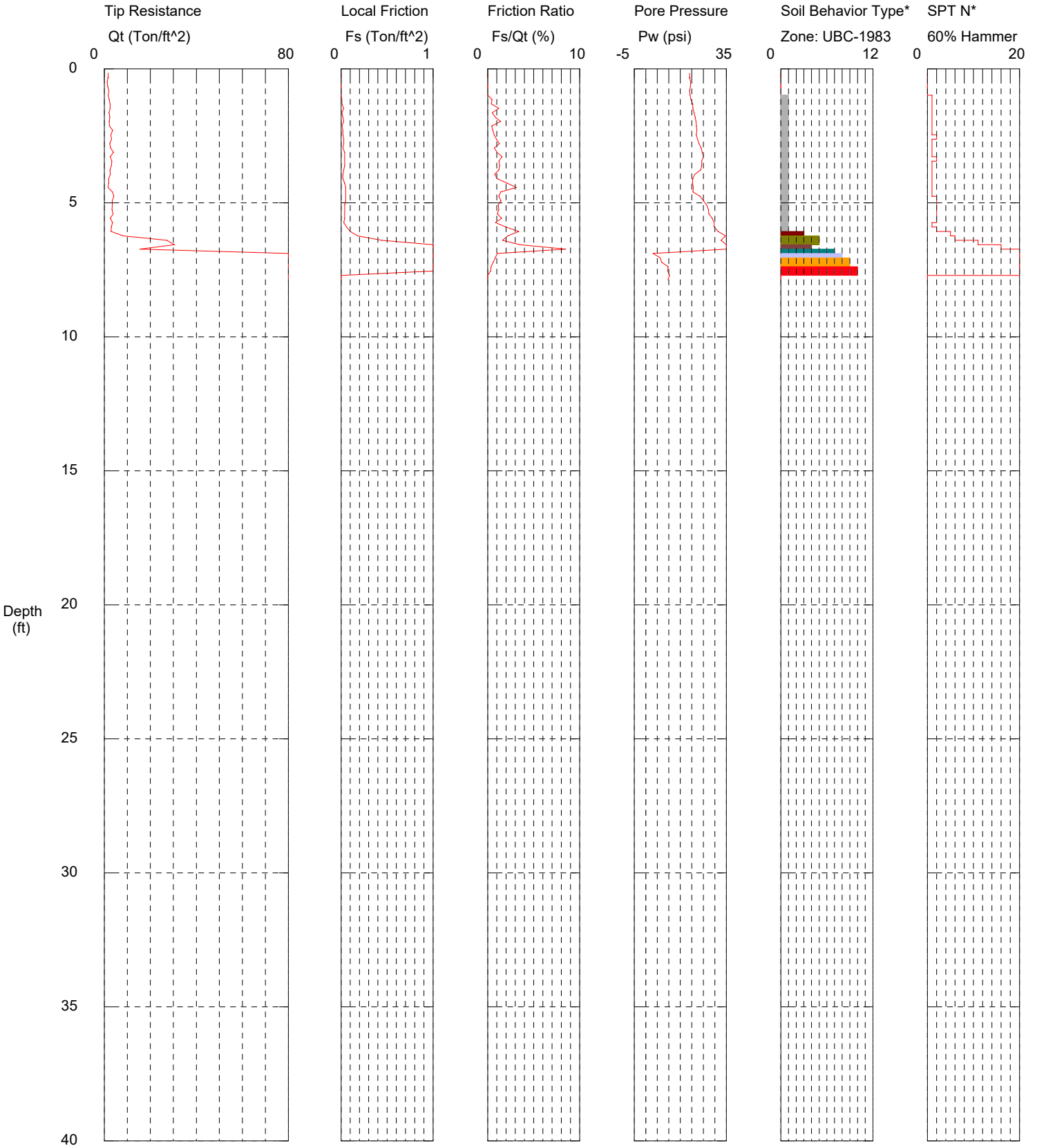
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

CPT-11

Operator: S.Vandehey
Sounding: CPT-11
Cone Used: 4CH

CPT Date/Time: 10-13-09 11:45
Location: Arkema, Portland, OR
Job Number: MN000609.0001.00007 (Arcadis)



Maximum Depth = 7.87 feet

Depth Increment = 0.164 feet

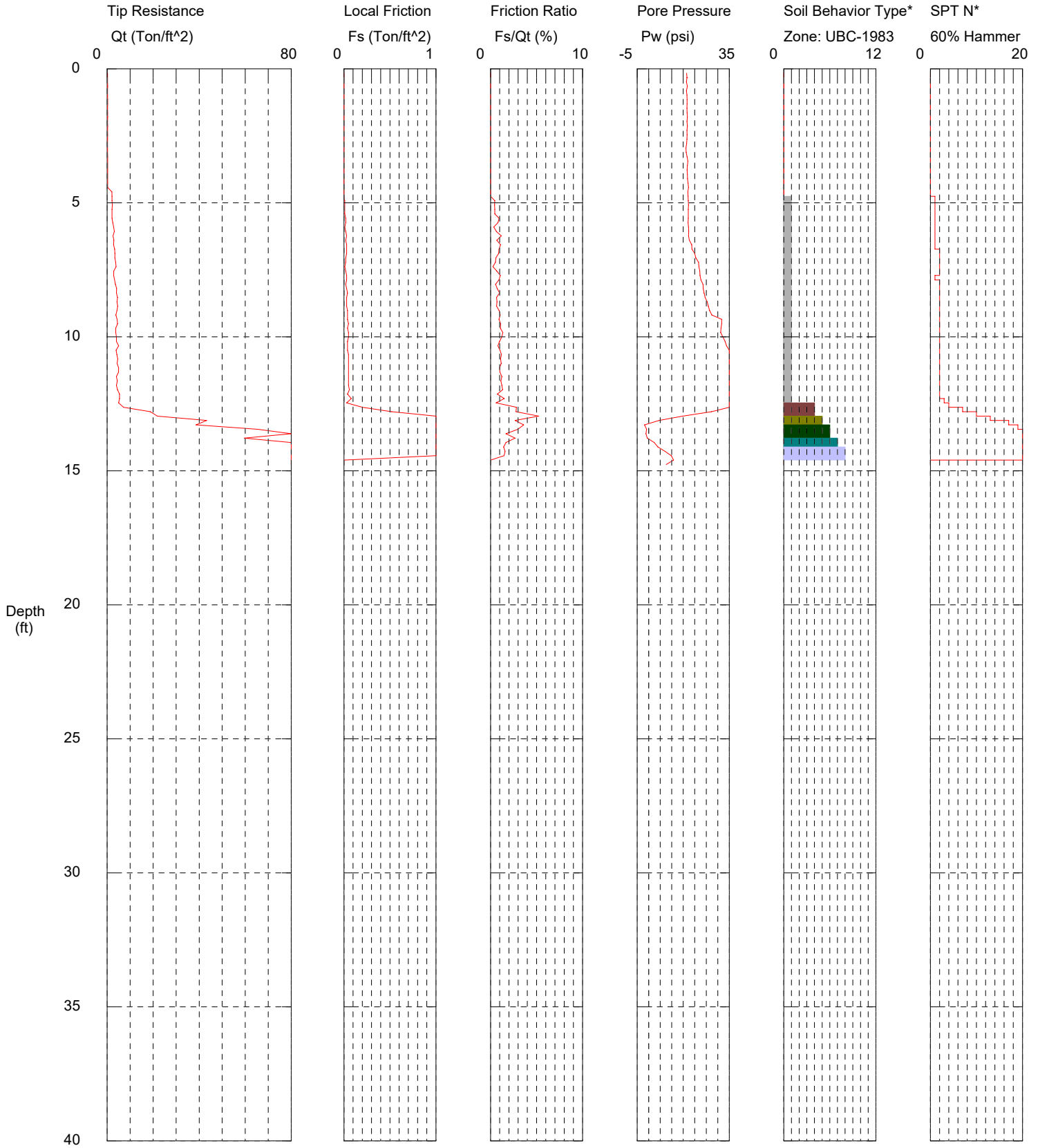
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

CPT-12

Operator: S.Vandehey
Sounding: CPT-12
Cone Used: 4CH

CPT Date/Time: 10-15-09 09:08
Location: Arkema, Portland, OR
Job Number: MN000609.0001.00007 (Arcadis)



Maximum Depth = 14.76 feet

Depth Increment = 0.164 feet

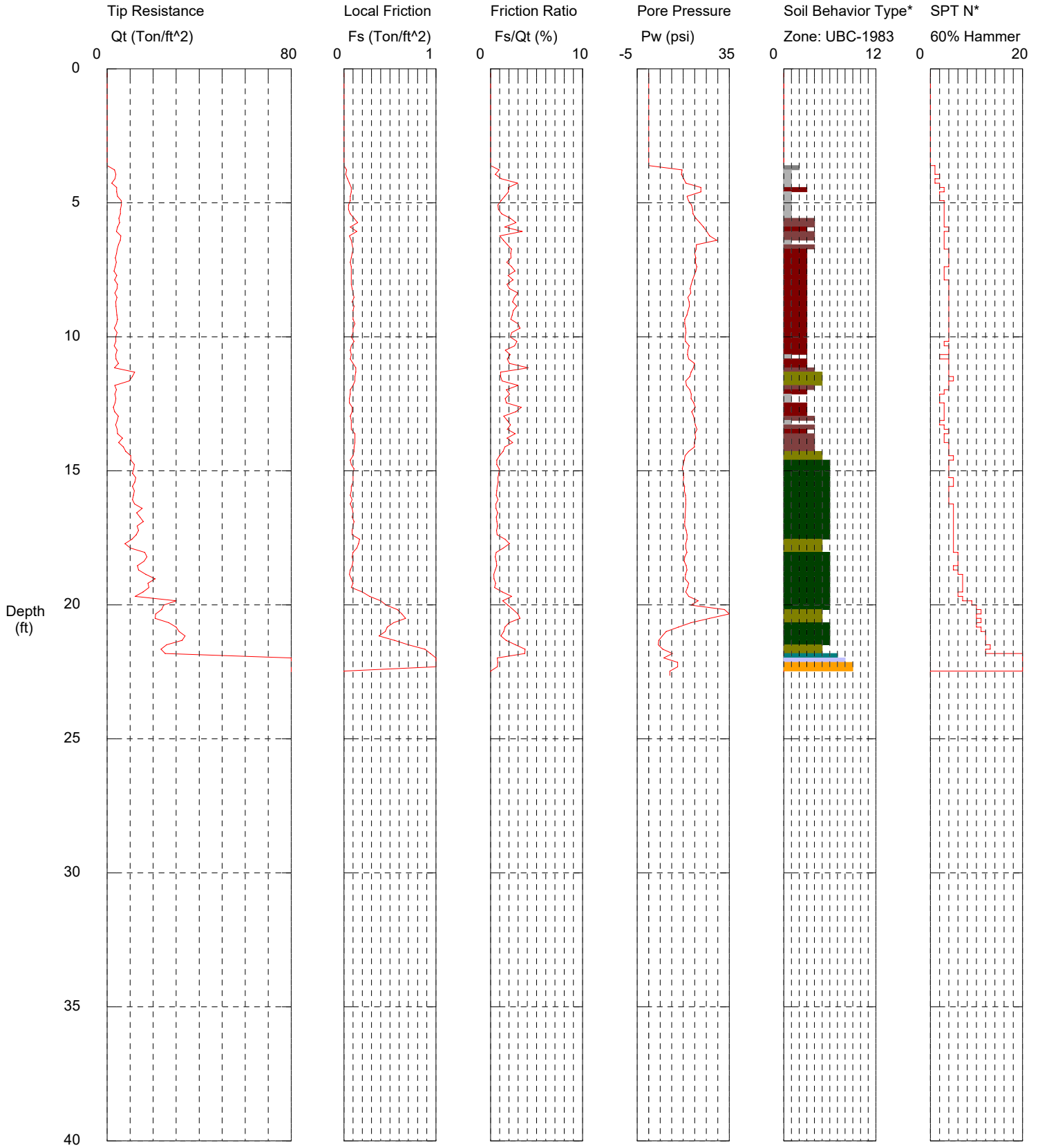
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

CPT-13

Operator: S.Vandehey
Sounding: CPT-13
Cone Used: 4CH

CPT Date/Time: 10-15-09 07:11
Location: Arkema, Portland, OR
Job Number: MN000609.0001.00007 (Arcadis)



Maximum Depth = 22.64 feet

Depth Increment = 0.164 feet

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

LOG OF SHELBY TUBE SAMPLE

KLEINFELDER
Bright People. Right Solutions.

Project Name: Arkema Early Action
Project Number: 107510 **Sheet:** __1___ of _1__

Boring No: ARK-SPT 1 (13-15)	**Sample Extraction Method:** Splitting (due to soft sample)	**Down Pressure (psi) at Sampling:**
Sample Type: Shelby Tube (24 in)	**Location:** NA	**Depth to Groundwater Initial/Time:** **Final/Time:**
Sample Depth: 13 to 15 ft	**Date Begin/End:** NA	**Coordinates (X/Y, Lat/Long):**
Recovery (in): ▯▯	**Field Logged By:** NA	**Coordinate System/Datum:**
Capped Sealed (y/n): YES	**Logged By (Lab)/Checked By:** K Wells	**Angle From Vertical/Bearing:**

Soil Description & Classification (ASTM D 2488) | **Notes**

Length (in)	Description Soil Type, Particle Size Range, Particle Hardness, Dry Strength, Dilatency, Toughness, Color, Odor, Reaction with HCL, Structure, Cementation	ASTM Symbol	Pocket Pen. (tsf) / Torvane Shear (tsf)	Plasticity	Lab Testing	Depth (ft)	Notes
0						13ft	
							Disturbed upper 3"
	SILT - Very soft to soft, saturated, dark	ML/MH					
2	brown, 5 to 15 percent fine sand.						Wood debris ------
					CU		Surficial stress marks
4							throughout sample,
							likely discontinuous
	Medium to high plasticity, elastic.						
6							
8							
10							
			PP<.25TSF				
					PERM		Fracture ----------
12						14ft	
	Sporadic bits of wood debris (black/rotted) up						
14	to 3/8 inch throughout sample						Fracture ----------
					CU		
16							
					SV		
					PI		
18							
20							
22					consol		
							Small wood debris at
						15ft	bottom of sample
24							

Shelby Tube Photo

NOTES:

Too little quality sample for torvane shear. All pocket pen results less than 0.25 TSF
Sample removed from shelby tube by splitting tube longitudinally

H - Hydrometer Tests
PI - Plasticity Index
SV - Sieve Analysis
CU - Consolidated Undrained Triaxial Comp
UU - Unconsolidated Undrained Triaxial Comp
Consol - Consolidation Test, Time Rate
SPG - Specific Gravity Test
Perm - Permeability
Note: Some laboratory testing may not be shown in log above

Soil Boring Field Log Sheet.fh11

Copyright Kleinfelder 2009

LOG OF SHELBY TUBE SAMPLE

KLEINFELDER
Bright People. Right Solutions.

Project Name: Arkema Early Action
Project Number: 107510 **Sheet:** __1___ of _1__

Boring No: ARK-SPT 1 (15-17)	**Sample Extraction Method:** Splitting (due to soft sample)	**Down Pressure (psi) at Sampling:**
Sample Type: Shelby Tube (24 in)	**Location:** NA	**Depth to Groundwater Initial/Time:** **Final/Time:**
Sample Depth: 15 to 17 ft	**Date Begin/End:** NA	**Coordinates (X/Y, Lat/Long):**
Recovery (in): 24	**Field Logged By:** NA	**Coordinate System/Datum:**
Capped Sealed (y/n): YES	**Logged By (Lab)/Checked By:** K Wells	**Angle From Vertical/Bearing:**

Length (in)	Description Soil Type, Particle Size Range, Particle Hardness, Dry Strength, Dilatency, Toughness, Color, Odor, Reaction with HCL, Structure, Cementation	ASTM Symbol	Pocket Pen. (tsf) / Torvane Shear (tsf)	Plasticity	Lab Testing	Depth (ft)	Notes
0							
						15 ft	
	SILT - Very soft to soft, saturated, dark	ML/MH			UU		
2	brown, 5 to 15 percent fine sand.						
4							
	Medium to high plasticity, elastic.						
6							
8					CU		Fracture ----------
	Sporadic bits of wood debris (black/rotted) up to 3/8 inch throughout sample						Wood debris ------
10	Some larger wood pieces observed up to 1 inch						
					SV		
					PI		Possible fine sand
12						16 ft	seam
14					SPG		
16							Wood debris ------
							Fracture ----------
18							Disturbed lower portion of sample. Blocky
			PP = 0.25 TSF				Fracture ----------
20							
22							
							Sandy at bottom.
						17 ft	
24							

Soil Description & Classification (ASTM D 2488) | **Notes**

Shelby Tube Photo

NOTES:
Sample removed from shelby tube by splitting tube longitudinally

H - Hydrometer Tests
PI - Plasticity Index
SV - Sieve Analysis
CU - Consolidated Undrained Triaxial Comp
UU - Unconsolidated Undrained Triaxial Comp
Consol - Consolidation Test, Time Rate
SPG - Specific Gravity Test
Perm - Permeability
Note: Some laboratory testing may not be shown in log above

Soil Boring Field Log Sheet.fh11

Copyright Kleinfelder 2009

LOG OF SHELBY TUBE SAMPLE

KLEINFELDER
Bright People. Right Solutions.

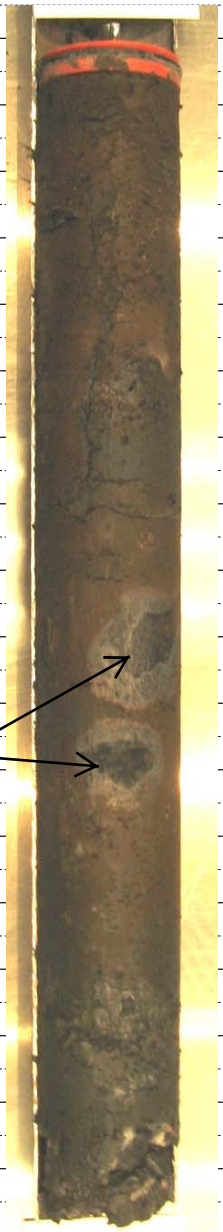
Project Name: Arkema Early Action
Project Number: 107510 **Sheet:** __1___ of _1__

Boring No: ARK-SPT 1 (18.5-20.5)	**Sample Extraction Method:** Splitting (due to soft sample)	**Down Pressure (psi) at Sampling:**
Sample Type: Shelby Tube (24 in)	**Location:** NA	**Depth to Groundwater Initial/Time:** **Final/Time:**
Sample Depth: 18.5 to 20.5 ft	**Date Begin/End:** NA	**Coordinates (X/Y, Lat/Long):**
Recovery (in): 24	**Field Logged By:** NA	**Coordinate System/Datum:**
Capped Sealed (y/n): YES	**Logged By (Lab)/Checked By:** K Wells	**Angle From Vertical/Bearing:**

Soil Description & Classification (ASTM D 2488) | **Notes**

Length (in)	Description Soil Type, Particle Size Range, Particle Hardness, Dry Strength, Dilatency, Toughness, Color, Odor, Reaction with HCL, Structure, Cementation	ASTM Symbol	Pocket Pen. (tsf) / Torvane Shear (tsf)	Plasticity	Lab Testing	Depth (ft)	Notes
0							
		ML/MH				18.5	
2							Disturbed upper 3"
	SILT - Very soft to soft, saturated, dark brown, 5 to 15 percent fine sand.						
4							Wood debris ------
			PP<.25TSF				
	Medium to high plasticity, elastic.						
6			TS=0.14TSF				
8							
10							Fracture ----------
12							
					UU	19.5	
							Fracture ----------
14							Staining
16							
18							
					consol		
20							Fracture ----------
22	Large GRAVEL at bottom of sample						
						20.5	
24							

Shelby Tube Photo



NOTES:
Sample removed from shelby tube by splitting tube longitudinally

H - Hydrometer Tests
PI - Plasticity Index
SV - Sieve Analysis
CU - Consolidated Undrained Triaxial Comp
UU - Unconsolidated Undrained Triaxial Comp
Consol - Consolidation Test, Time Rate
SPG - Specific Gravity Test
Perm - Permeability
Note: Some laboratory testing may not be shown in log above

Soil Boring Field Log Sheet.fh11

Copyright Kleinfelder 2009

LOG OF SHELBY TUBE SAMPLE

KLEINFELDER
Bright People. Right Solutions.

Project Name: Arkema Early Action
Project Number: 107510 **Sheet:** __1___ of _1__

Boring No: ARK-SPT 2 (20.5-22.5)	**Sample Extraction Method:** Splitting (due to soft sample)	**Down Pressure (psi) at Sampling:**
Sample Type: Shelby Tube (24 in)	**Location:** NA	**Depth to Groundwater Initial/Time:** **Final/Time:**
Sample Depth: 20.5 to 22.5 ft	**Date Begin/End:** NA	**Coordinates (X/Y, Lat/Long):**
Recovery (in): 20.5	**Field Logged By:** NA	**Coordinate System/Datum:**
Capped Sealed (y/n): YES	**Logged By (Lab)/Checked By:** R Goff / K Wells	**Angle From Vertical/Bearing:**

Length (in)	Description Soil Type, Particle Size Range, Particle Hardness, Dry Strength, Dilatency, Toughness, Color, Odor, Reaction with HCL, Structure, Cementation	ASTM Symbol	Pocket Pen. (tsf) / Torvane Shear (tsf)	Plasticity	Lab Testing	Depth (ft)	Notes
0	Sandy SILT - Very soft, saturated, dark grey, fine to medium grained sand	ML/MH				20.5	
2	Visible sands in upper 3.75 inch						Fracture ----------
4							
	Medium to high plasticity, elastic.						
6					consol		
8							Fracture ----------
					CU		
10					SPG		
	Occasional bits of wood debris (black/rotted) throughout sample up to 3/8 inch diameter.					21.5	
12							
14					CU		
16							
					PI		
					SV		
18					H		
20							
22							
24						22.5	

Notes

Shelby Tube Photo

NOTES:
Sample removed from shelby tube by splitting tube longitudinally
Torvane shear not possible (limited sample, very soft)

H - Hydrometer Tests
PI - Plasticity Index
SV - Sieve Analysis
CU - Consolidated Undrained Triaxial Comp
UU - Unconsolidated Undrained Triaxial Comp
Consol - Consolidation Test, Time Rate
SPG - Specific Gravity Test
Perm - Permeability
Note: Some laboratory testing may not be shown in log above

Soil Boring Field Log Sheet.fh11

Copyright Kleinfelder 2009

LOG OF SHELBY TUBE SAMPLE

KLEINFELDER
Bright People. Right Solutions.

Project Name: Arkema Early Action
Project Number: 107510 **Sheet:** __1___ of _1__

Boring No: ARK-SPT 2 (22.5-24.5)	**Sample Extraction Method:** Splitting (due to soft sample)	**Down Pressure (psi) at Sampling:**
Sample Type: Shelby Tube (24 in)	**Location:** NA	**Depth to Groundwater Initial/Time:** **Final/Time:**
Sample Depth: 22.5 to 24.5 ft	**Date Begin/End:** NA	**Coordinates (X/Y, Lat/Long):**
Recovery (in): 5	**Field Logged By:** NA	**Coordinate System/Datum:**
Capped Sealed (y/n): YES	**Logged By (Lab)/Checked By:** K Wells	**Angle From Vertical/Bearing:**

Length (in)	Description Soil Type, Particle Size Range, Particle Hardness, Dry Strength, Dilatency, Toughness, Color, Odor, Reaction with HCL, Structure, Cementation	ASTM Symbol	Pocket Pen. (tsf) / Torvane Shear (tsf)	Plasticity	Lab Testing	Depth (ft)	Notes
0							
	SILT - Very soft to soft, saturated, dark brown, trace fine sand	ML/MH				22.5	
2						consol	
4							
6	Poorly Graded SAND with SILT (SP-SM), saturated, olive brown, fine to medium grained.						Possible Slough from 5" to 24"
8							
10							
12						23.5	
14							
16							
18							
20							
22							
24						24.5	

Soil Description & Classification (ASTM D 2488) | **Notes**

Shelby Tube Photo

NOTES:
Sample removed from shelby tube by splitting tube longitudinally

H - Hydrometer Tests
PI - Plasticity Index
SV - Sieve Analysis
CU - Consolidated Undrained Triaxial Comp
UU - Unconsolidated Undrained Triaxial Comp
Consol - Consolidation Test, Time Rate
SPG - Specific Gravity Test
Perm - Permeability
Note: Some laboratory testing may not be shown in log above

Soil Boring Field Log Sheet.fh11

Copyright Kleinfelder 2009

LOG OF SHELBY TUBE SAMPLE

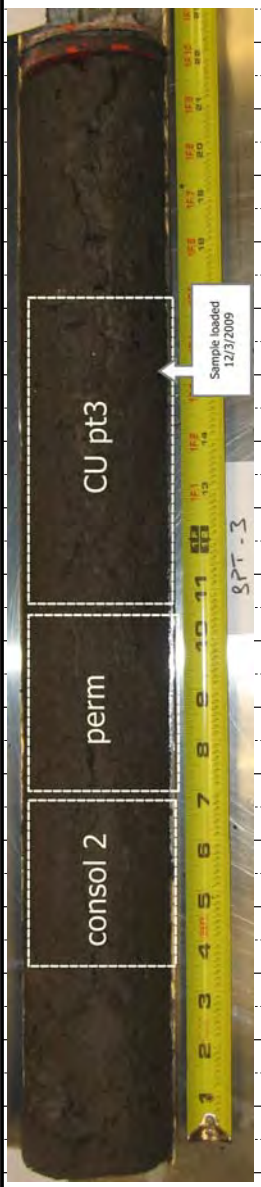
KLEINFELDER
Bright People. Right Solutions.

Project Name: Arkema Early Action
Project Number: 107510 **Sheet:** __1___ of _1__

Boring No: ARK-SPT 3 (13-15)	**Sample Extraction Method:** Splitting (due to soft sample)	**Down Pressure (psi) at Sampling:**
Sample Type: Shelby Tube (24 in)	**Location:** NA	**Depth to Groundwater Initial/Time:** **Final/Time:**
Sample Depth: 13 to 15 ft	**Date Begin/End:** NA	**Coordinates (X/Y, Lat/Long):**
Recovery (in): 21.5 NA	**Field Logged By:** NA	**Coordinate System/Datum:**
Capped Sealed (y/n): YES	**Logged By (Lab)/Checked By:** K Wells	**Angle From Vertical/Bearing:**

Length (in)	Description Soil Type, Particle Size Range, Particle Hardness, Dry Strength, Dilatency, Toughness, Color, Odor, Reaction with HCL, Structure, Cementation	ASTM Symbol	Pocket Pen. (tsf) / Torvane Shear (tsf)	Plasticity	Lab Testing	Depth (ft)	Notes
0							
						13 ft	
		ML/MH					
2							
			PP<.25TSF				Disturbed upper 5"
4	SILT - Very soft to soft, saturated, dark brown, trace fine sand						
6					CU-3		
8	Medium to high plasticity, elastic.						
10							
						14 ft	
12							
					PERM		
					PI		
14					SV		
16							
18							
20							Blocky chunks
							Fractured
22							
						15 ft	
24							

Shelby Tube Photo



NOTES:
Sample removed from shelby tube by splitting tube longitudinally
Sample range for Consol Test 2 saved for future testing.

H - Hydrometer Tests
PI - Plasticity Index
SV - Sieve Analysis
CU - Consolidated Undrained Triaxial Comp
UU - Unconsolidated Undrained Triaxial Comp
Consol - Consolidation Test, Time Rate
SPG - Specific Gravity Test
Perm - Permeability
Note: Some laboratory testing may not be shown in log above

Soil Boring Field Log Sheet.fh11

Copyright Kleinfelder 2009

LOG OF SHELBY TUBE SAMPLE

KLEINFELDER
Bright People. Right Solutions.

Project Name: Arkema Early Action
Project Number: 107510 **Sheet:** __1___ of _1__

Boring No: ARK-SPT 3 (9.5-11.5)	**Sample Extraction Method:** Splitting (due to soft sample)	**Down Pressure (psi) at Sampling:**
Sample Type: Shelby Tube (24 in)	**Location:** NA	**Depth to Groundwater Initial/Time:** **Final/Time:**
Sample Depth: 9.5 to 11.5 ft	**Date Begin/End:** NA	**Coordinates (X/Y, Lat/Long):**
Recovery (in): 22 NA	**Field Logged By:** NA	**Coordinate System/Datum:**
Capped Sealed (y/n): YES	**Logged By (Lab)/Checked By:** K Wells	**Angle From Vertical/Bearing:**

Length (in)	Description Soil Type, Particle Size Range, Particle Hardness, Dry Strength, Dilatency, Toughness, Color, Odor, Reaction with HCL, Structure, Cementation	ASTM Symbol	Pocket Pen. (tsf) / Torvane Shear (tsf)	Plasticity	Lab Testing	Depth (ft)	Notes
0							
		ML/MH				9.5	
2							
			PP<.25TSF				
4	SILT - Very soft to soft, saturated, dark brown, trace fine sand				CU-2		Disturbed upper 3"
	Medium to high plasticity, elastic.						
6							
8							
					CU-1		
10							
	Occasional bits of wood debris (black/rotted) throughout sample up to 3/8 inch diameter.						
12							
						10.5	
14							
					consol		
16							
					UU		Fracture ----------
18							
20							
22							
24						11.4	

Shelby Tube Photo

NOTES:
Sample removed from shelby tube by splitting tube longitudinally
Torvane shear not possible (limited sample, very soft)

H - Hydrometer Tests
PI - Plasticity Index
SV - Sieve Analysis
CU - Consolidated Undrained Triaxial Comp
UU - Unconsolidated Undrained Triaxial Comp
Consol - Consolidation Test, Time Rate
SPG - Specific Gravity Test
Perm - Permeability
Note: Some laboratory testing may not be shown in log above

Soil Boring Field Log Sheet.fh11

Copyright Kleinfelder 2009

KLEINFELDER
Bright People. Right Solutions.

PROJECT NAME: ARCADIS - Arkema Early Action
LOCATION: Portland, Oregon
SAMPLE DATE: October, 2009

PROJECT: 107510
REVIEWED BY: S. STEEL

MOISTURE CONTENT OF SOIL (ASTM D2216)

SAMPLE	SAMPLE SOURCE	WET WEIGHT (g)	DRY WEIGHT (g)	MOISTURE CONTENT %
2592-1	ARK-SPT-1 @ 4.0-5.5'	79.0	39.3	100.9
2592-2	ARK-SPT-1 @ 5.5-7.0'	129.1	49.2	162.2
2592-3	ARK-SPT-1 @ 7.0-8.5'	54.2	17.9	202.5
2592-4	ARK-SPT-1 @ 8.5-10.0'	135.3	76.6	76.7
2592-5	ARK-SPT-1 @ 10.0-11.5'	141.5	73.6	92.3
2592-6	ARK-SPT-1 @ 11.5-13.0'	128.6	70.0	83.6
2592-9	ARK-SPT-1 @ 17.0-18.5'	141.5	77.4	82.8
2592-11	ARK-SPT-1 @ 20.5-22.0'	147.6	105.7	39.7

9200 SW Nimbus Avenue, Suite A, Beaverton, OR 97008 p | 503.644.9447 f | 503.643.1905
This is a summarized report of the referenced procedures and does not include all reporting requirements. Additional data can be provided at client's request.

KLEINFELDER
Bright People. Right Solutions.

PROJECT NAME: ARCADIS - Arkema Early Action
LOCATION: Portland, Oregon
SAMPLE DATE: October, 2009

PROJECT: 107510
REVIEWED BY: S. STEEL

MOISTURE CONTENT OF SOIL (ASTM D2216)

SAMPLE	SAMPLE SOURCE	WET WEIGHT (g)	DRY WEIGHT (g)	MOISTURE CONTENT %
2592-13	ARK-SPT-2 @ 2.0-3.5'	103.1	53.8	91.6
2592-14	ARK-SPT-2 @ 3.5-5.0'	142.6	76.2	87.1
2592-15	ARK-SPT-2 @ 5.0-6.0'	149.7	93.9	59.5
2592-16	ARK-SPT-2 @ 6.0-6.5'	109.9	78.7	39.6
2592-17	ARK-SPT-2 @ 6.5-7.0'	118.6	89.3	32.8
2592-18	ARK-SPT-2 @ 7.0-7.5'	110.1	77.8	41.5
2592-20	ARK-SPT-2 @ 9.5-10.0'	120.2	71.9	67.0
2592-21	ARK-SPT-2 @ 10.0-10.5'	122.9	80.7	52.3
2592-22	ARK-SPT-2 @ 11.0-12.5'	115.5	78.3	47.5
2592-23	ARK-SPT-2 @ 12.5-14.0'	369.9	238.1	55.3
2592-24	ARK-SPT-2 @ 14.0-15.0'	148.0	94.5	56.6
2592-25	ARK-SPT-2 @ 15.0-15.5'	111.4	62.9	76.9
2592-28	ARK-SPT-2 @ 19.0-20.5'	144.5	82.9	74.3
2592-31	ARK-SPT-2 @ 24.5-26.0'	137.6	87.9	56.6
2592-32	ARK-SPT-2 @ 26.0-26.5'	185.1	124.8	48.3
2592-33	ARK-SPT-2 @ 26.5-27.5'	124.1	88.8	39.8
2592-35	ARK-SPT-2 @ 30.0-30.25'	100.5	58.8	71.0
2592-36	ARK-SPT-2 @ 30.25-31.5'	131.0	95.9	36.6
2592-37	ARK-SPT-2 @ 32.5-34.0'	173.0	117.7	47.0
2592-38	ARK-SPT-2 @ 35.0-36.0'	152.8	107.5	42.1

This is a summarized report of the referenced procedures and does not include all reporting requirements. Additional data can be provided at client's request.

KLEINFELDER
Bright People. Right Solutions.

PROJECT NAME: ARCADIS - Arkema Early Action
LOCATION: Portland, Oregon
SAMPLE DATE: October, 2009

PROJECT: 107510
REVIEWED BY: S. STEEL

MOISTURE CONTENT OF SOIL (ASTM D2216)

SAMPLE	SAMPLE SOURCE	WET WEIGHT (g)	DRY WEIGHT (g)	MOISTURE CONTENT %
2592-41	ARK-SPT-3 @ 5.0-6.5'	149.8	72.9	105.5
2592-42	ARK-SPT-3 @ 6.5-8.0'	125.1	70.2	78.3
2592-43	ARK-SPT-3 @ 8.0-9.5'	102.1	34.2	198.6
2592-45	ARK-SPT-3 @ 11.5-13.0'	125.9	63.8	97.3
2592-49	ARK-SPT-3 @ 19.0-20.5'	41.4	19.3	114.7
2592-50	ARK-SPT-3 @ 20.5-22.0'	33.4	21.5	55.0
2592-51	ARK-SPT-3 @ 22.0-22.25'	89.5	57.9	54.7
2592-52	ARK-SPT-3 @ 22.25-23.5'	74.4	52.2	42.4
2592-53	ARK-SPT-3 @ 23.5-25.0'	111.5	97.3	14.6

This is a summarized report of the referenced procedures and does not include all reporting requirements. Additional data can be provided at client's request.

KLEINFELDER
Bright People. Right Solutions.

9200 SW Nimbus Avenue
Beaverton, OR
97008
p | 503.644.9447
f | 503.643.1905
kleinfelder.com

PROJECT NAME: ARCADIS - Arkema Early Action
LOCATION: Portland, Oregon
SAMPLE DATE: October, 2009

PROJECT: 107510
REVIEWED BY: S. STEEL

MECHANICAL SIEVE ANALYSIS GROUP SYMBOL, USCS (ASTM D-2487)

								SIEVE SIZES: PERCENT PASSING BY WEIGHT									
				ATTERBERG LIMITS				GRAVEL			SAND						Silt or
			SPECIFIC					Fine			Coarse	Medium		Fine			Clay
Sample	Sample Source	USCS	GRAVITY	LL	ODLL	PL	PI	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
2592-2	ARK-SPT-1 @ 5.5-7.0'	OH	-	64	42	33	31	100	100	100	100	99.7	98.5	96.5	93.8	89.9	79.4
2592-7	ARK-SPT-1 @ 13.0-15.0'	OH	2.604	76	53	38	38	100	100	100	99.7	99.6	99.3	99.2	98.9	98.3	94.9
2592-8	ARK-SPT-1 @ 15.0-17.0'	MH/OH	-	81	-	39	42	100	100	100	99.3	98.2	97.3	96.5	95.3	93.4	86.9
2592-10	ARK-SPT-1 @ 18.5-20.5'	MH	-	53	43	36	17	100	100	100	100	100	100	100	99.9	99.9	99.1
2592-14	ARK-SPT-2 @ 3.5-5.0'	OL	-	47	33	34	13	100	100	99.3	99.0	98.3	97.5	95.6	92.2	87.9	77.6
2592-18	ARK-SPT-2 @ 7.0-7.5'	-	-	-	-	-	-	100	100	100	99.8	98.9	96.8	82.4	61.3	47.1	38.9
2592-23	ARK-SPT-2 @ 12.5-14.0'	-	-	-	-	-	-	100	100	100	99.9	99.7	98.1	70.2	24.0	14.5	10.8
2592-29	ARK-SPT-2 @ 20.5-22.5'	OH	-	73	41	32	41	100	100	100	100	99.8	98.6	88.7	73.6	69.8	66.6
2592-29	ARK-SPT-2 @ 20.5-22.5'	-	2.661	-	-	-	-	100	100	100	100	100	99.8	97.2	91.8	89.9	85.6
2592-32	ARK-SPT-2 @ 26.0-26.5'	-	-	-	-	-	-	100	100	98.1	96.8	96.3	95.4	92.1	77.3	56.3	43.7
2592-41	ARK-SPT-3 @ 5.0-6.5'	OH	-	67	46	35	32	100	100	100	99.9	99.6	98.8	95.7	91.6	85.9	69.9
2592-44	ARK-SPT-3 @ 9.5-10.0'	OH	2.658	68	46	33	35	100	100	100	100	100	99.9	99.8	99.3	99.0	94.5
2592-44	ARK-SPT-3 @ 11.0-11.5'	MH/OH	2.700	63	-	36	27	100	100	100	100	100	99.6	99.6	99.4	98.1	88.8
2592-44	ARK-SPT-3 @ 13.0-15.0'	MH/OH	-	63	-	38	25	100	100	100	99.9	99.5	99.3	99.1	98.9	98.7	95.7
2592-50	ARK-SPT-3 @ 20.5-22.0'	-	-	-	-	-	-	100	100	100	99.6	99.5	98.9	94.3	67.1	42.4	28.9
2592-44	ARK-SPT-3 @ 10.0-10.5'	MH/OH	-	69	-	34	35	100	100	100	100	99.9	99.7	99.4	98.2	95.7	87.9

This is a summarized report of the referenced procedures and does not include all reporting requirements. Additional data can be provided at client's request.

KLEINFELDER
Bright People. Right Solutions.

9200 SW Nimbus Avenue
Beaverton, OR
97008
p | 503.644.9447
f | 503.643.1905
kleinfelder.com

PROJECT: ARCADIS - Arkema Early Action
LOCATION: Portland, Oregon

PROJECT NO: 107510.00
WORK ORDER NO: 2592
DATE SAMPLED: October, 2009
REVIEWED BY: S. STEEL

ORGANIC CONTENT BY IGNITION (ASTM D 2974, METHOD C)

SAMPLE:	SPT-1	SPT-2	SPT-3
DEPTH:	8.5 - 10'	20.5 - 22.5'	5 - 6.5'
TARE + DRY SOIL (g):	259.74	308.71	190.75
TARE + ASH (g):	255.58	299.72	188.19
TARE (g):	168.80	163.26	162.83
MASS OVEN DRY SOIL (g):	90.94	145.45	27.92
MASS of ASH (g):	86.78	136.46	25.36
ASH CONTENT (%):	95.4%	93.8%	90.8%
ORGANIC CONTENT (%):	**4.6%**	**6.2%**	**9.2%**

KLEINFELDER
Bright People. Right Solutions.

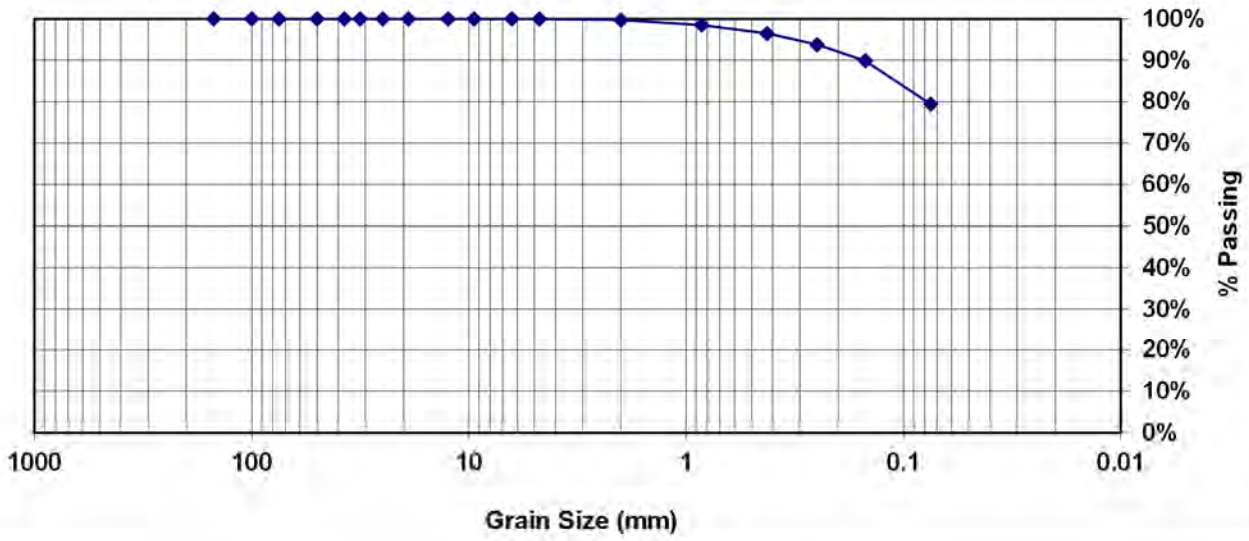
9200 SW Nimbus Avenue
Beaverton, OR
97008
p| 503.644.9447
f| 503.643.1905
kleinfelder.com

PROJECT NAME: ARCADIS - Arkema Early Action
LOCATION: Portland, Oregon
SAMPLE DATE: October, 2009

PROJECT: 107510
REVIEWED BY: S. STEEL

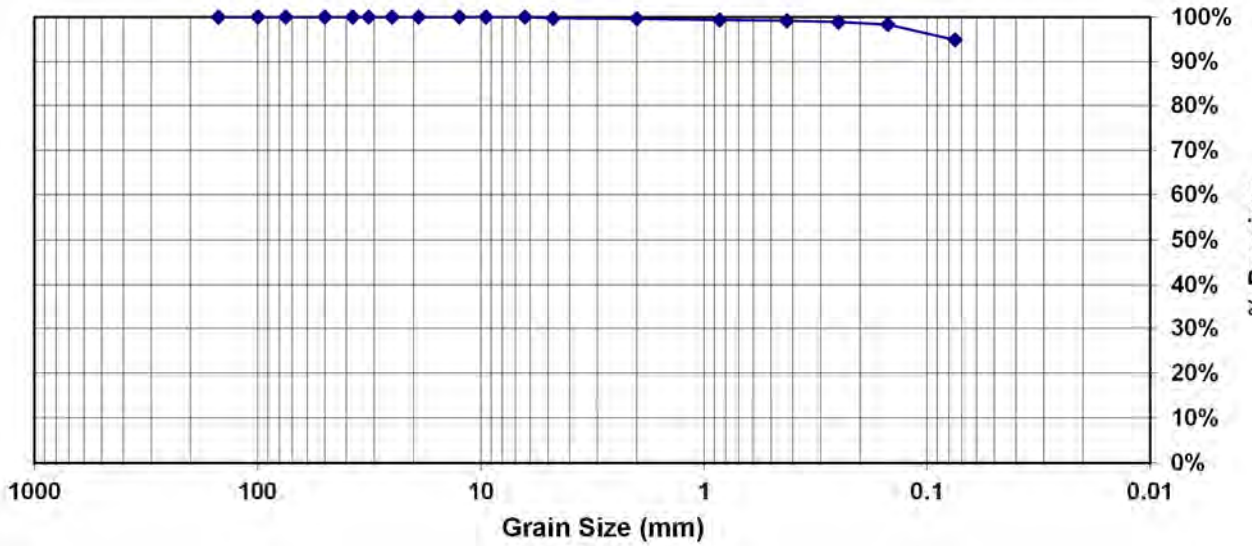
ARK-SPT-1 @ 5.5-7.0'

%PASSING #200	LL	PI	USCS	AASHTO
79.4	64	31	MH	A-7-5(28):



ARK-SPT-1 @ 13.0-15.0'

%PASSING #200	LL	PI	USCS	AASHTO
94.9	76	38	MH	A-7-5(45):



 This is a summarized report of the referenced procedures ad does not include all reporting requirements. Additional data can be provided at client's request. 10/13/2010

KLEINFELDER
Bright People. Right Solutions.

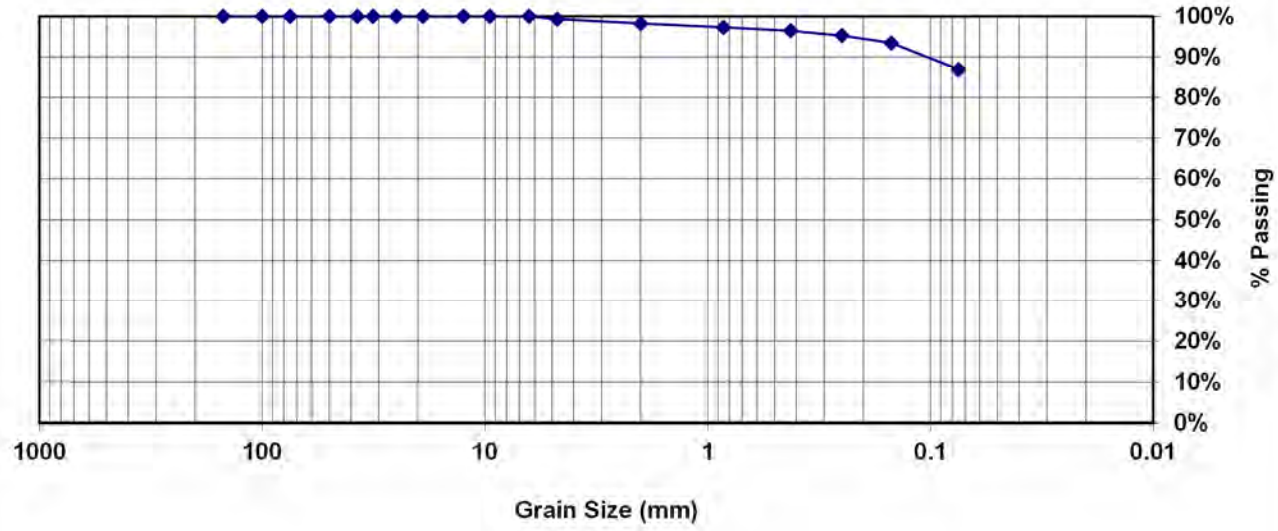
9200 SW Nimbus Avenue
Beaverton, OR
97008
p| 503.644.9447
f| 503.643.1905
kleinfelder.com

PROJECT NAME: ARCADIS - Arkema Early Action
LOCATION: Portland, Oregon
SAMPLE DATE: October, 2009

PROJECT: 107510
REVIEWED BY: S. STEEL

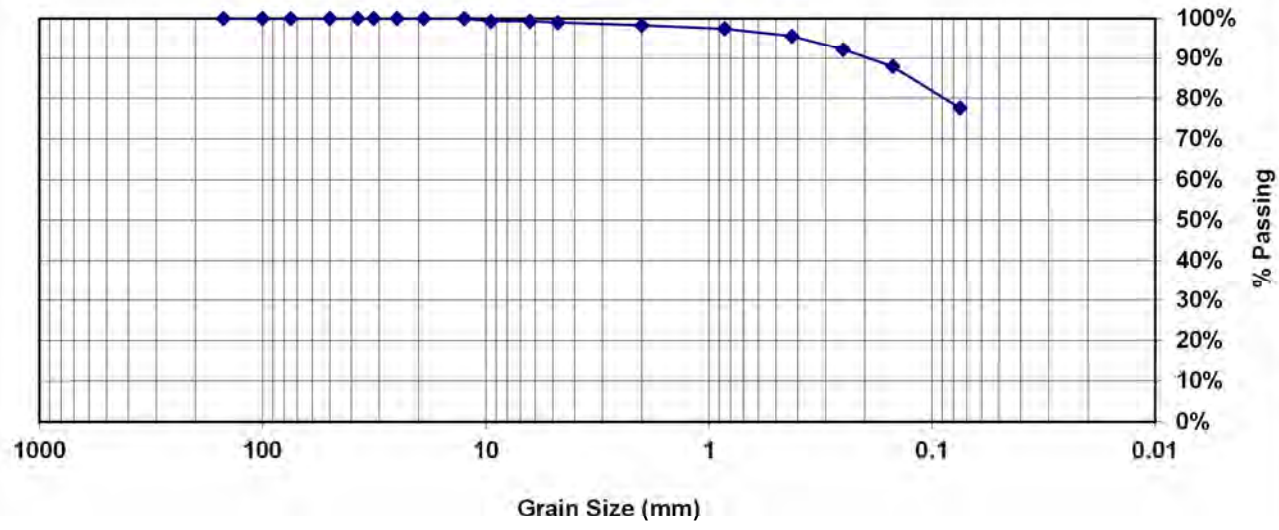
ARK-SPT-1 @ 15.0-17.0'

%PASSING #200	LL	PI	USCS	AASHTO
86.9	81	42	MH	A-7-5(42):



ARK-SPT-2 @ 3.5-5.0'

%PASSING #200	LL	PI	USCS	AASHTO
77.6	47	13	ML	A-7-6(25):



 This is a summarized report of the referenced procedures ad does not include all reporting requirements. Additional data can be provided at client's request. 10/13/2010

KLEINFELDER
Bright People. Right Solutions.

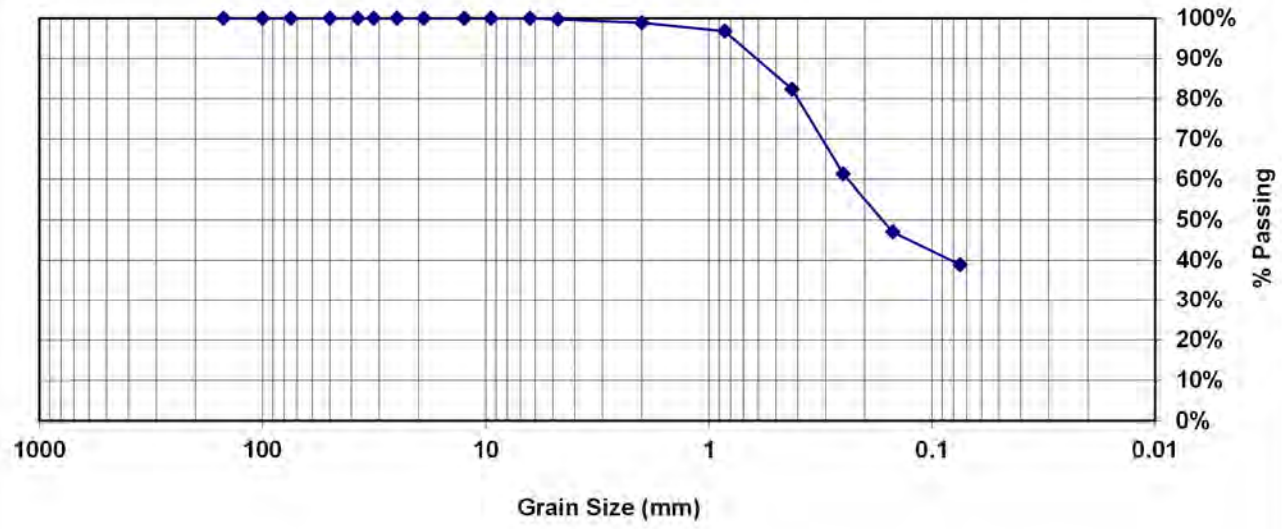
9200 SW Nimbus Avenue
Beaverton, OR
97008
p| 503.644.9447
f| 503.643.1905
kleinfelder.com

PROJECT NAME: ARCADIS - Arkema Early Action
LOCATION: Portland, Oregon
SAMPLE DATE: October, 2009

PROJECT: 107510
REVIEWED BY: S. STEEL

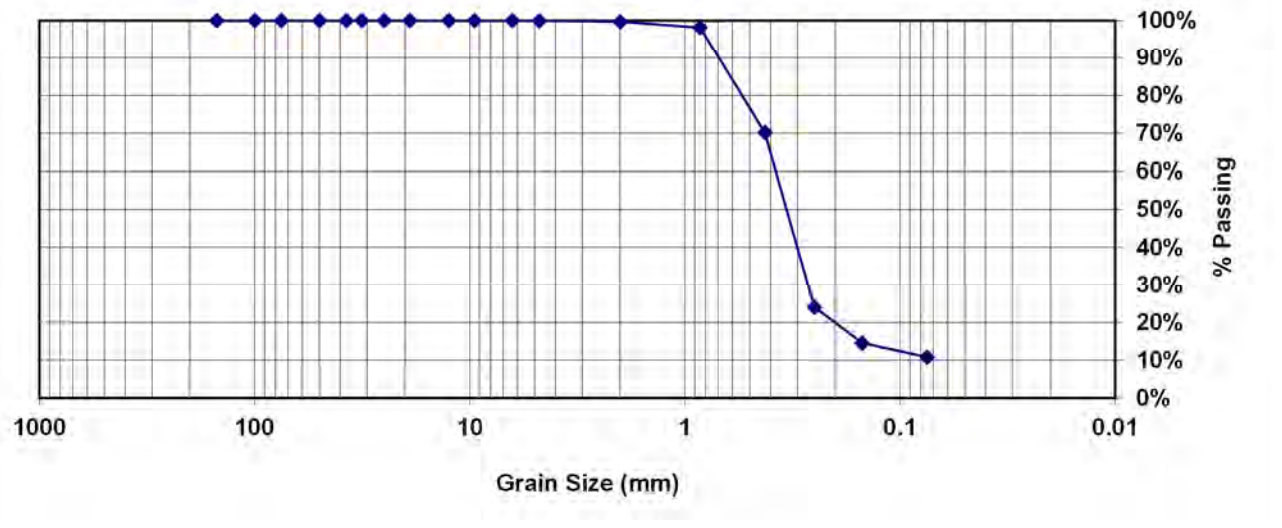
ARK-SPT-2 @ 7.0-7.5'

%PASSING #200
38.9



ARK-SPT-2 @ 12.5-14.0'

%PASSING #200
10.8



 This is a summarized report of the referenced procedures ad does not include all reporting requirements. Additional data can be provided at client's request. 10/13/2010

KLEINFELDER
Bright People. Right Solutions.

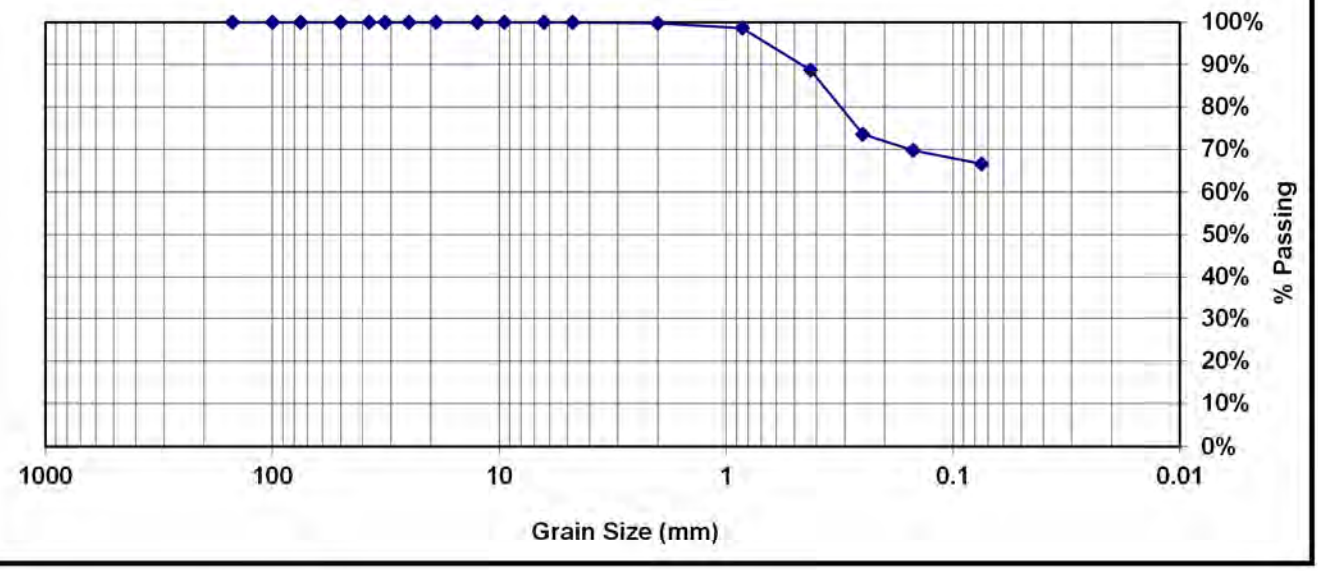
9200 SW Nimbus Avenue
Beaverton, OR
97008
p| 503.644.9447
f| 503.643.1905
kleinfelder.com

PROJECT NAME: ARCADIS - Arkema Early Action
LOCATION: Portland, Oregon
SAMPLE DATE: October, 2009

PROJECT: 107510
REVIEWED BY: S. STEEL

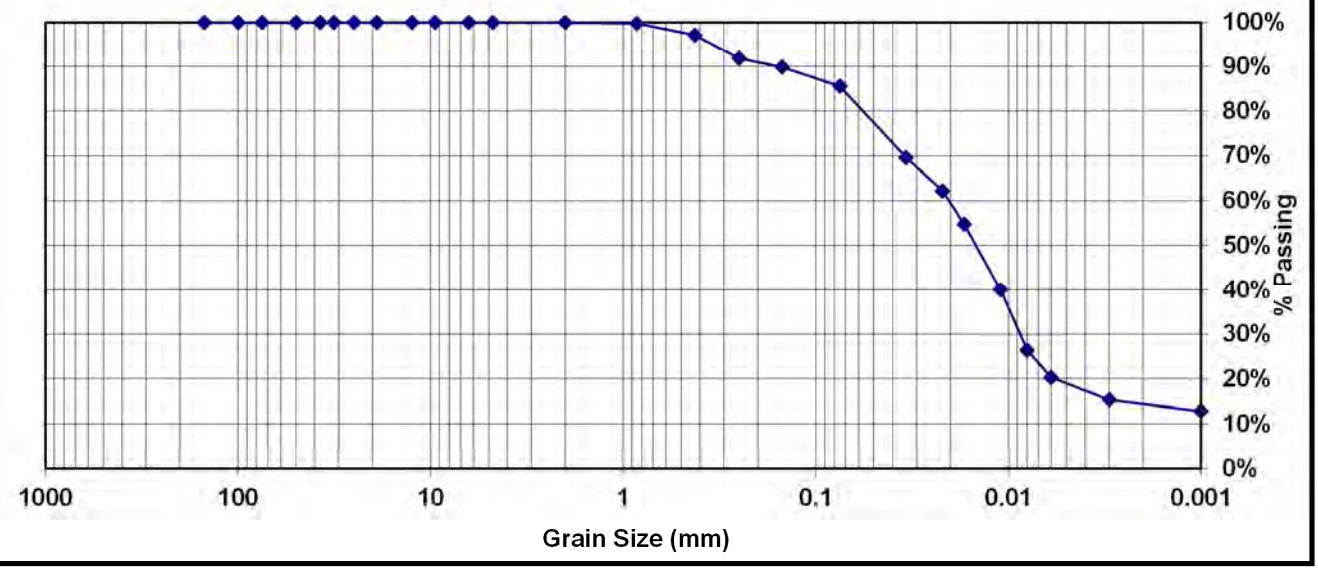
ARK-SPT-2 @ 20.5-22.5'

%PASSING #200	LL	PI	USCS	AASHTO
66.6	73	41	MH	A-7-5(23):



ARK-SPT-2 @ 20.5-22.5'

%PASSING #200
85.6



 This is a summarized report of the referenced procedures ad does not include all reporting requirements. Additional data can be provided at client's request. 10/13/2010

KLEINFELDER
Bright People. Right Solutions.

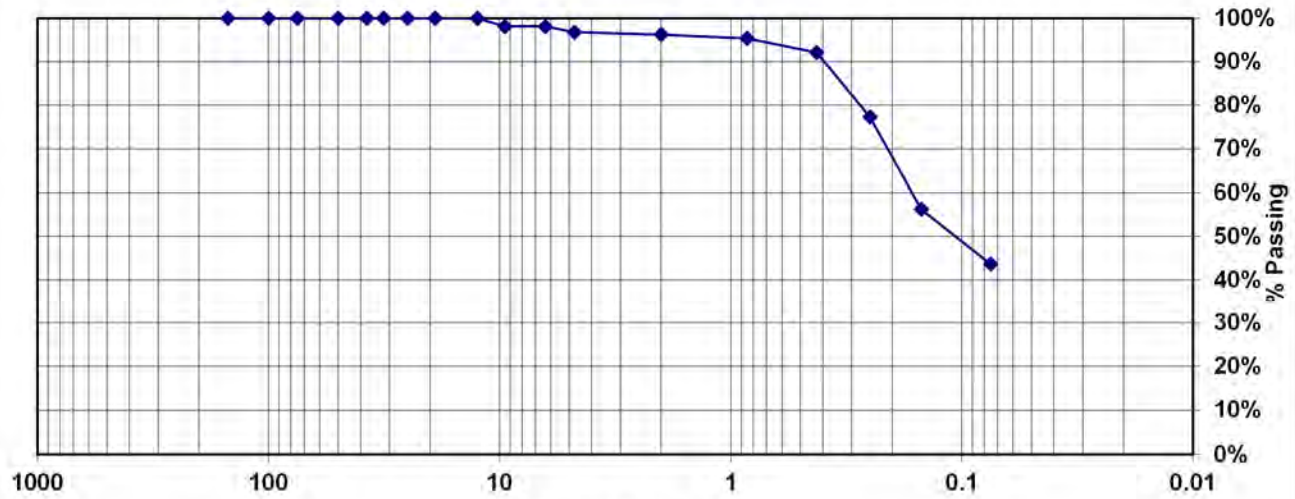
9200 SW Nimbus Avenue
Beaverton, OR
97008
p| 503.644.9447
f| 503.643.1905
kleinfelder.com

PROJECT NAME: ARCADIS - Arkema Early Action
LOCATION: Portland, Oregon
SAMPLE DATE: October, 2009

PROJECT: 107510
REVIEWED BY: S. STEEL

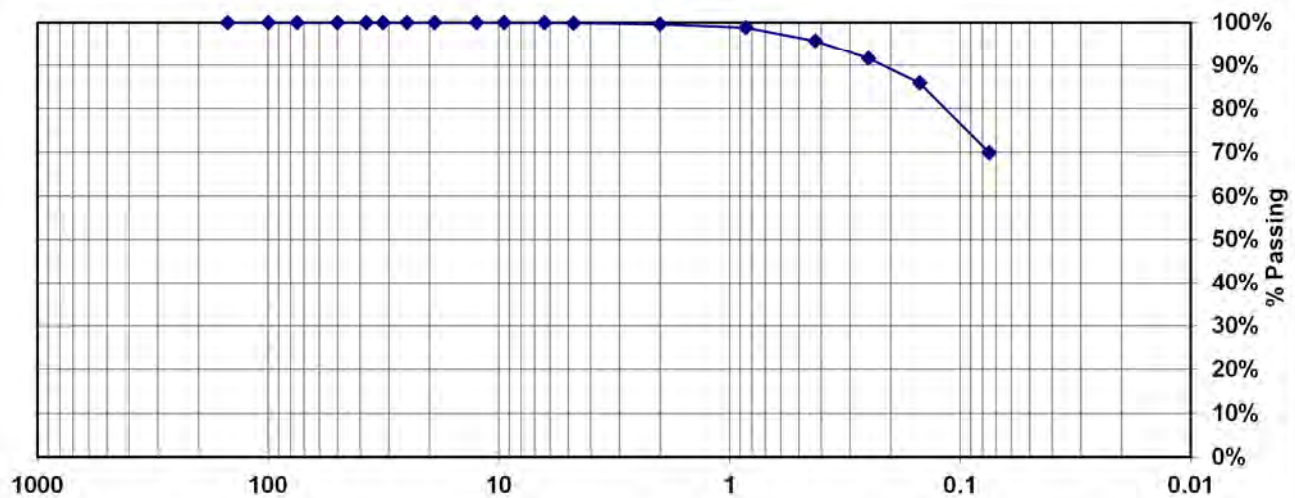
ARK-SPT-2 @ 26.0-26.5'

%PASSING #200
43.7



ARK-SPT-3 @ 5.0-6.5'

%PASSING #200	LL	PI	USCS	AASHTO
69.9	67	32	MH	A-7-5(26):



 This is a summarized report of the referenced procedures ad does not include all reporting requirements. Additional data can be provided at client's request. 10/13/2010

KLEINFELDER
Bright People. Right Solutions.

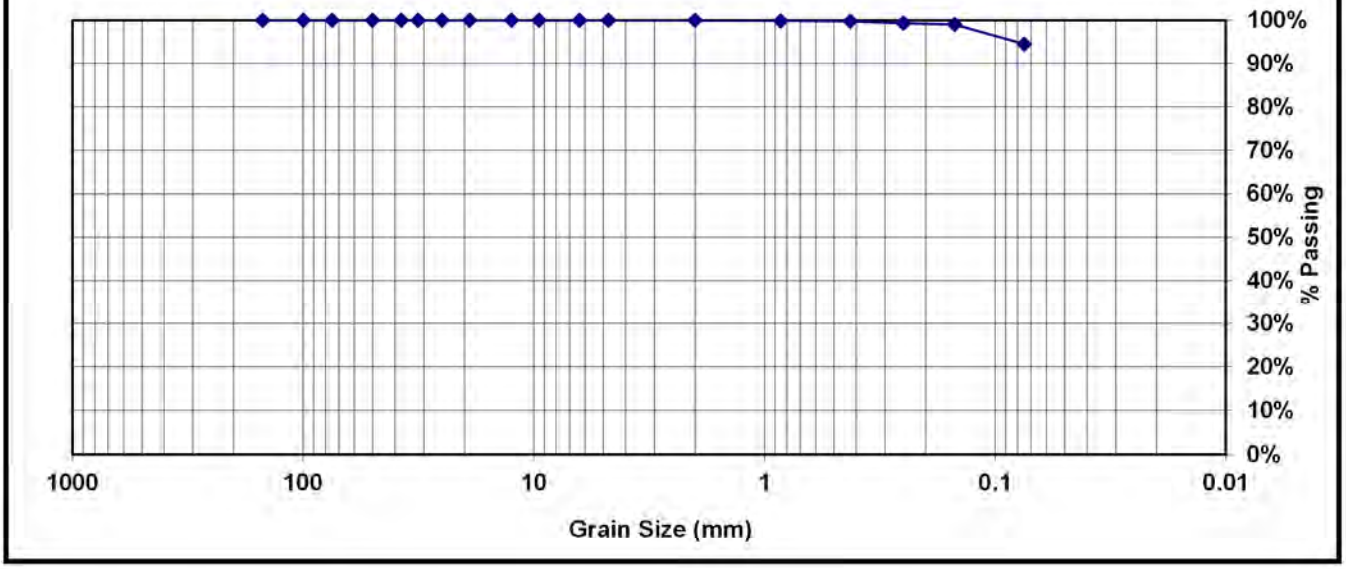
9200 SW Nimbus Avenue
Beaverton, OR
97008
p| 503.644.9447
f| 503.643.1905
kleinfelder.com

PROJECT NAME: ARCADIS - Arkema Early Action
LOCATION: Portland, Oregon
SAMPLE DATE: October, 2009

PROJECT: 107510
REVIEWED BY: S. STEEL

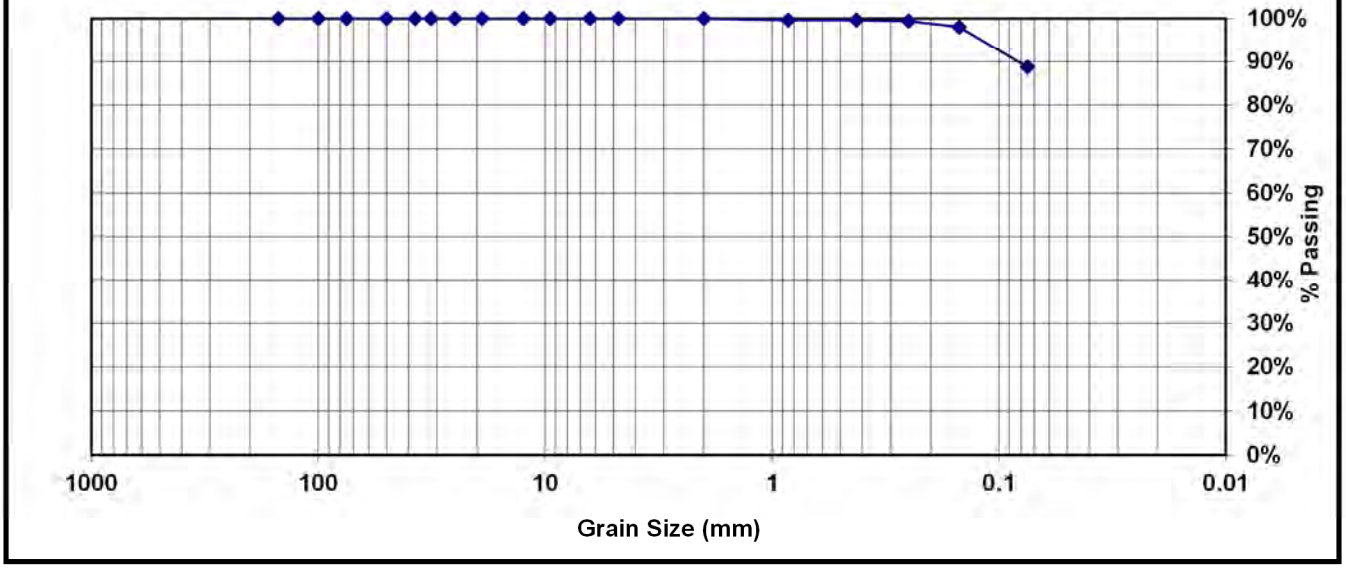
ARK-SPT-3 @ 9.5-10.0'

%PASSING #200	LL	PI	USCS	AASHTO
94.5	68	35	MH	A-7-5(39):



ARK-SPT-3 @ 11.0-11.5'

%PASSING #200	LL	PI	USCS	AASHTO
88.8	63	27	MH	A-7-6(36):



 This is a summarized report of the referenced procedures ad does not include all reporting requirements. Additional data can be provided at client's request. 10/13/2010

KLEINFELDER
Bright People. Right Solutions.

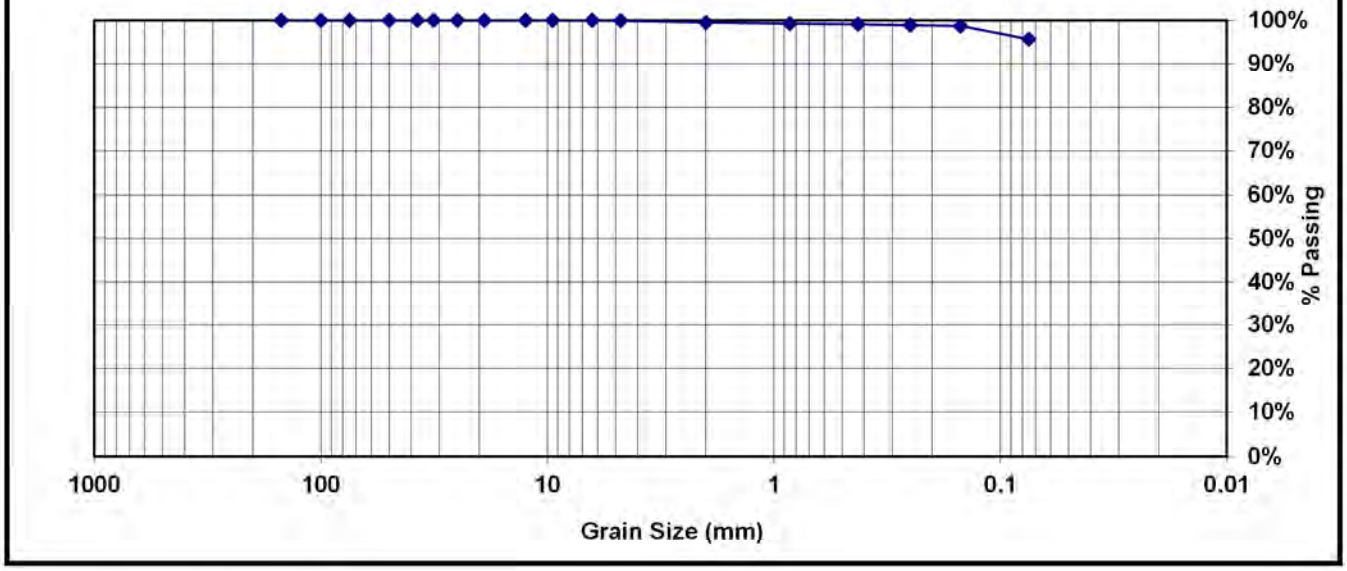
9200 SW Nimbus Avenue
Beaverton, OR
97008
p| 503.644.9447
f| 503.643.1905
kleinfelder.com

PROJECT NAME: ARCADIS - Arkema Early Action
LOCATION: Portland, Oregon
SAMPLE DATE: October, 2009

PROJECT: 107510
REVIEWED BY: S. STEEL

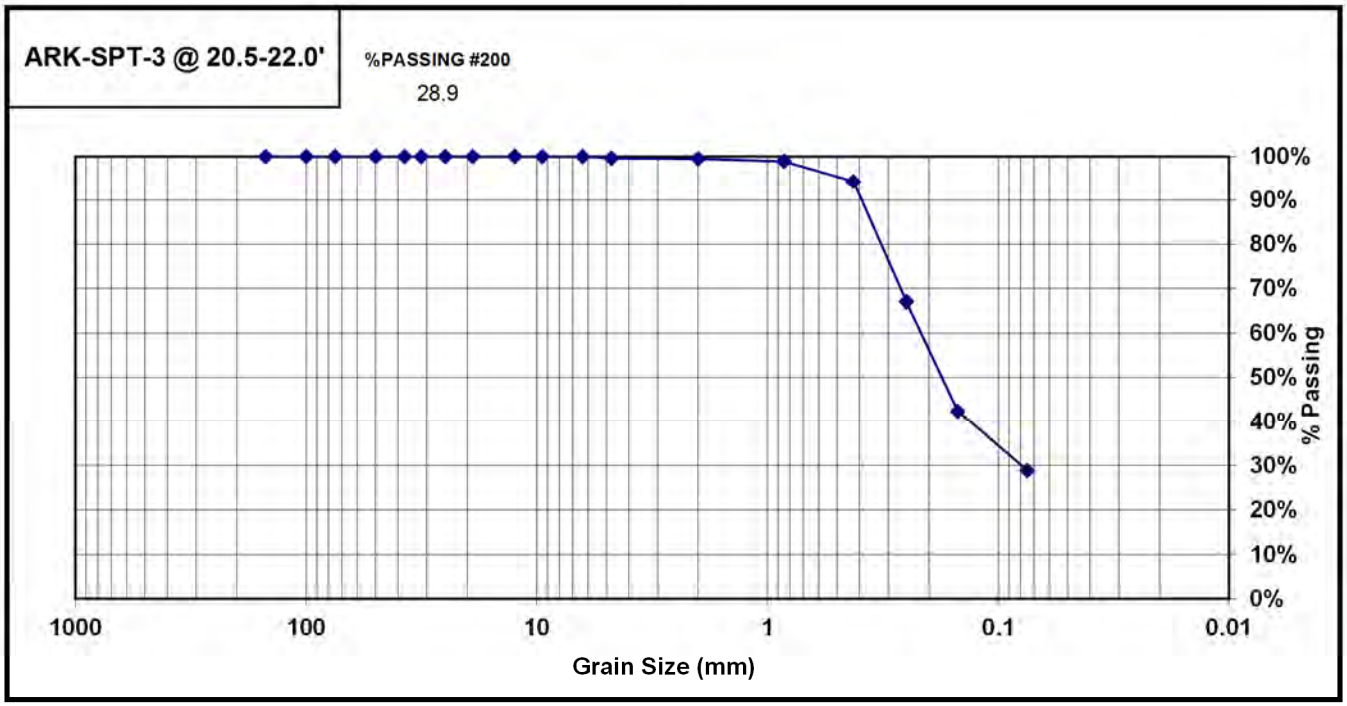
ARK-SPT-3 @ 13.0-15.0'

%PASSING #200	LL	PI	USCS	AASHTO
95.7	63	25	MH	A-7-6(42):



ARK-SPT-3 @ 20.5-22.0'

%PASSING #200
28.9



 This is a summarized report of the referenced procedures ad does not include all reporting requirements. Additional data can be provided at client's request. 10/13/2010

KLEINFELDER
Bright People. Right Solutions.

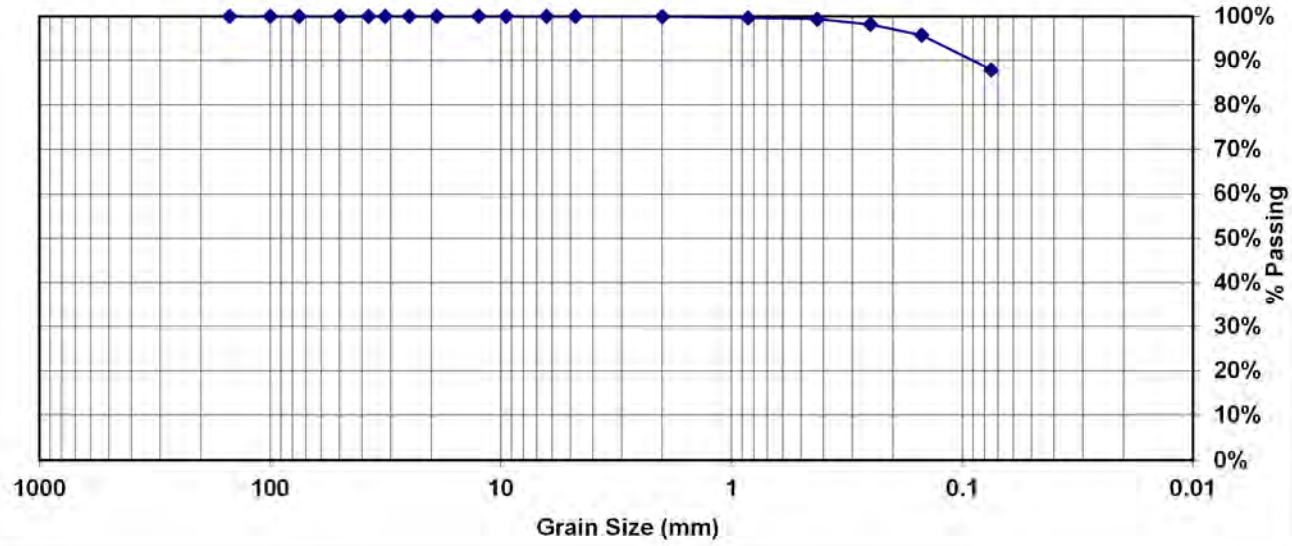
9200 SW Nimbus Avenue
Beaverton, OR
97008
p| 503.644.9447
f| 503.643.1905
kleinfelder.com

PROJECT NAME: ARCADIS - Arkema Early Action
LOCATION: Portland, Oregon
SAMPLE DATE: October, 2009

PROJECT: 107510
REVIEWED BY: S. STEEL

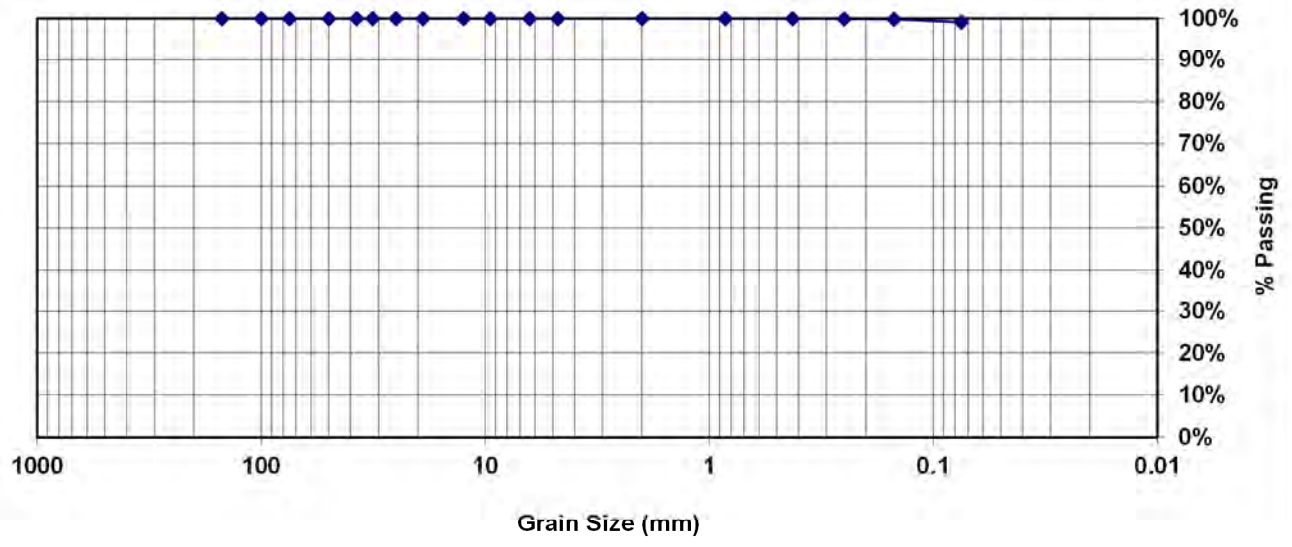
ARK-SPT-3 @ 10.0-10.5'

%PASSING #200	LL	PI	USCS	AASHTO
87.9	69	35	MH	A-7-5(36):

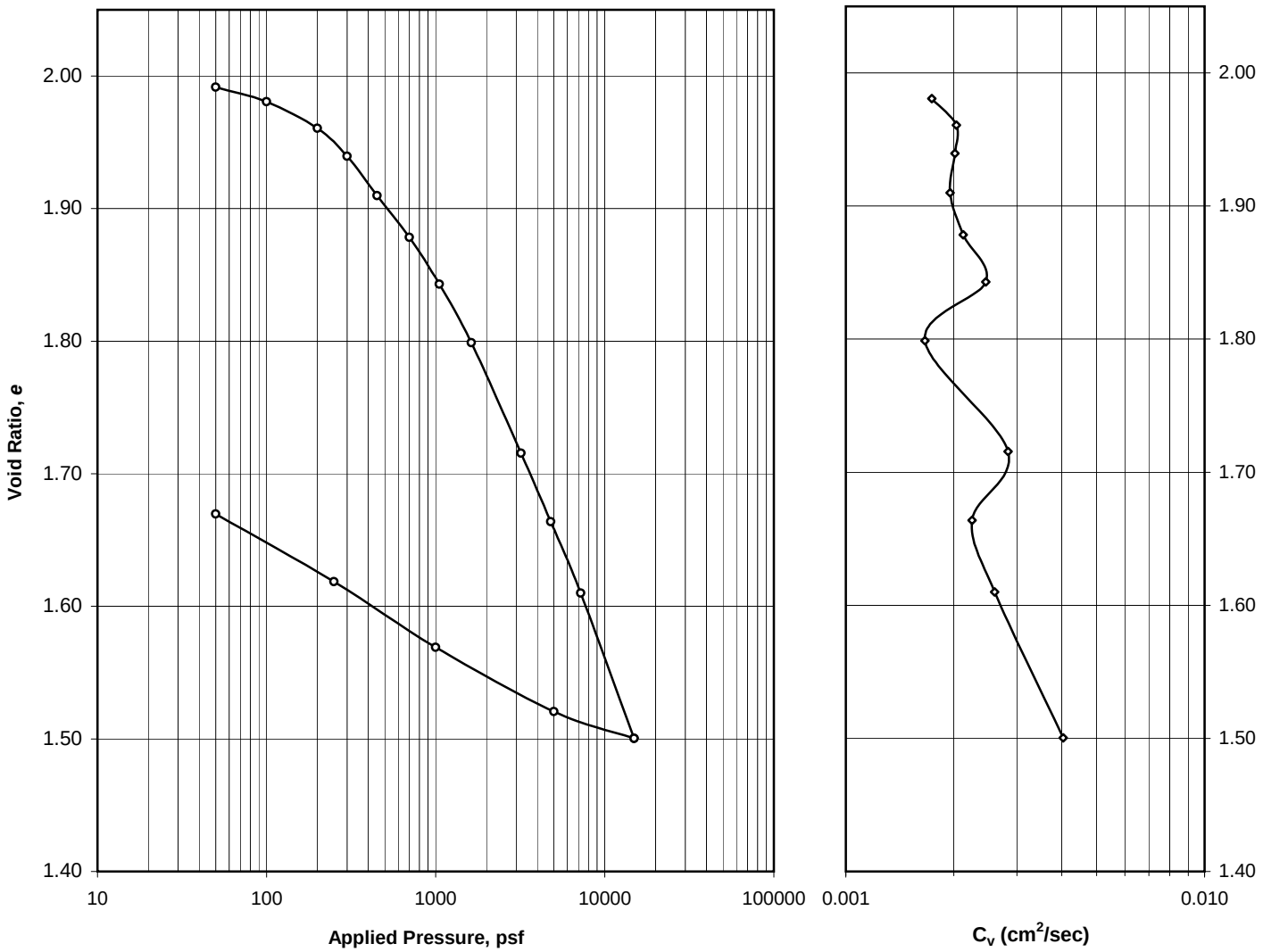


ARK-SPT-1 @ 18.5-20.5'

%PASSING #200	LL	PI	USCS	AASHTO
99.1	53	17	MH	A-7-6(39):



 This is a summarized report of the referenced procedures ad does not include all reporting requirements. Additional data can be provided at client's request. 10/13/2010



Boring	Sample	Depth (ft)	LL	PL	Spec Grav	Sample Description
SPT-1	SPT-1	13.5	76	38	2.66	Dark Gray SILT (MH)

	Moisture Content (%)	Dry Density (pcf)	Void Ratio	Satruation (%)
INITIAL	72.0	55.5	1.992	96.2
FINAL	48.7	62.2	1.670	100.0

Recompresion Index $Cr^{(1)}$	Compression Index $Cc^{(1)}$	$Est^{(1)}$ Preconsolidation Pressure, Po' (pcf)
N/A	N/A	N/A

SAMPLE PREPARATION: Wet Method

(1) Estimated preconsilidation pressure and index values (Cr/Cc) generally based on Casaegrade Method.

KLEINFELDER
Bright People. Right Solutions.

Test Date:	7-Jan-10
Tested By:	RG
Checked By:	SAS
File:	SPT-1@13-15'
PROJECT NO.: 107510	Lab No.: 2592

CONSOLIDATION TEST

Arkema Early Action
Portland, Oregon

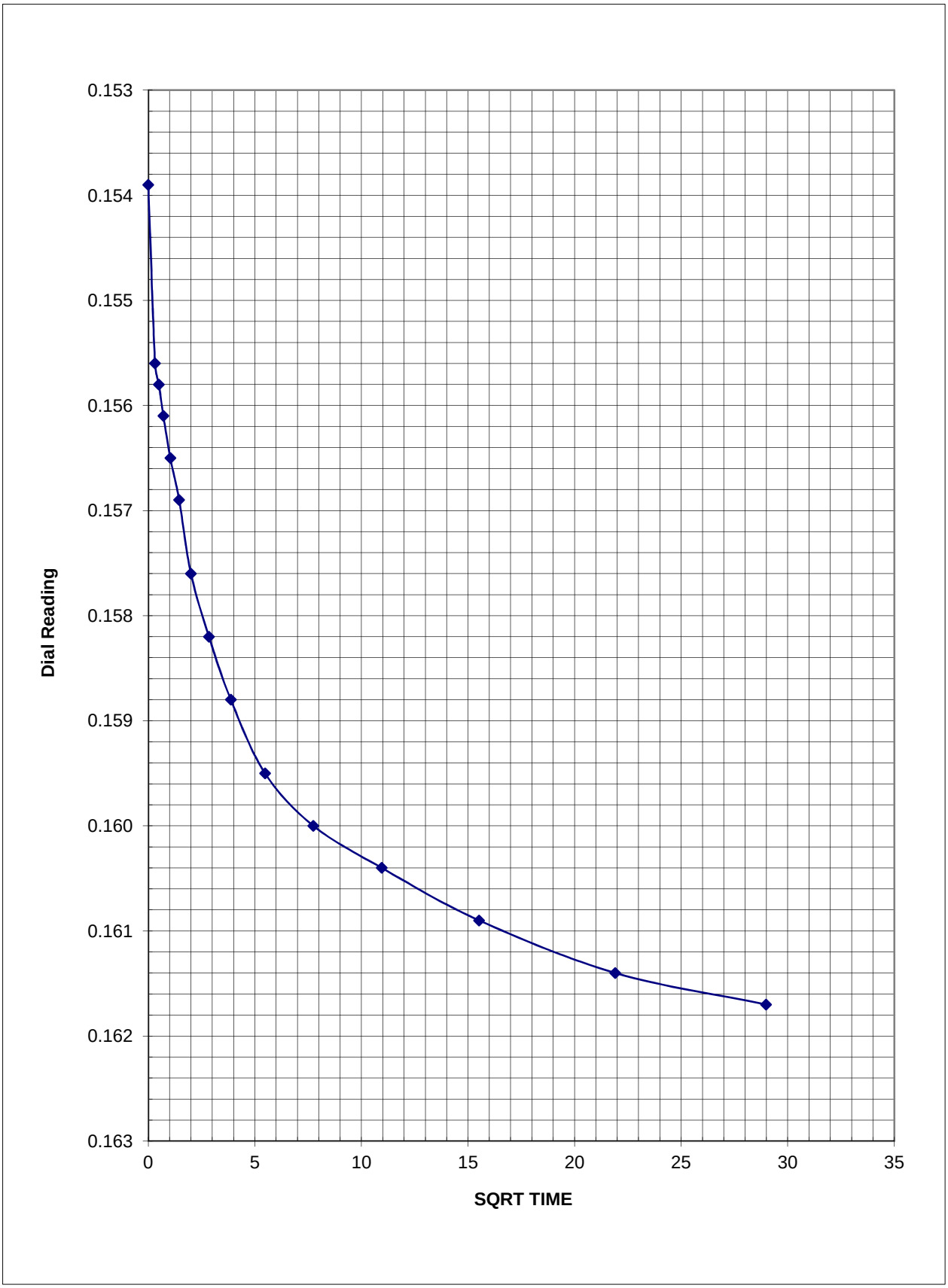
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**

Load Increment (psf):	**100**

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.01	0.00	***0.1539***
6s		0.1	0.32	0.1556
15s		0.25	0.50	0.1558
30s		0.5	0.71	0.1561
1 min		1.07	1.03	0.1565
2 min		2.1	1.45	0.1569
4 min		4	2.00	0.1576
8 min		8.1	2.85	0.1582
15 min		15	3.87	0.1588
30 min		30	5.48	0.1595
1hr		60	7.75	0.1600
2 hr		120	10.95	0.1604
4 hr		241	15.52	0.1609
8 hr		480	21.91	0.1614
16 hr		840	28.98	0.1617
24 hr				

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.1558	0.1561	0.1565
D:4	0.1565	0.1569	0.1576
Delta 1:4	-0.0007	-0.0008	-0.0011
D_o (calc)	0.1551	0.1553	0.1554



Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**
		Load Increment (psf):	**100**

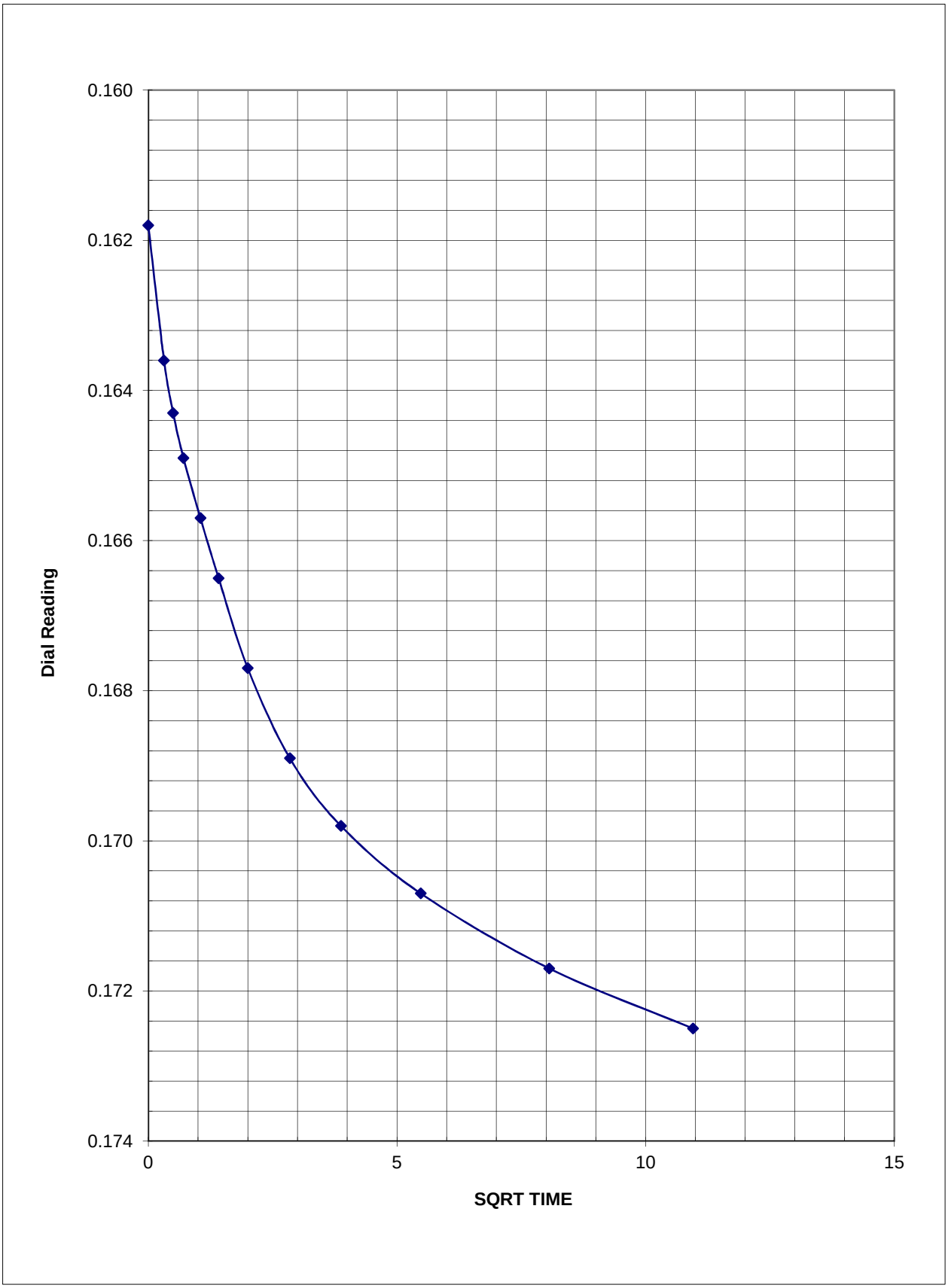
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**

Load Increment (psf):	**200**

Target Time sec/min/hr	**Recorded Time**	**Actual Time (min)**	**SQRT TIME (min)**	**Dial Reading**
Start		0.01	0.00	***0.1618***
6s		0.1	0.32	0.1636
15s		0.25	0.50	0.1643
30s		0.5	0.71	0.1649
1 min		1.1	1.05	0.1657
2 min		2	1.41	0.1665
4 min		4	2.00	0.1677
8 min		8.1	2.85	0.1689
15 min		15	3.87	0.1698
30 min		30	5.48	0.1707
1hr		65	8.06	0.1717
2 hr		120	10.95	0.1725
4 hr				
8 hr				
16 hr				
24 hr				

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.1643	0.1649	0.1657
D:4	0.1657	0.1665	0.1677
Delta 1:4	-0.0014	-0.0016	-0.0020
D_o (calc)	0.1629	0.1633	0.1637



Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**
		Load Increment (psf):	**200**

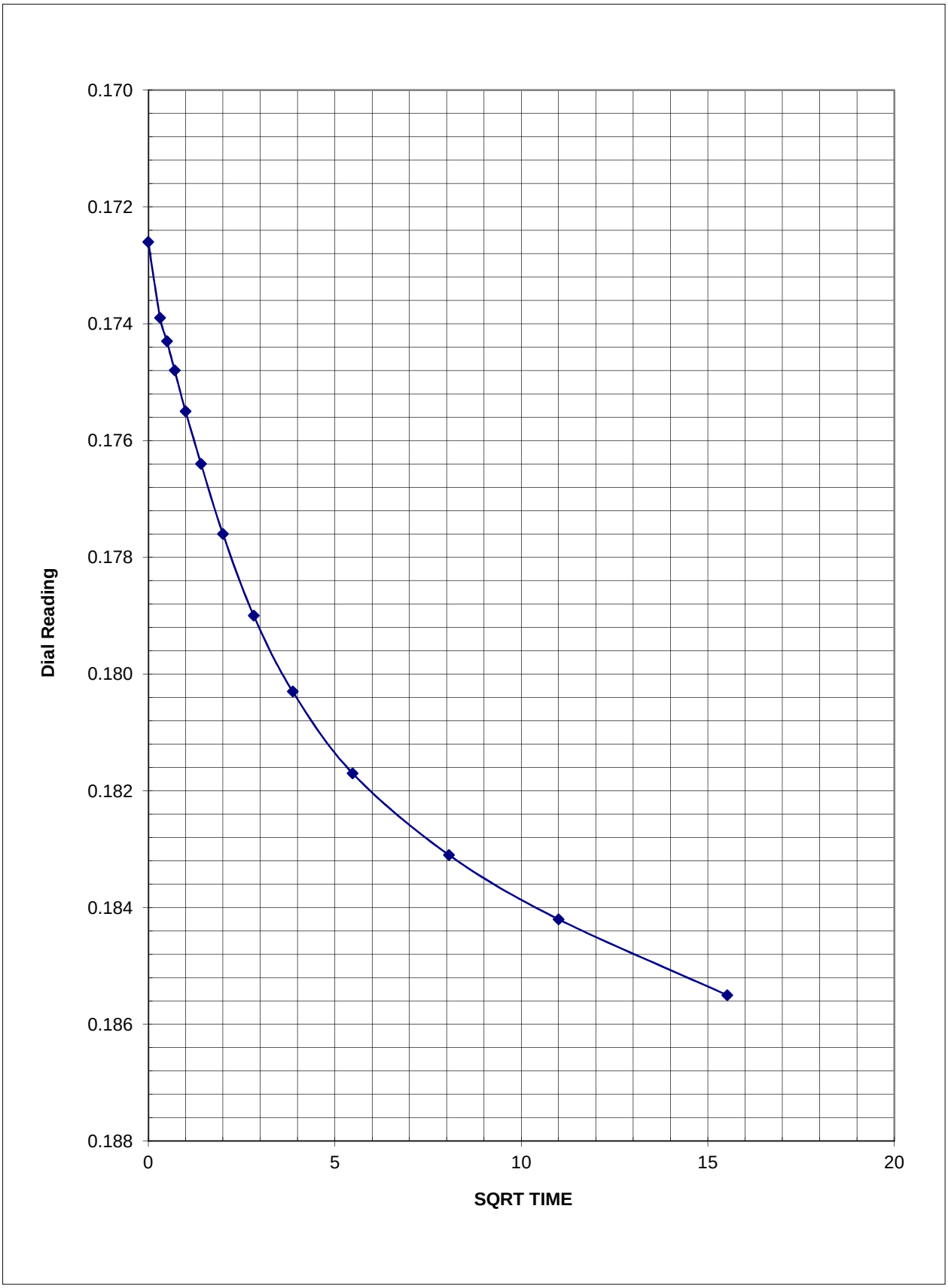
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**

Load Increment (psf):	**300**

Target Time sec/min/hr	**Recorded Time**	**Actual Time (min)**	**SQRT TIME (min)**	**Dial Reading**
Start		0.01	0.00	***0.1726***
6s		0.1	0.32	0.1739
15s		0.25	0.50	0.1743
30s		0.5	0.71	0.1748
1 min		1	1.00	0.1755
2 min		2	1.41	0.1764
4 min		4	2.00	0.1776
8 min		8	2.83	0.1790
15 min		15	3.87	0.1803
30 min		30	5.48	0.1817
1hr		65	8.06	0.1831
2 hr		121	11.00	0.1842
4 hr		241	15.52	0.1855
8 hr				
16 hr				
24 hr				

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.1743	0.1748	0.1755
D:4	0.1755	0.1764	0.1776
Delta 1:4	-0.0012	-0.0016	-0.0021
D_o (calc)	0.1731	0.1732	0.1734



Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**
		Load Increment (psf):	**300**

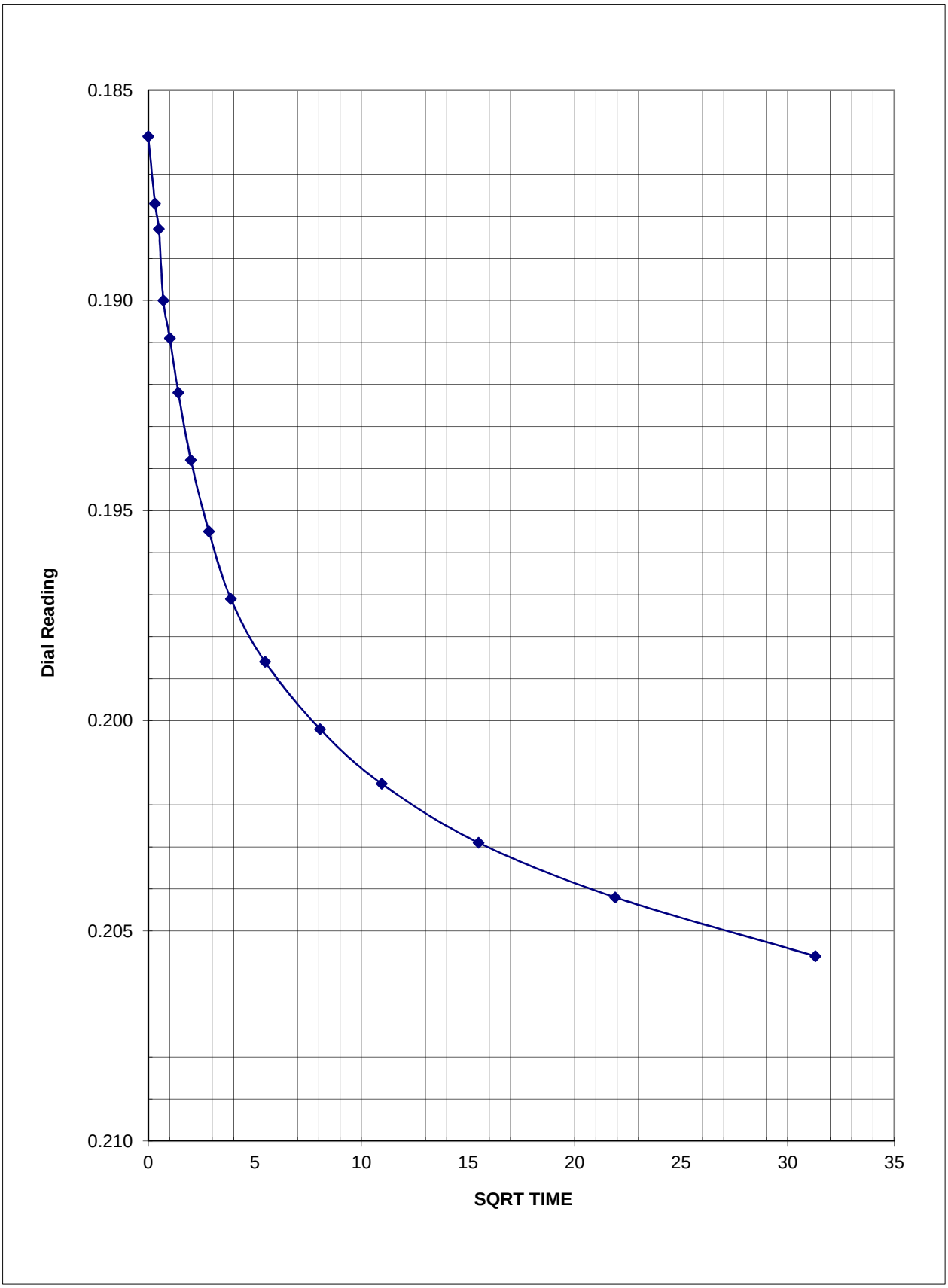
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**

Load Increment (psf):	**450**

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.01	0.00	***0.1861***
6s		0.1	0.32	0.1877
15s		0.25	0.50	0.1883
30s		0.5	0.71	0.1900
1 min		1.02	1.01	0.1909
2 min		2	1.41	0.1922
4 min		4	2.00	0.1938
8 min		8.1	2.85	0.1955
15 min		15	3.87	0.1971
30 min		30	5.48	0.1986
1hr		65	8.06	0.2002
2 hr		120	10.95	0.2015
4 hr		240	15.49	0.2029
8 hr		480	21.91	0.2042
16 hr		980	31.30	0.2056
24 hr				

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.1883	0.19	0.1909
D:4	0.1909	0.1922	0.1938
Delta 1:4	-0.0026	-0.0022	-0.0029
D_o (calc)	0.1857	0.1878	0.1880



Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**
		Load Increment (psf):	**450**

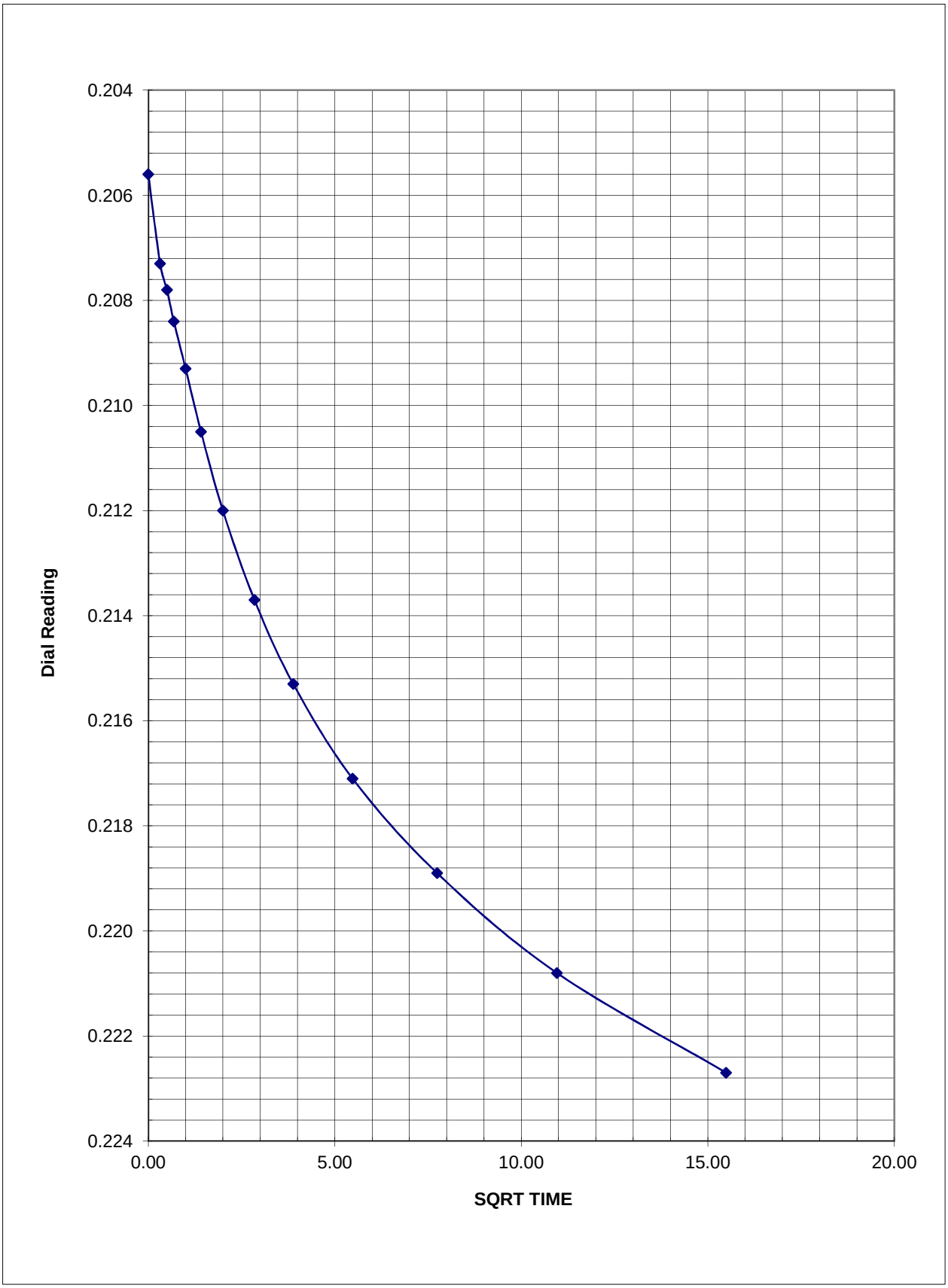
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**

Load Increment (psf):	**700**

Target Time sec/min/hr	**Recorded Time**	**Actual Time (min)**	**SQRT TIME (min)**	**Dial Reading**
Start		0.01	0.00	***0.2056***
6s		0.1	0.32	0.2073
15s		0.25	0.50	0.2078
30s		0.47	0.69	0.2084
1 min		1	1.00	0.2093
2 min		2	1.41	0.2105
4 min		4	2.00	0.2120
8 min		8.1	2.85	0.2137
15 min		15.1	3.89	0.2153
30 min		30	5.48	0.2171
1hr		60	7.75	0.2189
2 hr		120	10.95	0.2208
4 hr		240	15.49	0.2227
8 hr				
16 hr				
24 hr				

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.2078	0.2084	0.2093
D:4	0.2093	0.2105	0.2120
Delta 1:4	-0.0015	-0.0021	-0.0027
D_o (calc)	0.2063	0.2063	0.2066



Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**
		Load Increment (psf):	**700**

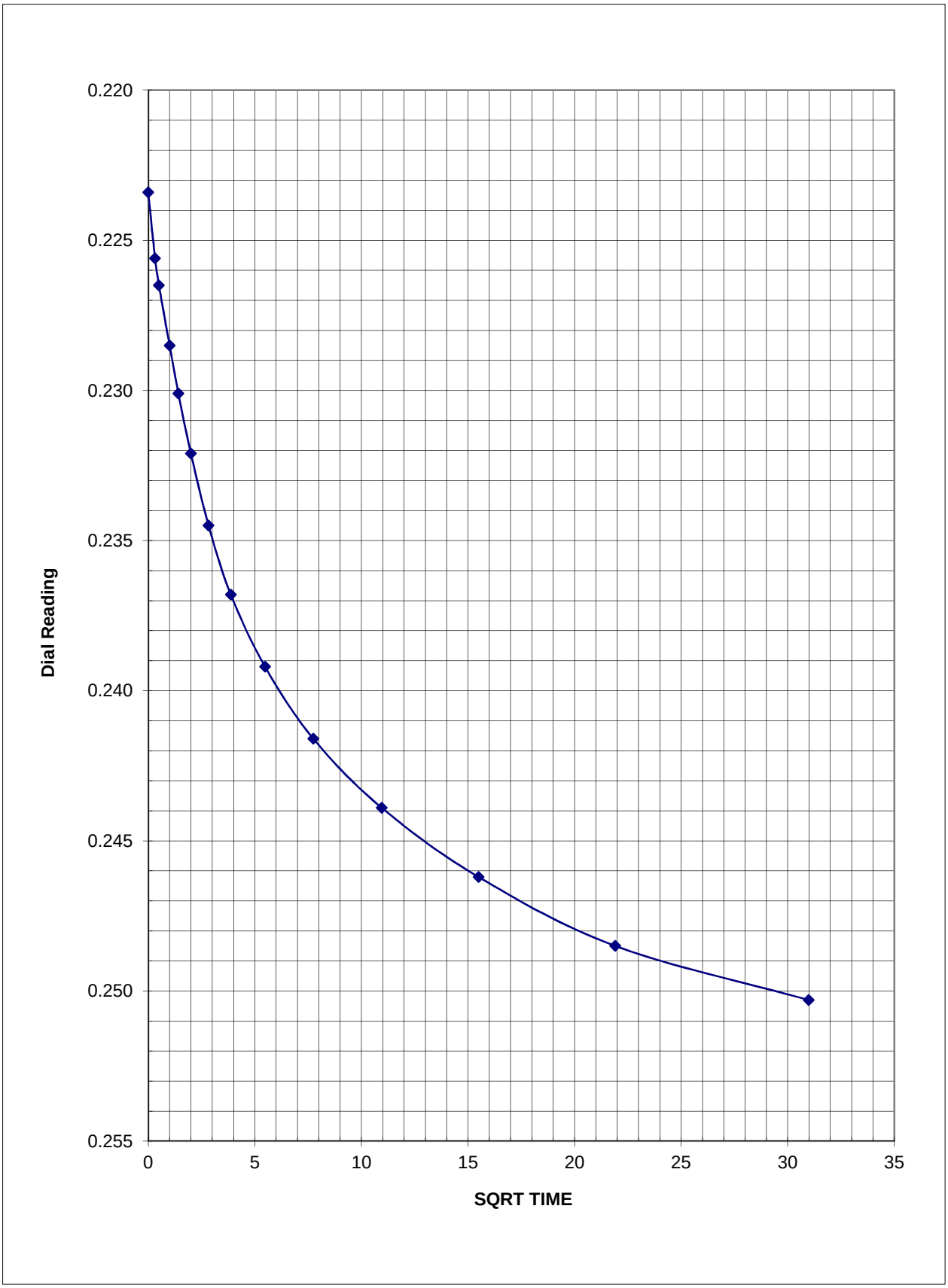
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**

Load Increment (psf):	**1050**

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.01	0.00	***0.2234***
6s		0.1	0.32	0.2256
15s		0.25	0.50	0.2265
30s		1	1.00	0.2285
1 min		2	1.41	0.2301
2 min		4	2.00	0.2321
4 min		8	2.83	0.2345
8 min		15	3.87	0.2368
15 min		30	5.48	0.2392
30 min		60	7.75	0.2416
1hr		120	10.95	0.2439
2 hr		240	15.49	0.2462
4 hr		480	21.91	0.2485
8 hr		960	30.98	0.2503
16 hr				
24 hr				

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.2265	0.2285	0.2301
D:4	0.2301	0.2321	0.2345
Delta 1:4	-0.0036	-0.0036	-0.0044
D_o (calc)	0.2229	0.2249	0.2257



Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**
		Load Increment (psf):	**1050**

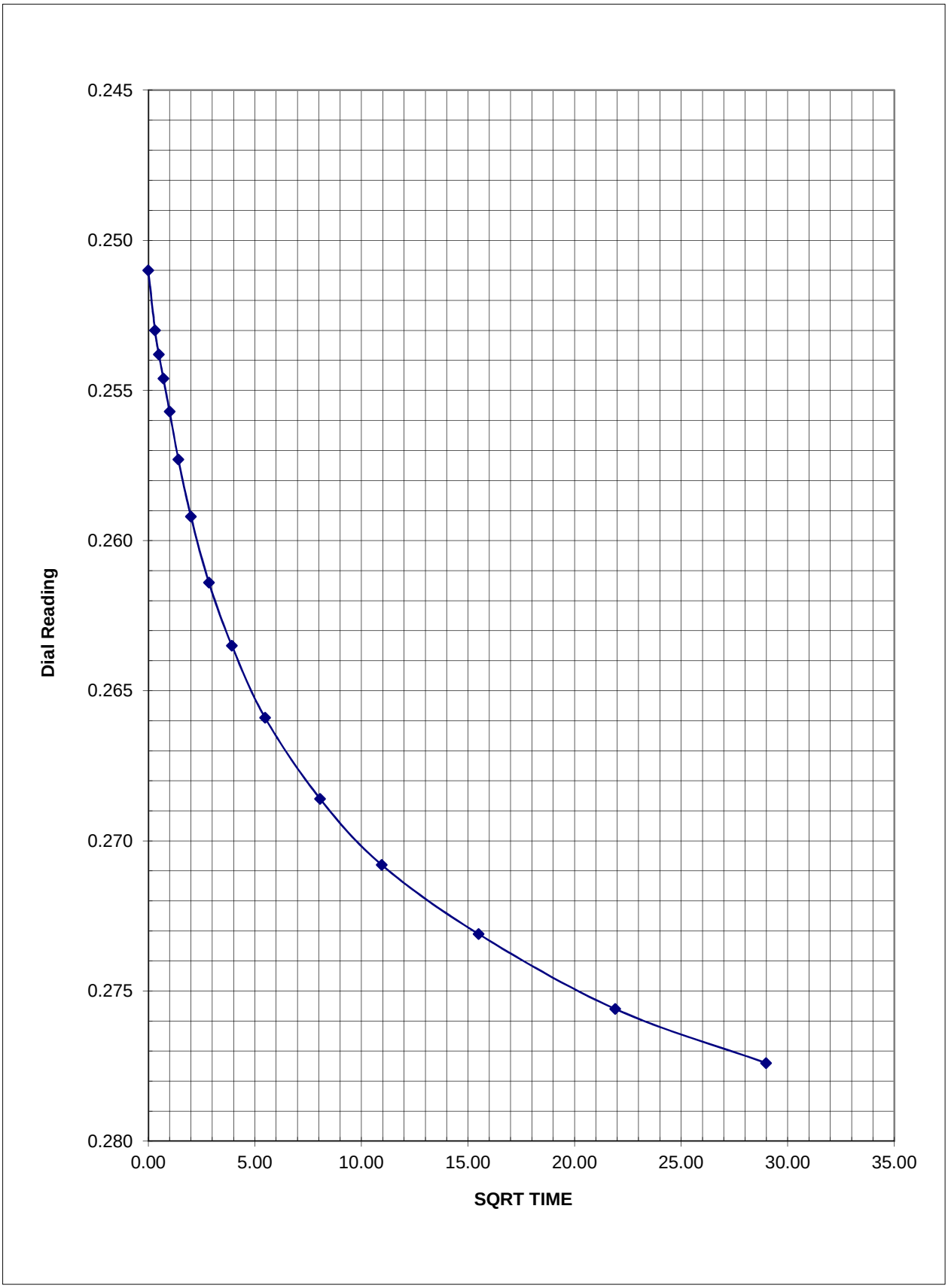
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**

Load Increment (psf):	**1625**

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.01	0.00	***0.2510***
6s		0.1	0.32	0.2530
15s		0.25	0.50	0.2538
30s		0.5	0.71	0.2546
1 min		1	1.00	0.2557
2 min		2	1.41	0.2573
4 min		4	2.00	0.2592
8 min		8.1	2.85	0.2614
15 min		15.4	3.92	0.2635
30 min		30	5.48	0.2659
1hr		65	8.06	0.2686
2 hr		120	10.95	0.2708
4 hr		240	15.49	0.2731
8 hr		480	21.91	0.2756
16 hr		840	28.98	0.2774
24 hr				

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.2538	0.2546	0.2557
D:4	0.2557	0.2573	0.2592
Delta 1:4	-0.0019	-0.0027	-0.0035
D_o (calc)	0.2519	0.2519	0.2522



Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**
		Load Increment (psf):	**1625**

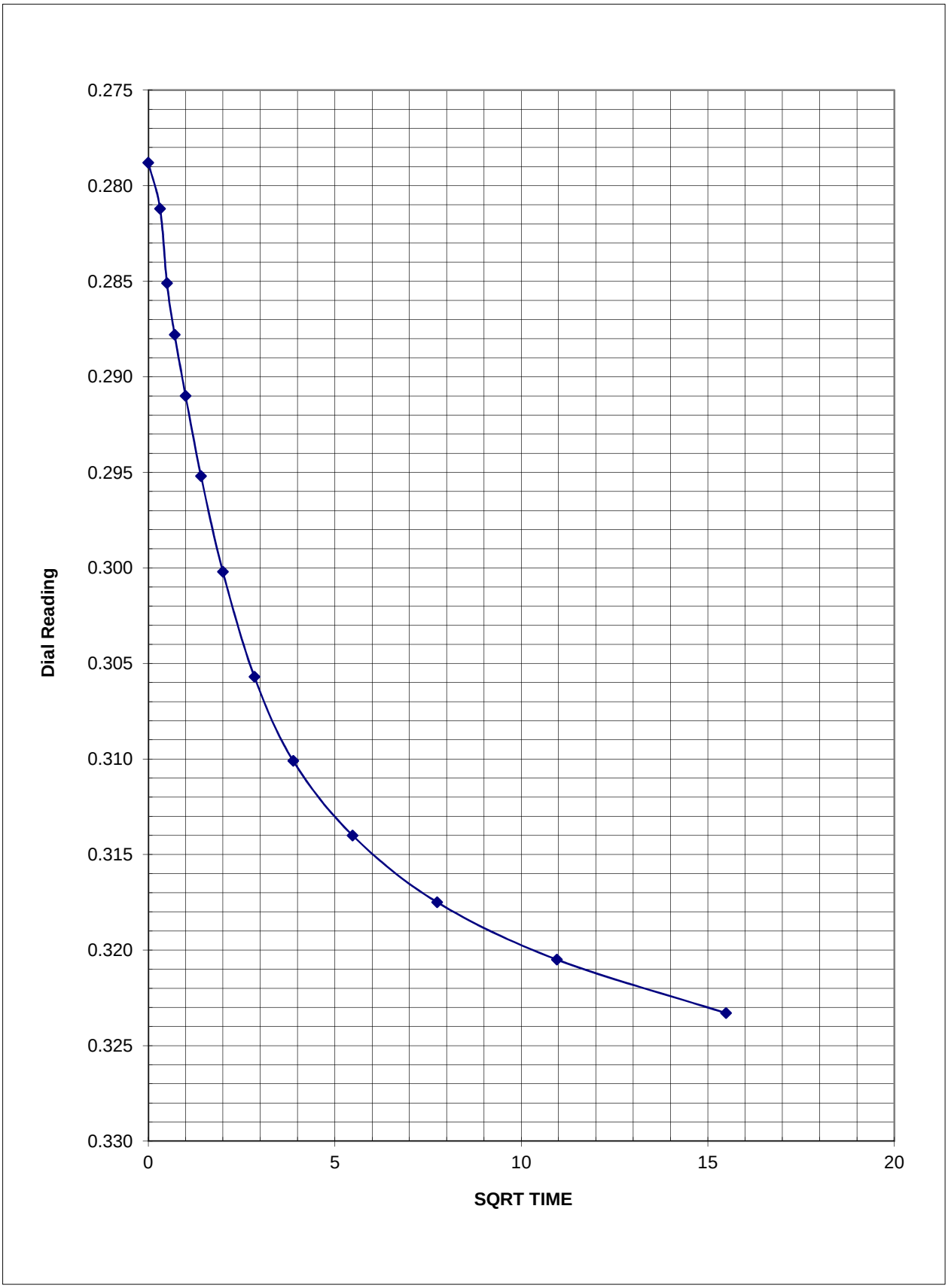
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**

Load Increment (psf):	**3200**

Target Time sec/min/hr	**Recorded Time**	**Actual Time (min)**	**SQRT TIME (min)**	**Dial Reading**
Start		0.01	0.00	***0.2788***
6s		0.1	0.32	0.2812
15s		0.25	0.50	0.2851
30s		0.5	0.71	0.2878
1 min		1	1.00	0.2910
2 min		2	1.41	0.2952
4 min		4	2.00	0.3002
8 min		8.1	2.85	0.3057
15 min		15.1	3.89	0.3101
30 min		30	5.48	0.3140
1hr		60	7.75	0.3175
2 hr		120	10.95	0.3205
4 hr		240	15.49	0.3233
8 hr				
16 hr				
24 hr				

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.2851	0.2878	0.2910
D:4	0.2910	0.2952	0.3002
Delta 1:4	-0.0059	-0.0074	-0.0092
D_o (calc)	0.2792	0.2804	0.2818



Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**
		Load Increment (psf):	**3200**

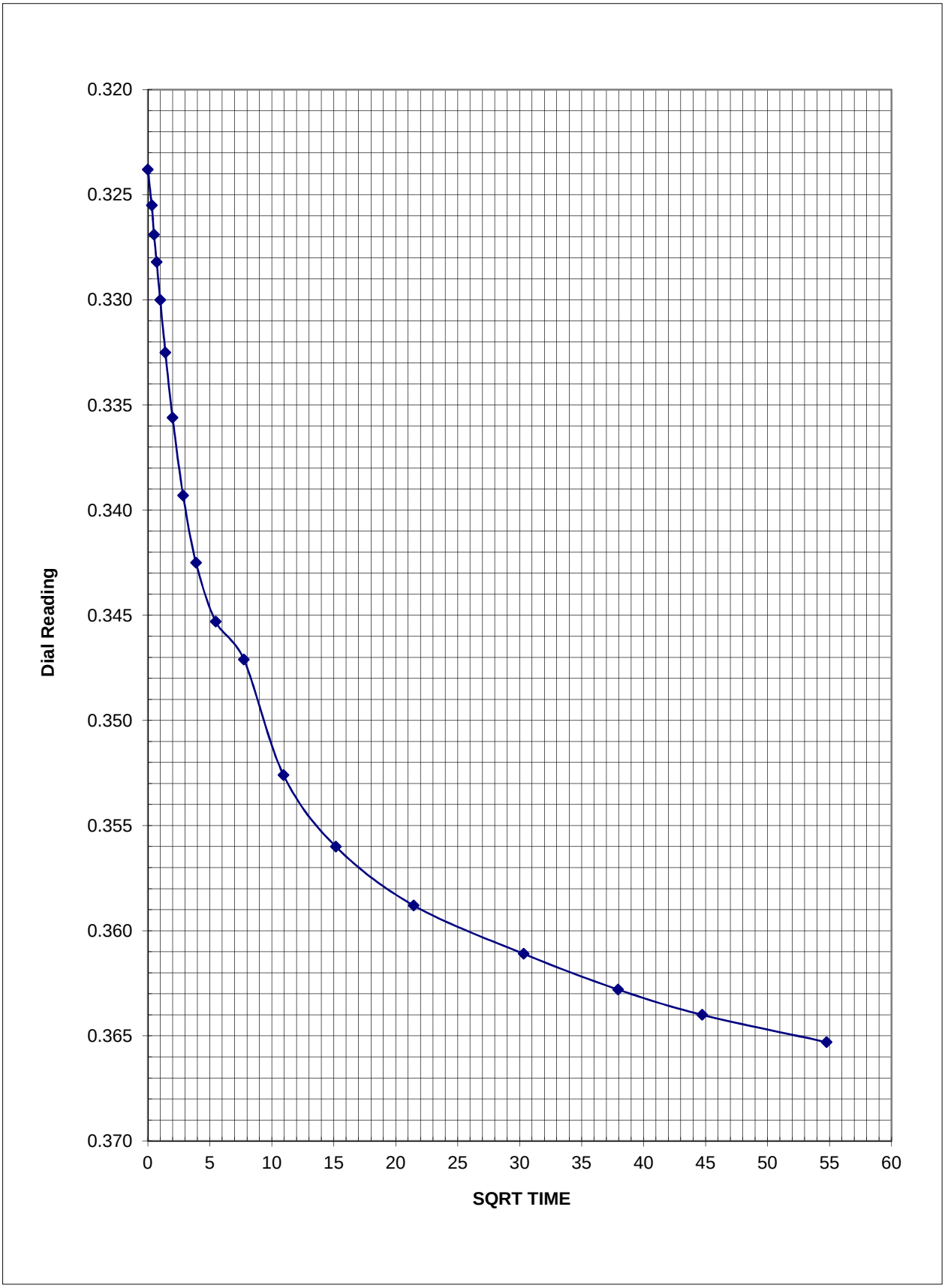
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**

Load Increment (psf):	**4800**

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.01	0.00	***0.3238***
6s		0.1	0.32	0.3255
15s		0.25	0.50	0.3269
30s		0.5	0.71	0.3282
1 min		1	1.00	0.3300
2 min		2	1.41	0.3325
4 min		4	2.00	0.3356
8 min		8.1	2.85	0.3393
15 min		15.1	3.89	0.3425
30 min		30	5.48	0.3453
1hr		60	7.75	0.3471
2 hr		120	10.95	0.3526
4 hr		230	15.17	0.3560
8 hr		460	21.45	0.3588
16 hr		920	30.33	0.3611
24 hr		1440	37.95	0.3628
		2000	44.72	0.3640
		3000	54.77	0.3653

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.3269	0.3282	0.3300
D:4	0.3300	0.3325	0.3356
Delta 1:4	-0.0031	-0.0043	-0.0056
D_o (calc)	0.3238	0.3239	0.3244



Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**
		Load Increment (psf):	**4800**

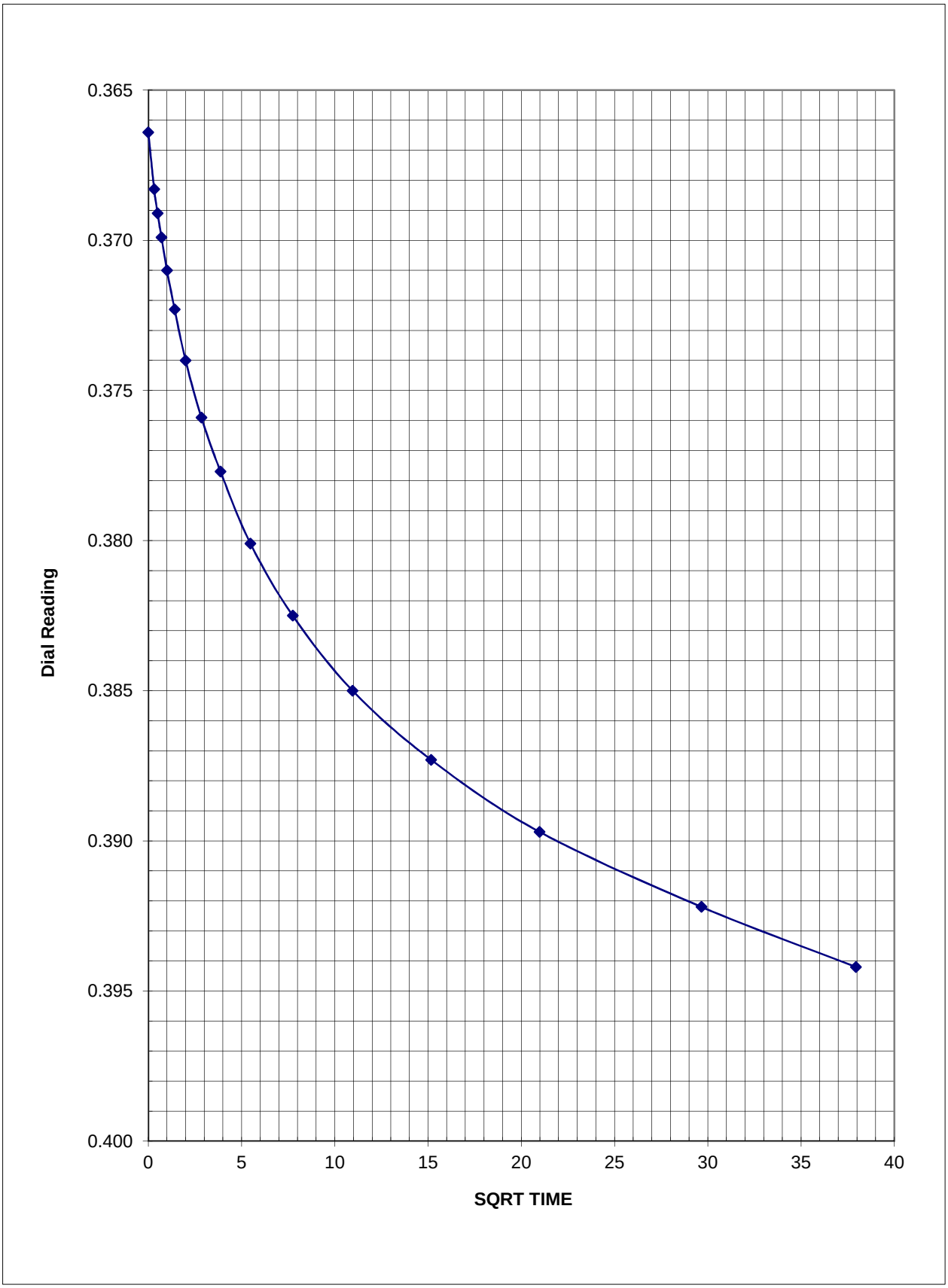
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**

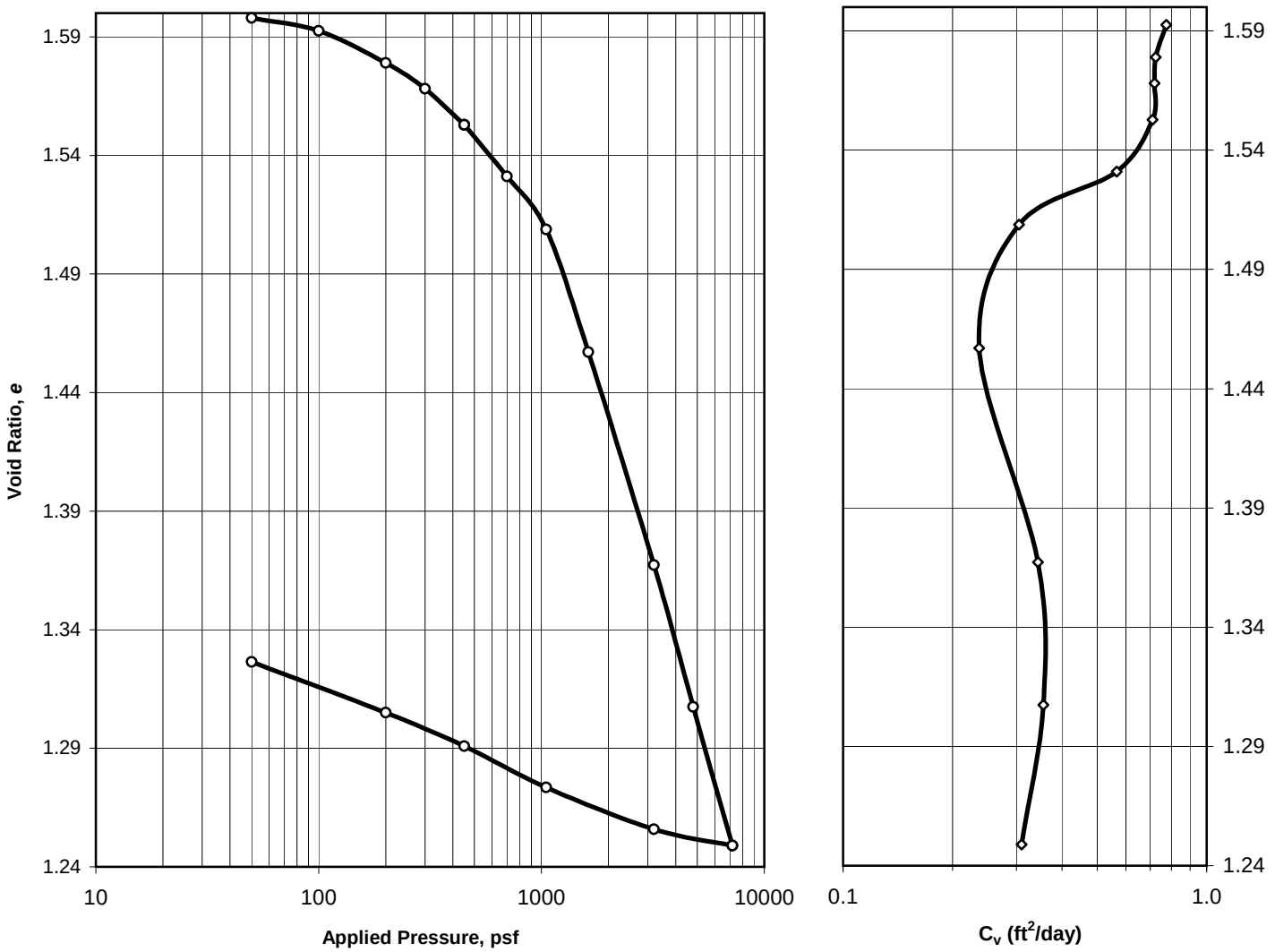
Load Increment (psf):	**7200**

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.01	0.00	***0.3664***
6s		0.1	0.32	0.3683
15s		0.25	0.50	0.3691
30s		0.5	0.71	0.3699
1 min		1	1.00	0.3710
2 min		2	1.41	0.3723
4 min		4	2.00	0.3740
8 min		8.1	2.85	0.3759
15 min		15	3.87	0.3777
30 min		30	5.48	0.3801
1hr		60	7.75	0.3825
2 hr		120	10.95	0.3850
4 hr		230	15.17	0.3873
8 hr		440	20.98	0.3897
16 hr		880	29.66	0.3922
24 hr		1440	37.95	0.3942

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.3691	0.3699	0.3710
D:4	0.3710	0.3723	0.3740
Delta 1:4	-0.0019	-0.0024	-0.0030
D_o (calc)	0.3672	0.3675	0.3680



Project:	**107510**	**Sample:**	**SPT1**
Date:	**1/7/2010**	**Depth (ft):**	**14**
		Load Increment (psf):	**7200**



Boring	Sample	Depth (ft)	LL	PL	Spec Gravity	Sample Description
SPT-1	18.5-20.5	20	53	36	2.7	Gray SILT (MH)

	Moisture Content (%)	Dry Density (pcf)	Void Ratio	Satruation (%)
INITIAL	64.6	64.9	1.598	109.2
FINAL	48.1	72.4	1.326	--

Recompresion Index $Cr^{(1)}$	Compression Index $Cc^{(1)}$	$Est^{(1)}$ Preconsolidation Pressure, Po' (pcf)
N/A	N/A	N/A

SAMPLE PREPARATION: ☐ Remolded ☑ Intact

(1) Estimated preconsolidation pressure and index values (Cr/Cc) generally based on Casagrande Method.

KLEINFELDER
Bright People. Right Solutions.

Test Date:	8-Mar-10
Tested By:	RPG
Checked By:	SAS
File:	SPT-1@20.0' Consol
PROJECT NO.:	107510
Lab No.:	2592

CONSOLIDATION TEST

Arkema Early Action
Portland, Oregon

LOAD INCREMENT WORK SHEET

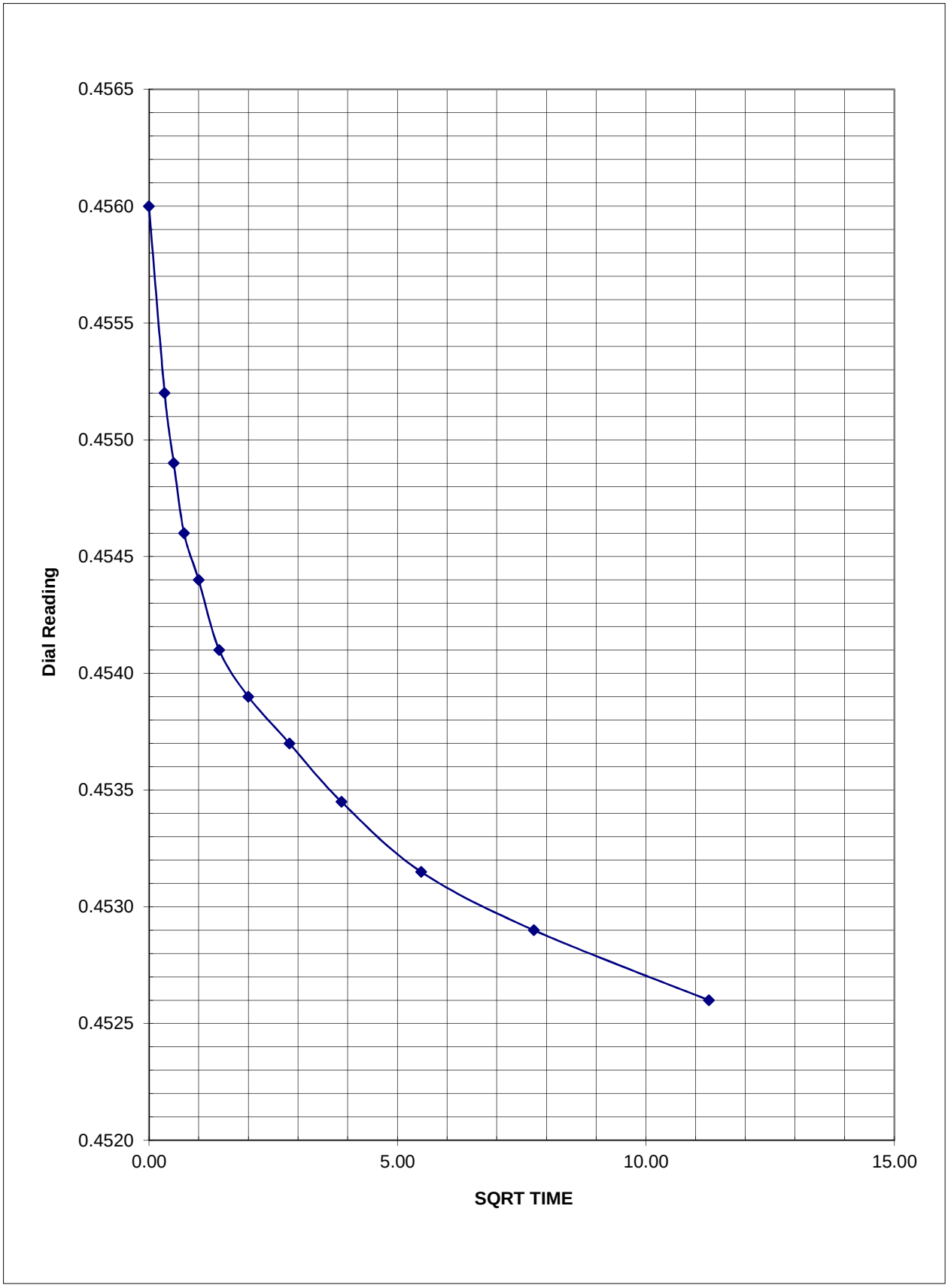
Project: 107510 **Sample:** SPT1
Date: 2/26/2010 **Depth (ft):** 20

Load Increment (psf):	100

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.4560***
6s	target	0.1	0.32	0.4552
15s	target	0.25	0.50	0.4549
30s	target	0.5	0.71	0.4546
1 min	target	1	1.00	0.4544
2 min	target	2	1.41	0.4541
4 min	target	4	2.00	0.4539
8 min	target	8	2.83	0.4537
15 min	stop	15	3.87	0.4535
30 min		30	5.48	0.4532
1hr		60	7.75	0.4529
2 hr	2:07	127	11.27	0.4526
4 hr			0.00	
8 hr			0.00	
16 hr			0.00	
24 hr			0.00	

Log-Time D_o Calculation

Time Ratio	$(1:4)_{@0.25}$	$(1:4)_{@0.5}$	$(1:4)_{@1.0}$
D:1	0.4549	0.4546	0.4544
D:4	0.4544	0.4541	0.4539
Delta 1:4	0.0005	0.0005	0.0005
D_o (calc)	0.4554	0.4551	0.4549



Project: 107510 **Sample:** SPT-1

Date: 2/26/2010 **Depth (ft):** 20

Load Increment (psf): 100

LOAD INCREMENT WORK SHEET

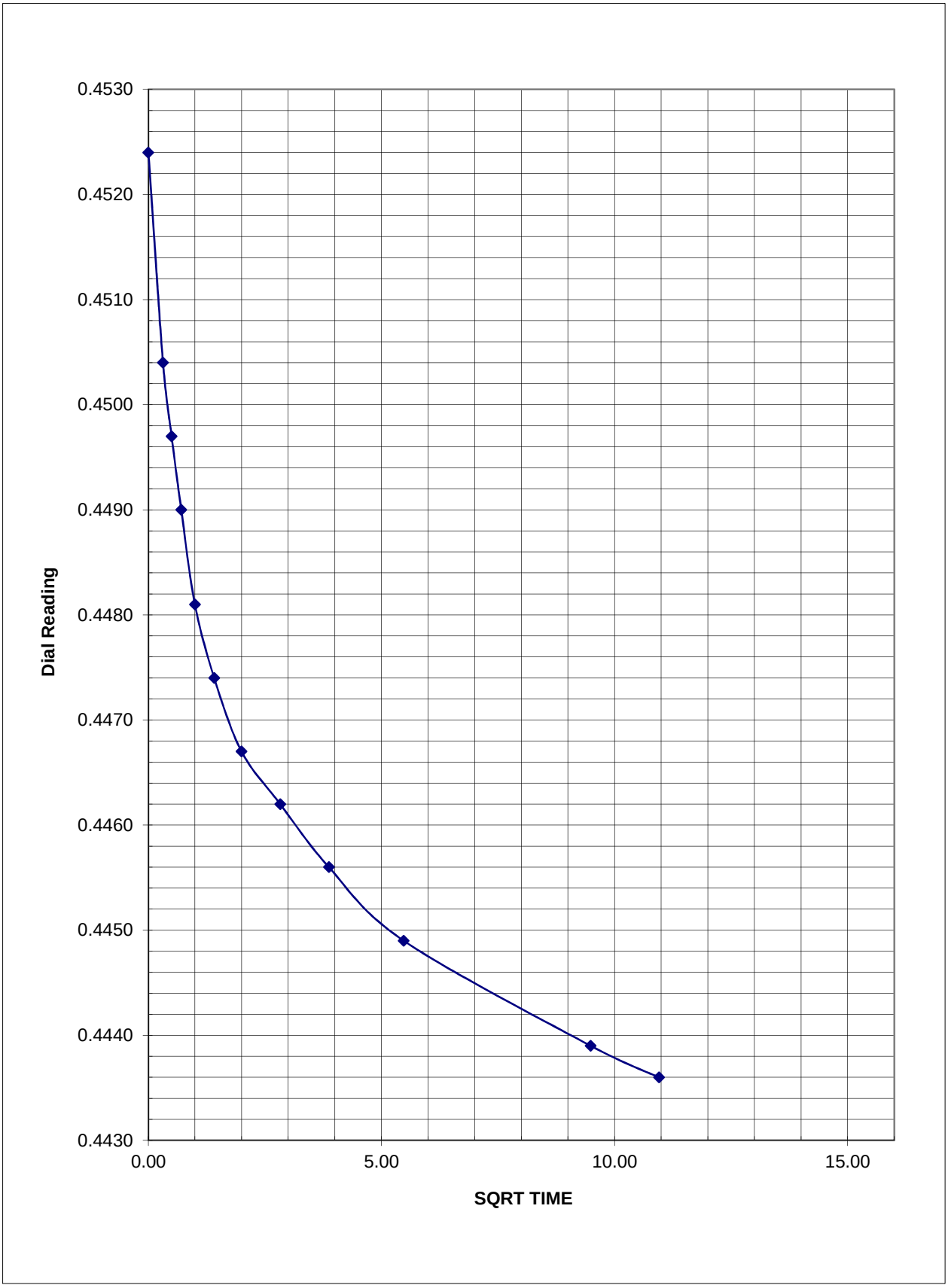
Project: 107510 **Sample:** SPT-1
Date: 2/26/2010 **Depth (ft):** 20

Load Increment (psf): 200

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start	0.0001	0.0001	0.00	***0.4524***
6s	0.1	0.1	0.32	0.4504
15s	0.25	0.25	0.50	0.4497
30s	0.5	0.5	0.71	0.4490
1 min		1	1.00	0.4481
2 min		2	1.41	0.4474
4 min		4	2.00	0.4467
8 min		8	2.83	0.4462
15 min		15	3.87	0.4456
30 min		30	5.48	0.4449
1hr	90	90	9.49	0.4439
2 hr		120	10.95	0.4436
4 hr		240	15.49	
8 hr			0.00	
16 hr			0.00	
24 hr			0.00	

Log-Time D_o Calculation

Time Ratio	$(1:4)_{@0.25}$	$(1:4)_{@0.5}$	$(1:4)_{@1.0}$
D:1	0.4497	0.449	0.4481
D:4	0.4481	0.4474	0.4467
Delta 1:4	0.0016	0.0016	0.0014
D_o (calc)	0.4513	0.4506	0.4495



Project:	**107510**	**Sample:**	**SPT-1**
Date:	**2/26/2010**	**Depth (ft):**	**20**
		Load Increment (psf):	**200**

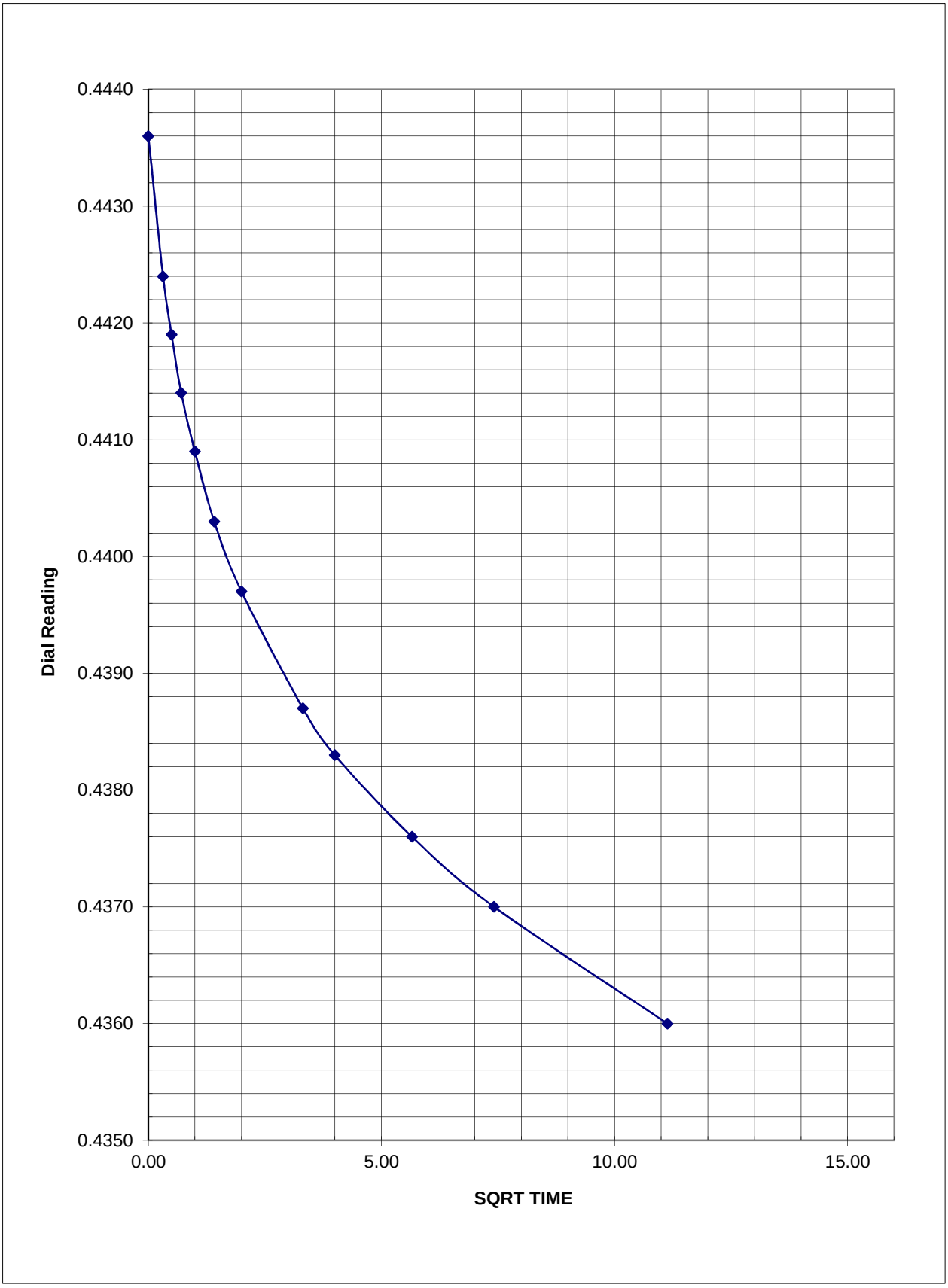
LOAD INCREMENT WORK SHEET

Project: 107510 **Sample:** SPT1
Date: 2/26/2010 **Depth (ft):** 20

Load Increment (psf):	300

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.4436***
6s		0.1	0.32	0.4424
15s		0.25	0.50	0.4419
30s		0.5	0.71	0.4414
1 min		1	1.00	0.4409
2 min		2	1.41	0.4403
4 min		4	2.00	0.4397
8 min	11	11	3.32	0.4387
15 min	16	16	4.00	0.4383
30 min	32	32	5.66	0.4376
1hr	55	55	7.42	0.4370
2 hr	124	124	11.14	0.4360
4 hr		1021	31.95	
8 hr		496	22.27	
16 hr		1359	36.86	
24 hr		1550	39.37	

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.4419	0.4414	0.4409
D:4	0.4409	0.4403	0.4397
Delta 1:4	0.001	0.0011	0.0012
D_o (calc)	0.4429	0.4425	0.4421



Project:	**107510**	**Sample:**	**SPT1**
Date:	**2/26/2010**	**Depth (ft):**	**20**
		Load Increment (psf):	**300**

LOAD INCREMENT WORK SHEET

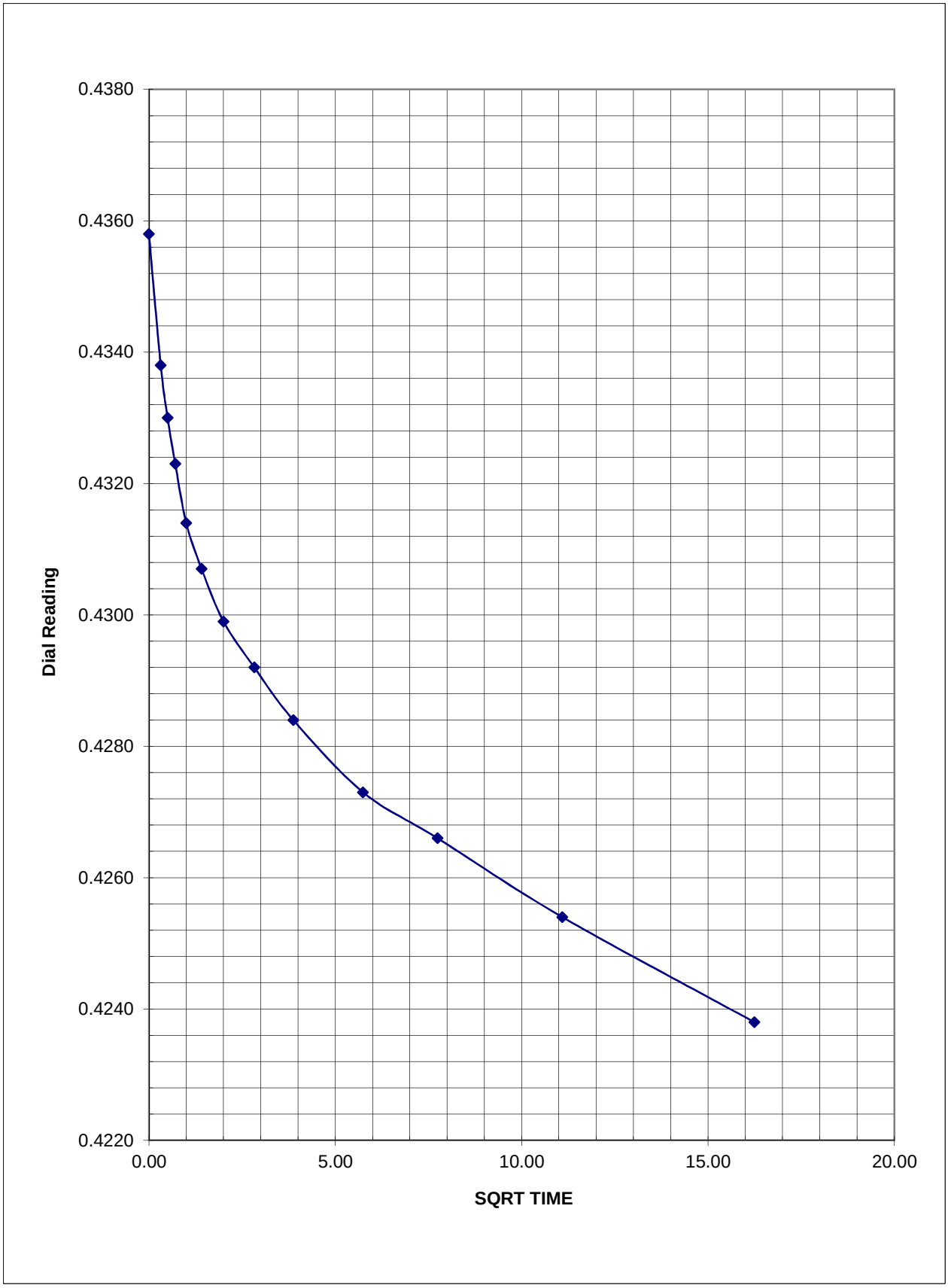
Project: 107510 **Sample:** SPT1
Date: 3/1/2010 **Depth (ft):** 20

Load Increment (psf): 450

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.4358***
6s		0.1	0.32	0.4338
15s		0.25	0.50	0.4330
30s		0.5	0.71	0.4323
1 min		1	1.00	0.4314
2 min		2	1.41	0.4307
4 min		4	2.00	0.4299
8 min		8	2.83	0.4292
15 min		15	3.87	0.4284
30 min	33	33	5.74	0.4273
1hr		60	7.75	0.4266
2 hr	2:03	123	11.09	0.4254
4 hr	4:24	264	16.25	0.4238
8 hr		336	18.33	
16 hr		1359	36.86	
24 hr		1550	39.37	

Log-Time D_o Calculation

Time Ratio	$(1:4)_{@0.25}$	$(1:4)_{@0.5}$	$(1:4)_{@1.0}$
D:1	0.4330	0.4323	0.4314
D:4	0.4314	0.4307	0.4299
Delta 1:4	0.0016	0.0016	0.0015
D_o (calc)	0.4346	0.4339	0.4329



Project:	**107510**	**Sample:**	**SPT1**
Date:	**3/1/2010**	**Depth (ft):**	**20**
		Load Increment (psf):	**450**

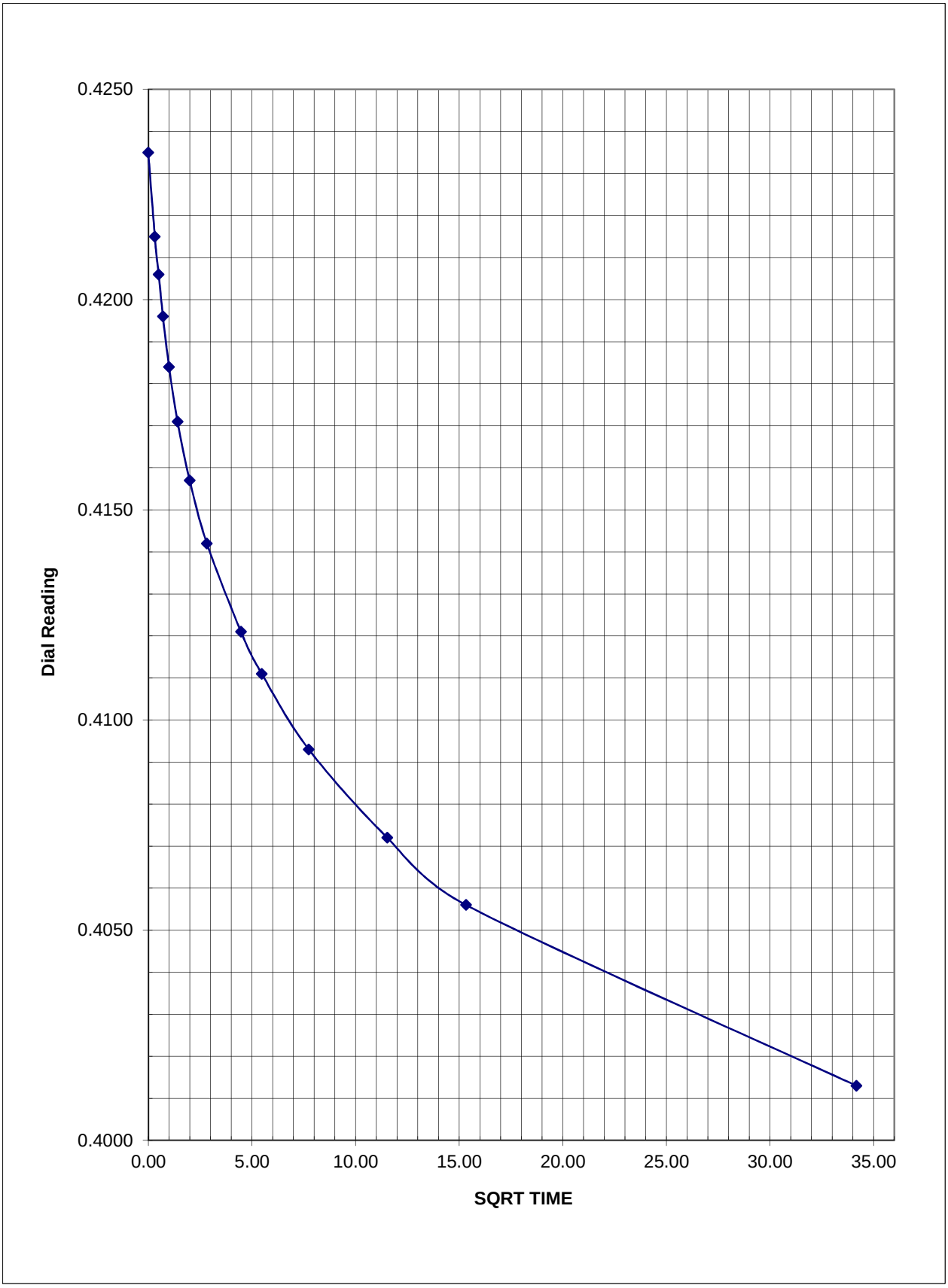
LOAD INCREMENT WORK SHEET

Project: 107510 **Sample:** SPT1
Date: 3/1/2010 **Depth (ft):** 20

Load Increment (psf):	700

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.4235***
6s		0.1	0.32	0.4215
15s		0.25	0.50	0.4206
30s		0.5	0.71	0.4196
1 min		1	1.00	0.4184
2 min		2	1.41	0.4171
4 min		4	2.00	0.4157
8 min		8	2.83	0.4142
15 min	20	20	4.47	0.4121
30 min		30	5.48	0.4111
1hr		60	7.75	0.4093
2 hr	2:13	133	11.53	0.4072
4 hr	3:55	235	15.33	0.4056
8 hr	19:28	1168	34.18	0.4013
16 hr		1359	36.86	
24 hr		1550	39.37	

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.4206	0.4196	0.4184
D:4	0.4184	0.4171	0.4157
Delta 1:4	0.0022	0.0025	0.0027
D_o (calc)	0.4228	0.4221	0.4211



Project:	**107510**	**Sample:**	**SPT-1**
Date:	**3/1/2010**	**Depth (ft):**	**20**
		Load Increment (psf):	**700**

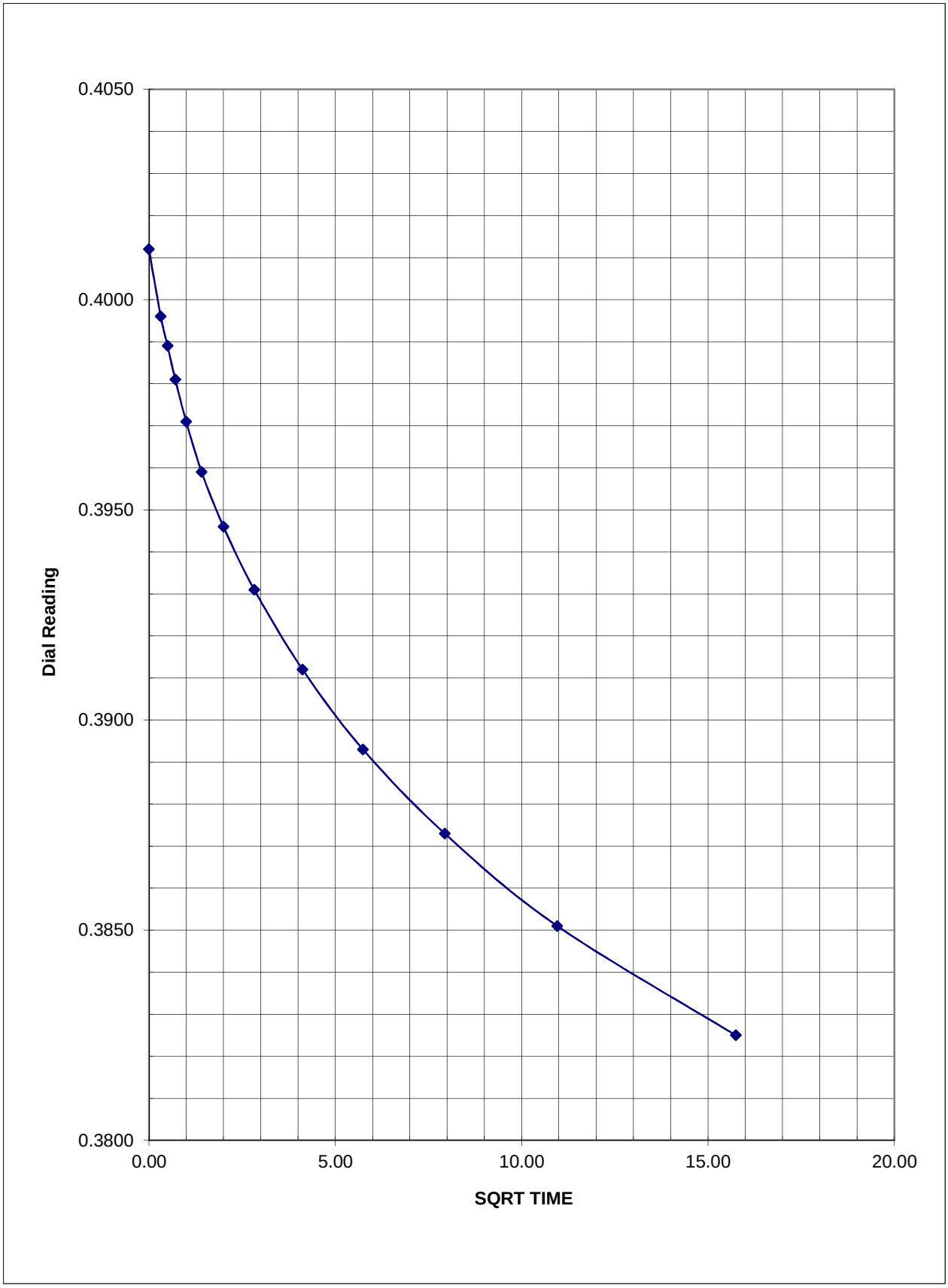
LOAD INCREMENT WORK SHEET

Project: 107510 **Sample:** SPT1
Date: 3/2/2010 **Depth (ft):** 20

Load Increment (psf):	1050

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.4012***
6s		0.1	0.32	0.3996
15s		0.25	0.50	0.3989
30s		0.5	0.71	0.3981
1 min		1	1.00	0.3971
2 min		2	1.41	0.3959
4 min		4	2.00	0.3946
8 min		8	2.83	0.3931
15 min	17	17	4.12	0.3912
30 min	33	33	5.74	0.3893
1hr	63	63	7.94	0.3873
2 hr		120	10.95	0.3851
4 hr	4:08	248	15.75	0.3825
8 hr		453	21.28	
16 hr		1390	37.28	
24 hr		1550	39.37	

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.3989	0.3981	0.3971
D:4	0.3971	0.3959	0.3946
Delta 1:4	0.0018	0.0022	0.0025
D_o (calc)	0.4007	0.4003	0.3996



Project:	**107510**	**Sample:**	**SPT1**
Date:	**3/2/2010**	**Depth (ft):**	**20**
		Load Increment (psf):	**1050**

LOAD INCREMENT WORK SHEET

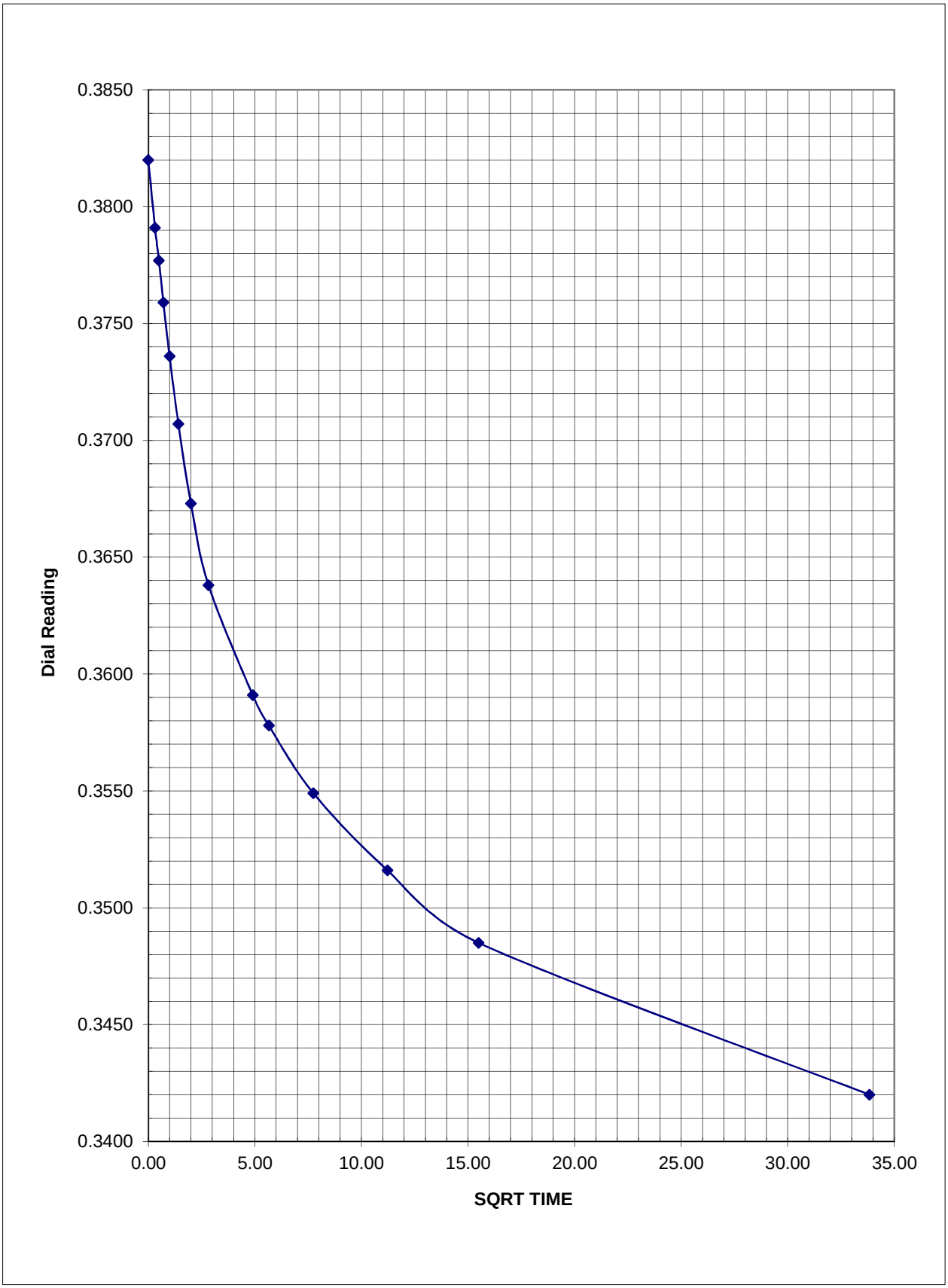
Project: 107510 **Sample:** SPT1
Date: 3/2/2010 **Depth (ft):** 20

Load Increment (psf): 1625

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.3820***
6s		0.1	0.32	0.3791
15s		0.25	0.50	0.3777
30s		0.5	0.71	0.3759
1 min		1	1.00	0.3736
2 min		2	1.41	0.3707
4 min		4	2.00	0.3673
8 min		8	2.83	0.3638
15 min	24	24	4.90	0.3591
30 min	32	32	5.66	0.3578
1hr		60	7.75	0.3549
2 hr	2:06	126	11.22	0.3516
4 hr		240	15.49	0.3485
8 hr	19:05	1145	33.84	0.3420
16 hr		1359	36.86	
24 hr		1550	39.37	

Log-Time D_o Calculation

Time Ratio	$(1:4)_{@0.25}$	$(1:4)_{@0.5}$	$(1:4)_{@1.0}$
D:1	0.3777	0.3759	0.3736
D:4	0.3736	0.3707	0.3673
Delta 1:4	0.0041	0.0052	0.0063
D_o (calc)	0.3818	0.3811	0.3799



Project: 107510 **Sample:** SPT1

Date: 3/2/2010 **Depth (ft):** 20

Load Increment (psf): 1625

LOAD INCREMENT WORK SHEET

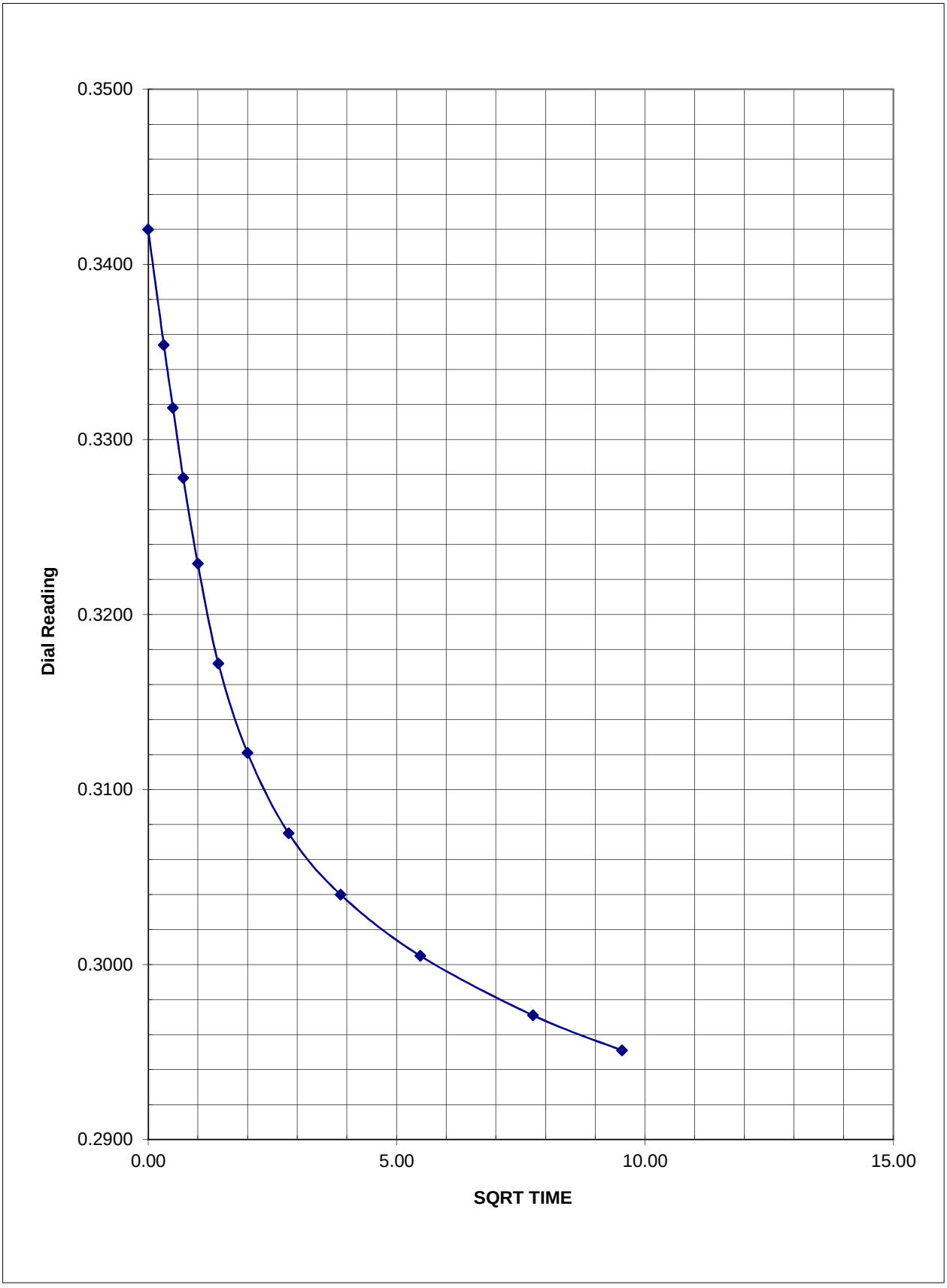
Project: 107510 **Sample:** SPT1
Date: 3/3/2010 **Depth (ft):** 20

Load Increment (psf): 3200

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.3420***
6s		0.1	0.32	0.3354
15s		0.25	0.50	0.3318
30s		0.5	0.71	0.3278
1 min		1	1.00	0.3229
2 min		2	1.41	0.3172
4 min		4	2.00	0.3121
8 min		8	2.83	0.3075
15 min		15	3.87	0.3040
30 min		30	5.48	0.3005
1hr		60	7.75	0.2971
2 hr	1:31	91	9.54	0.2951
4 hr		210	14.49	
8 hr		496	22.27	
16 hr		1359	36.86	
24 hr		1550	39.37	

Log-Time D_o Calculation

Time Ratio	$(1:4)_{@0.25}$	$(1:4)_{@0.5}$	$(1:4)_{@1.0}$
D:1	0.3318	0.3278	0.3229
D:4	0.3229	0.3172	0.3121
Delta 1:4	0.0089	0.0106	0.0108
D_o (calc)	0.3407	0.3384	0.3337



Project: 107510 **Sample:** SPT-1

Date: 3/3/2010 **Depth (ft):** 20

Load Increment (psf): 3200

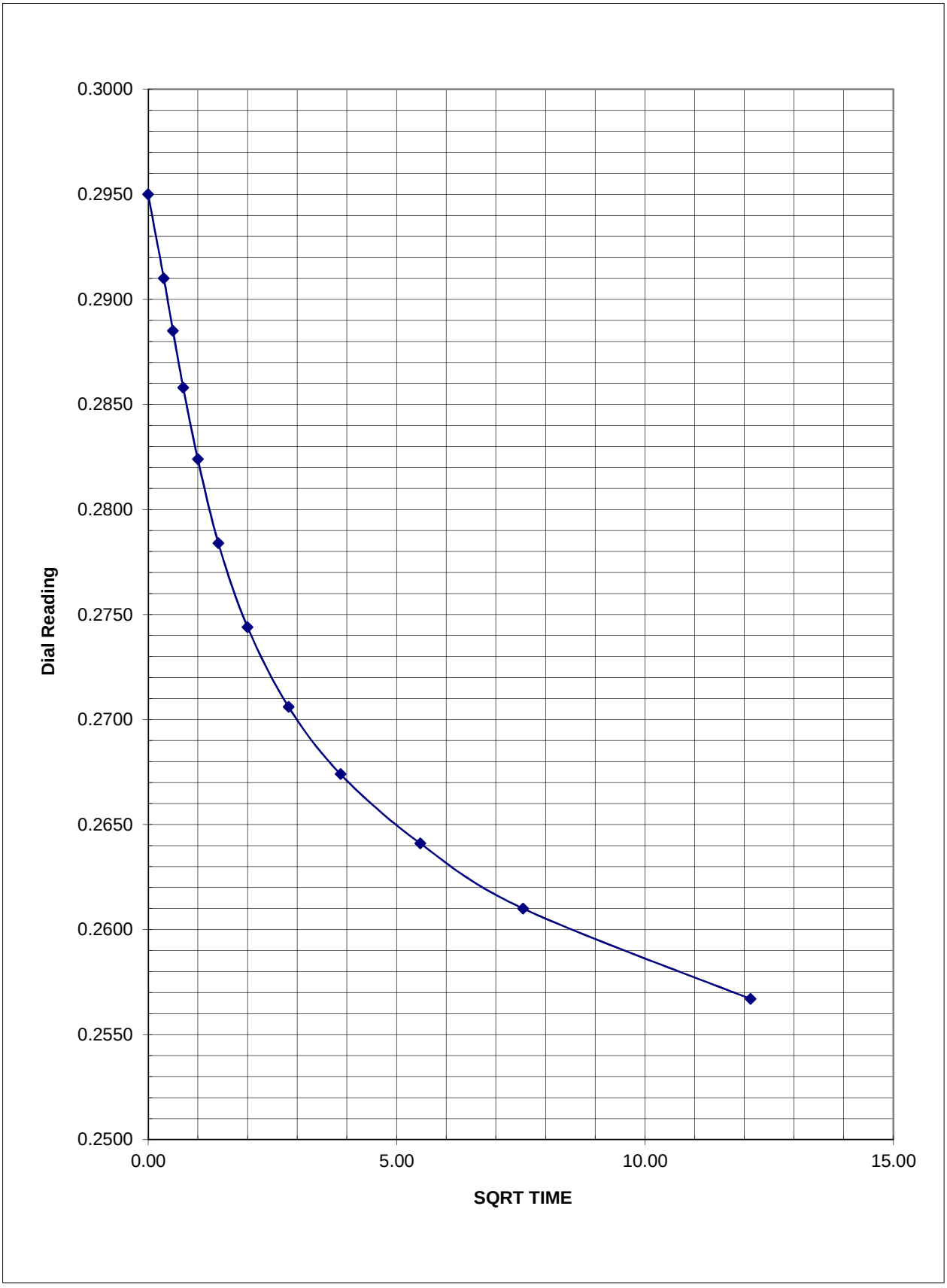
LOAD INCREMENT WORK SHEET

Project: 107510 **Sample:** SPT1
Date: 3/3/2010 **Depth (ft):** 20

Load Increment (psf):	4800

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.2950***
6s		0.1	0.32	0.2910
15s		0.25	0.50	0.2885
30s		0.5	0.71	0.2858
1 min		1	1.00	0.2824
2 min		2	1.41	0.2784
4 min		4	2.00	0.2744
8 min		8	2.83	0.2706
15 min		15	3.87	0.2674
30 min		30	5.48	0.2641
1hr	57	57	7.55	0.2610
2 hr	2:27	147	12.12	0.2567
4 hr		240	15.49	
8 hr		496	22.27	
16 hr		1359	36.86	
24 hr		1550	39.37	

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.2885	0.2858	0.2824
D:4	0.2824	0.2784	0.2744
Delta 1:4	0.0061	0.0074	0.0080
D_o (calc)	0.2946	0.2932	0.2904



Project: 107510 **Sample:** SPT-1

Date: 3/3/2010 **Depth (ft):** 20

Load Increment (psf): 4800

LOAD INCREMENT WORK SHEET

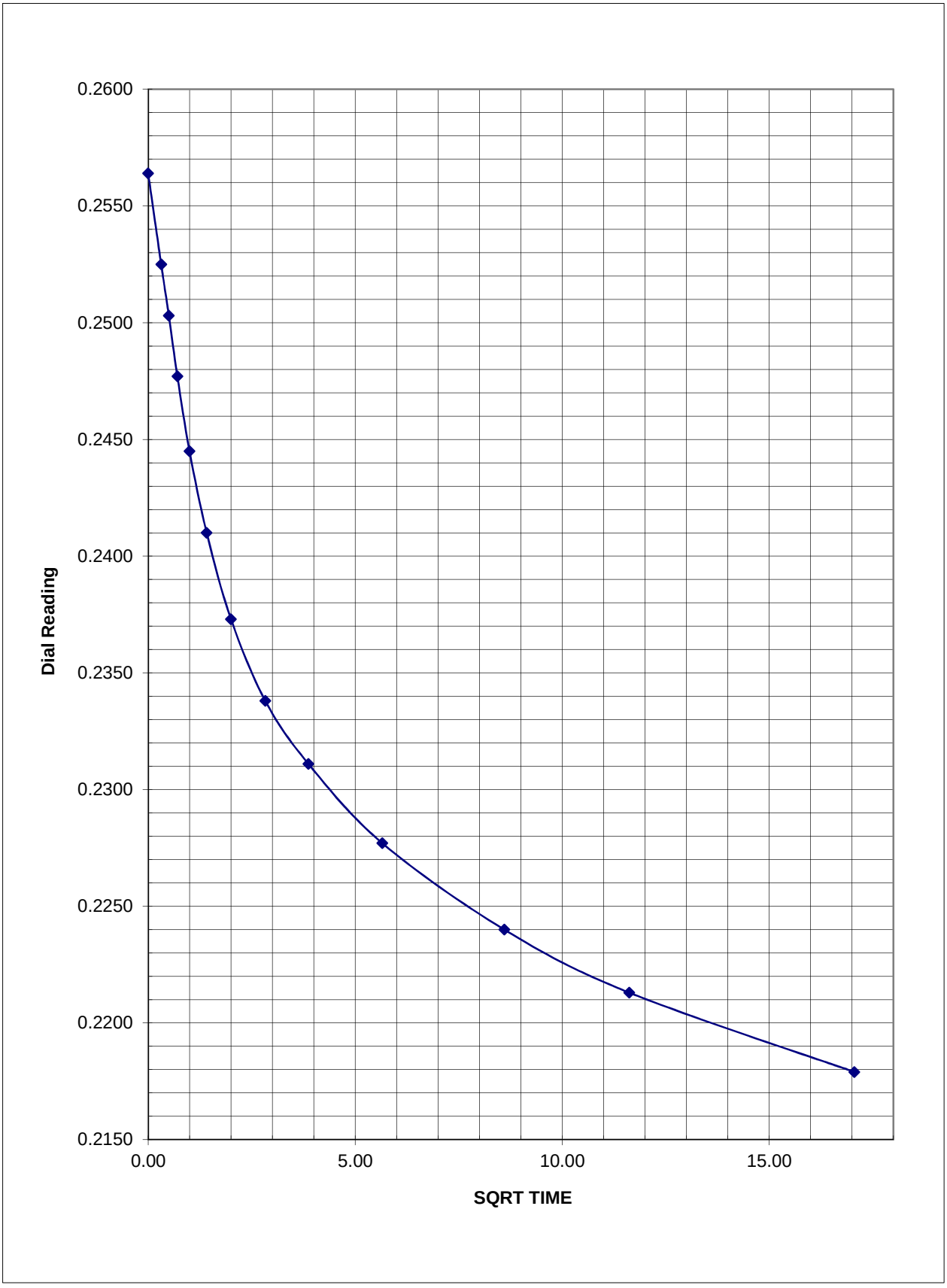
Project: 107510 **Sample:** SPT1
Date: 3/3/2010 **Depth (ft):** 20

Load Increment (psf): 7200

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.2564***
6s		0.1	0.32	0.2525
15s		0.25	0.50	0.2503
30s		0.5	0.71	0.2477
1 min		1	1.00	0.2445
2 min		2	1.41	0.2410
4 min		4	2.00	0.2373
8 min		8	2.83	0.2338
15 min		15	3.87	0.2311
30 min	32	32	5.66	0.2277
1hr	1:14	74	8.60	0.2240
2 hr	2:15	135	11.62	0.2213
4 hr	4:51	291	17.06	0.2179
8 hr	18:11	1091	33.03	
16 hr		1359	36.86	
24 hr		1550	39.37	

Log-Time D_o Calculation

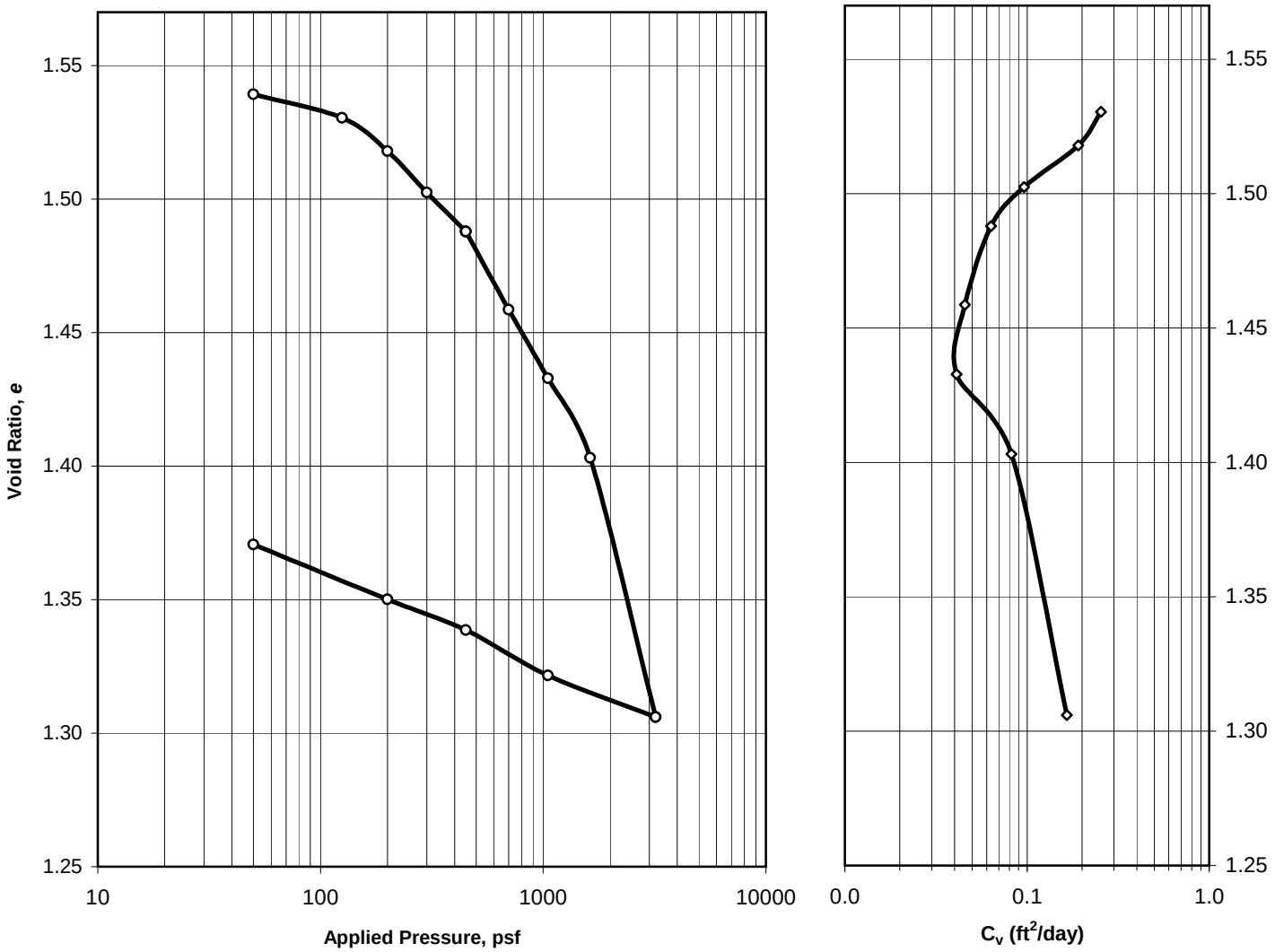
Time Ratio	$(1:4)_{@0.25}$	$(1:4)_{@0.5}$	$(1:4)_{@1.0}$
D:1	0.2503	0.2477	0.2445
D:4	0.2445	0.241	0.2373
Delta 1:4	0.0058	0.0067	0.0072
D_o (calc)	0.2561	0.2544	0.2517



Project: 107510 **Sample:** SPT-1

Date: 3/3/2010 **Depth (ft):** 20

Load Increment (psf): 7200



Boring	Sample	Depth (ft)	LL	PL	Spec Gravity	Sample Description
SPT-2	ARK-SPT-2	22.5-24.5'	73	41	2.661	CH - Fat Clay

	Moisture Content (%)	Dry Density (pcf)	Void Ratio	Satruation (%)
INITIAL	57.1	65.4	1.539	98.7
FINAL	51.6	70.0	1.371	--

Recompresion Index $Cr^{(1)}$	Compression Index $Cc^{(1)}$	Est$^{(1)}$ Preconsolidation Pressure, Po' (pcf)
0.150	0.03	3,900

SAMPLE PREPARATION: ☐ Remolded ☑ Intact

(1) Estimated preconsolidation pressure and index values (Cr/Cc) generally based on Casagrande Method.

KLEINFELDER
Bright People. Right Solutions.

Test Date:	23-Nov-09
Tested By:	RPG
Checked By:	SAS
File:	SPT-2@22.5' Consol
PROJECT NO.: 107510	Lab No.: 2592

CONSOLIDATION TEST

Arkema Early Action
Portland, Oregon

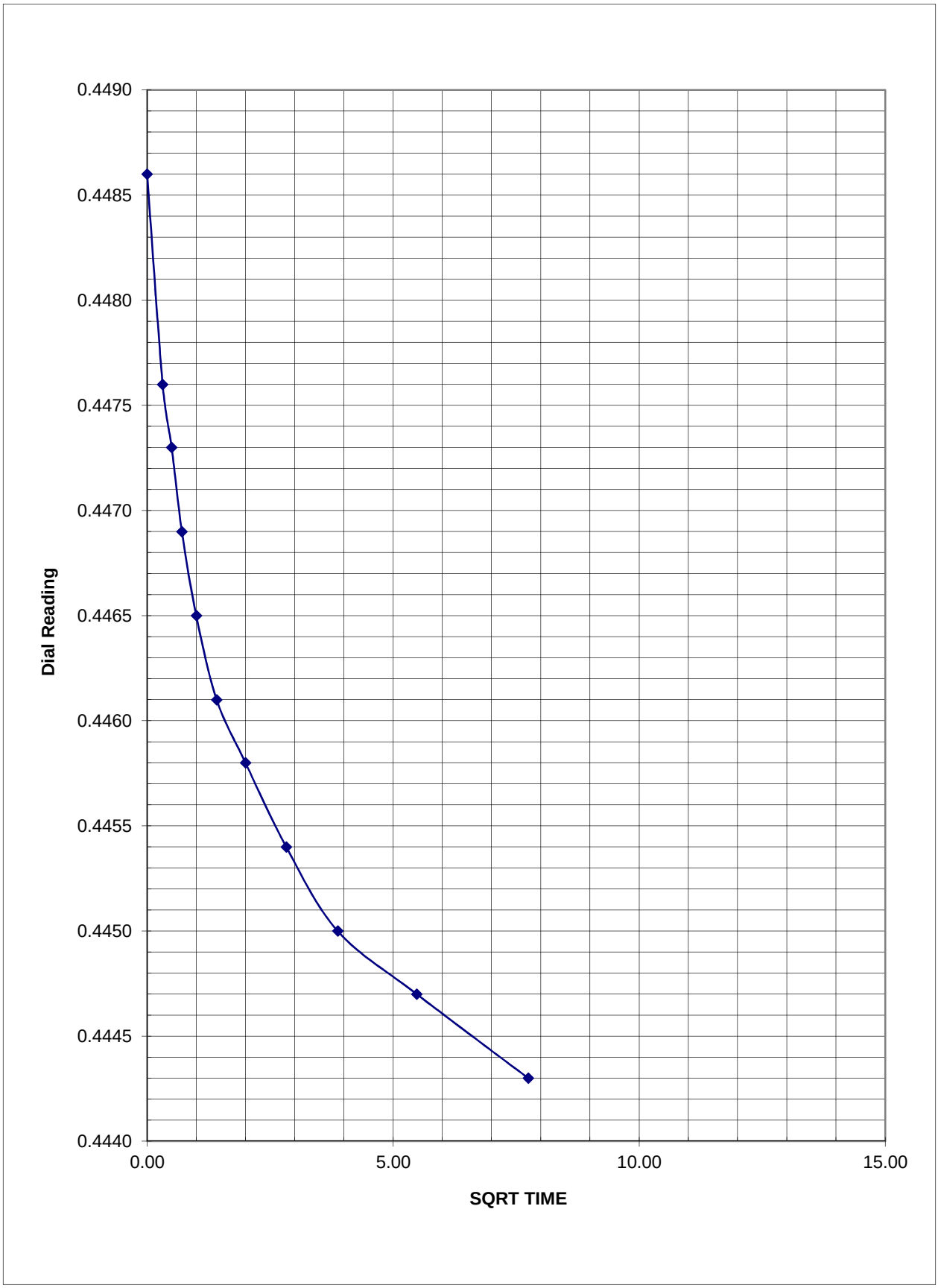
LOAD INCREMENT WORK SHEET

Project: 107510 **Sample:** SPT2
Date: 11/23/2009 **Depth (ft):** 22.5

Load Increment (psf):	125

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.4486***
6s	target	0.1	0.32	0.4476
15s	target	0.25	0.50	0.4473
30s	target	0.5	0.71	0.4469
1 min	target	1	1.00	0.4465
2 min	target	2	1.41	0.4461
4 min	target	4	2.00	0.4458
8 min	target	8	2.83	0.4454
15 min	stop	15	3.87	0.4450
30 min		30	5.48	0.4447
1hr		60	7.75	0.4443
2 hr			0.00	
4 hr			0.00	
8 hr			0.00	
16 hr			0.00	
24 hr			0.00	

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.4473	0.4469	0.4465
D:4	0.4465	0.4461	0.4458
Delta 1:4	0.0008	0.0008	0.0007
D_o (calc)	0.4481	0.4477	0.4472



Project: 107510 **Sample:** SPT2

Date: 11/23/2009 **Depth (ft):** 22.5

Load Increment (psf): 125

LOAD INCREMENT WORK SHEET

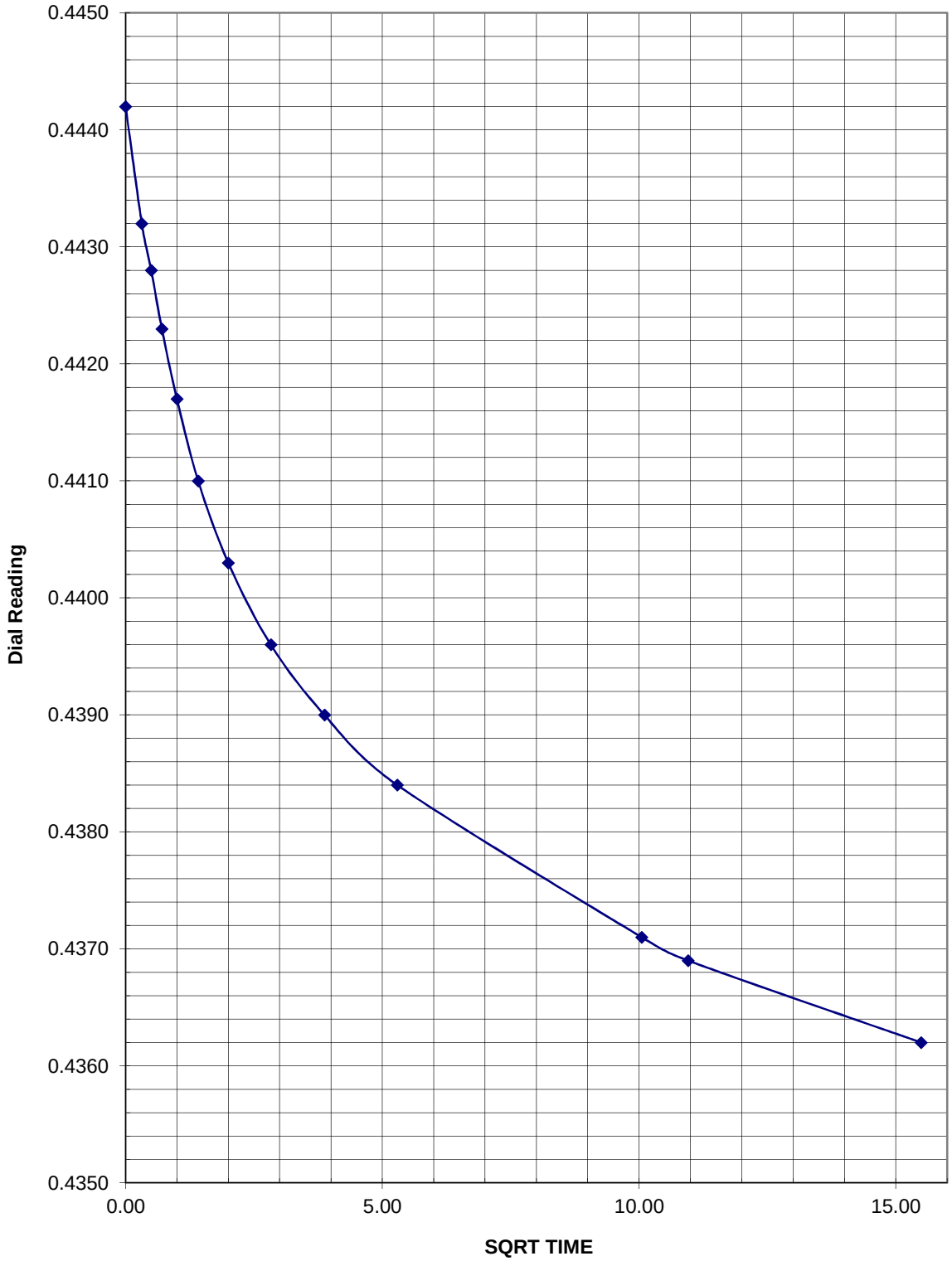
Project: 107510 **Sample:** SPT-2
Date: 11/23/2009 **Depth (ft):** 22.5

Load Increment (psf):	200

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start	0.0001	0.0001	0.00	***0.4442***
6s	0.1	0.1	0.32	0.4432
15s	0.25	0.25	0.50	0.4428
30s	0.5	0.5	0.71	0.4423
1 min		1	1.00	0.4417
2 min		2	1.41	0.4410
4 min		4	2.00	0.4403
8 min		8	2.83	0.4396
15 min		15	3.87	0.4390
30 min		28	5.29	0.4384
1hr		101	10.05	0.4371
2 hr		120	10.95	0.4369
4 hr		240	15.49	0.4362
8 hr			0.00	
16 hr			0.00	
24 hr			0.00	

Log-Time D_o Calculation

Time Ratio	$(1:4)_{@0.25}$	$(1:4)_{@0.5}$	$(1:4)_{@1.0}$
D:1	0.4428	0.4423	0.4417
D:4	0.4417	0.441	0.4403
Delta 1:4	0.0011	0.0013	0.0014
D_o (calc)	0.4439	0.4436	0.4431



Project: 107510 **Sample:** SPT-2

Date: 11/23/2009 **Depth (ft):** 22.5

Load Increment (psf): 200

LOAD INCREMENT WORK SHEET

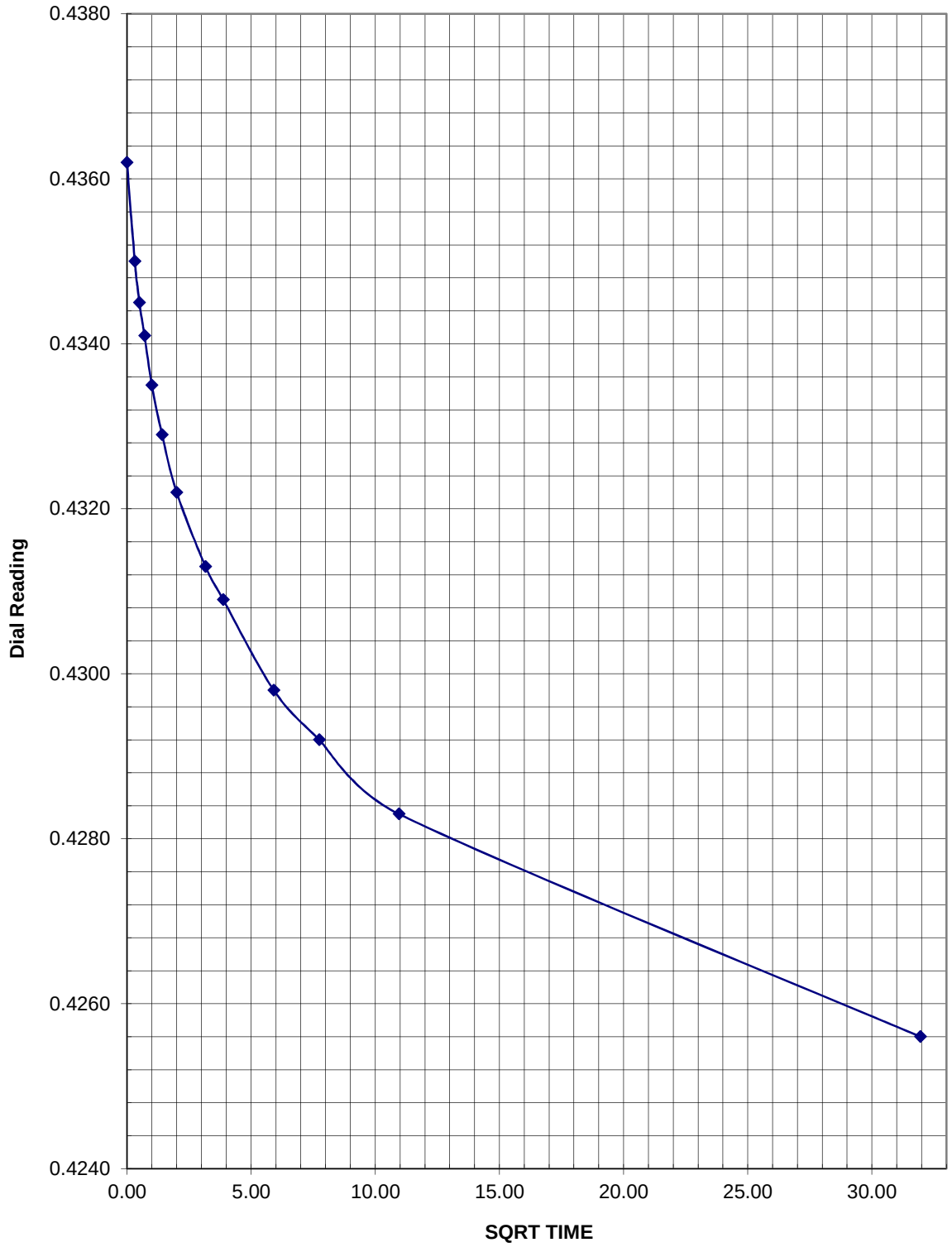
Project: 107510 **Sample:** SPT2
Date: 11/23/2009 **Depth (ft):** 22.5

Load Increment (psf):	300

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.4362***
6s		0.1	0.32	0.4350
15s		0.25	0.50	0.4345
30s		0.5	0.71	0.4341
1 min		1	1.00	0.4335
2 min		2	1.41	0.4329
4 min		4	2.00	0.4322
8 min		10	3.16	0.4313
15 min		15	3.87	0.4309
30 min		35	5.92	0.4298
1hr		60	7.75	0.4292
2 hr		120	10.95	0.4283
4 hr		1021	31.95	0.4256
8 hr			0.00	
16 hr			0.00	
24 hr			0.00	

Log-Time D_o Calculation

Time Ratio	$(1:4)_{@0.25}$	$(1:4)_{@0.5}$	$(1:4)_{@1.0}$
D:1	0.4345	0.4341	0.4335
D:4	0.4335	0.4329	0.4322
Delta 1:4	0.001	0.0012	0.0013
D_o (calc)	0.4355	0.4353	0.4348



Project:	**107510**	**Sample:**	**SPT2**
Date:	**11/23/2009**	**Depth (ft):**	**22.5**
		Load Increment (psf):	**300**

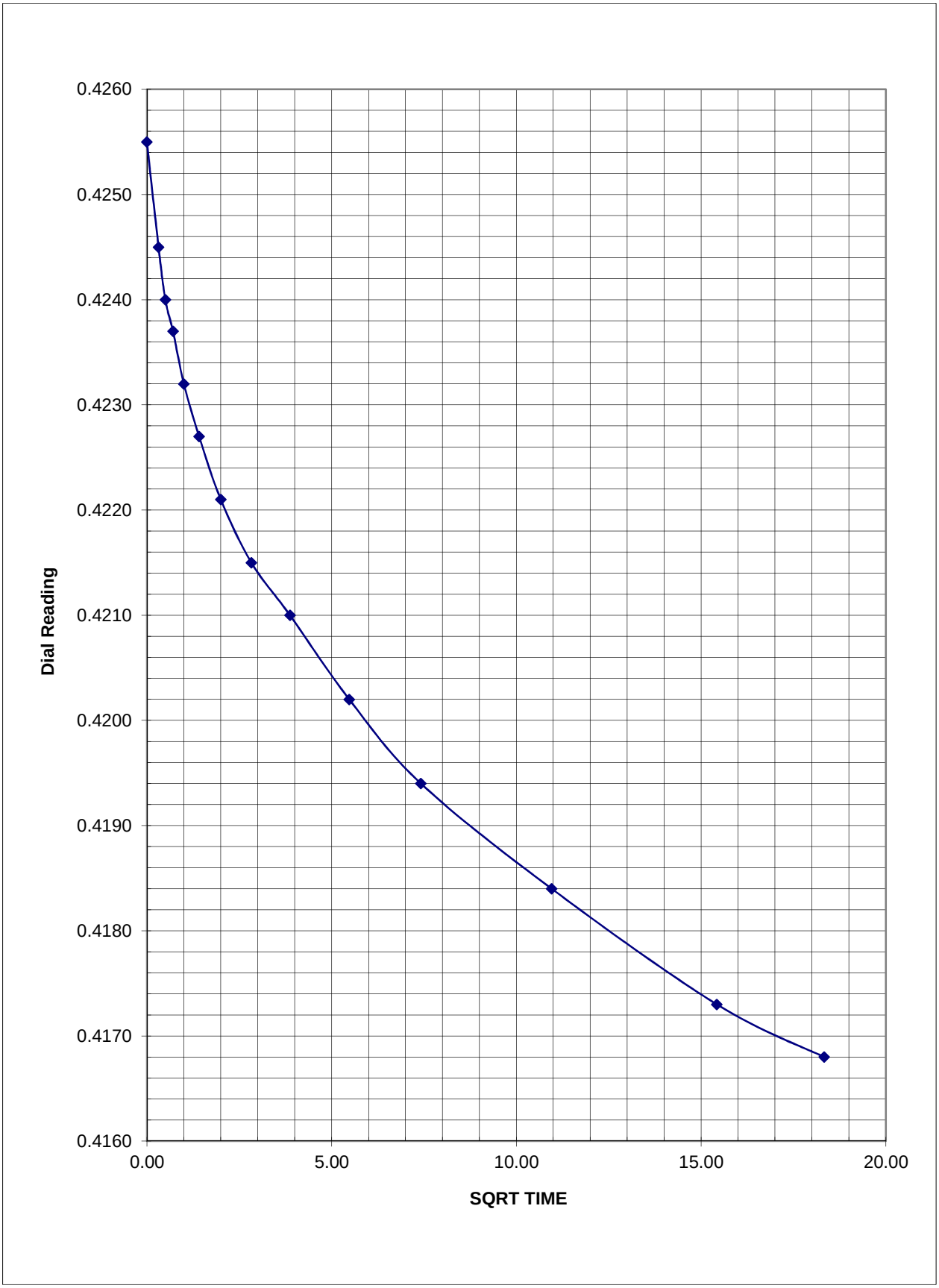
LOAD INCREMENT WORK SHEET

Project: 107510 **Sample:** SPT2
Date: 11/24/2009 **Depth (ft):** 22.5

Load Increment (psf):	450

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.4255***
6s		0.1	0.32	0.4245
15s		0.25	0.50	0.4240
30s		0.5	0.71	0.4237
1 min		1	1.00	0.4232
2 min		2	1.41	0.4227
4 min		4	2.00	0.4221
8 min		8	2.83	0.4215
15 min		15	3.87	0.4210
30 min		30	5.48	0.4202
1hr		55	7.42	0.4194
2 hr		120	10.95	0.4184
4 hr		238	15.43	0.4173
8 hr		336	18.33	0.4168
16 hr			0.00	
24 hr			0.00	

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.4240	0.4237	0.4232
D:4	0.4232	0.4227	0.4221
Delta 1:4	0.0008	0.001	0.0011
D_o (calc)	0.4248	0.4247	0.4243



Project:	**107510**	**Sample:**	**SPT2**
Date:	**11/24/2009**	**Depth (ft):**	**22.5**
		Load Increment (psf):	**450**

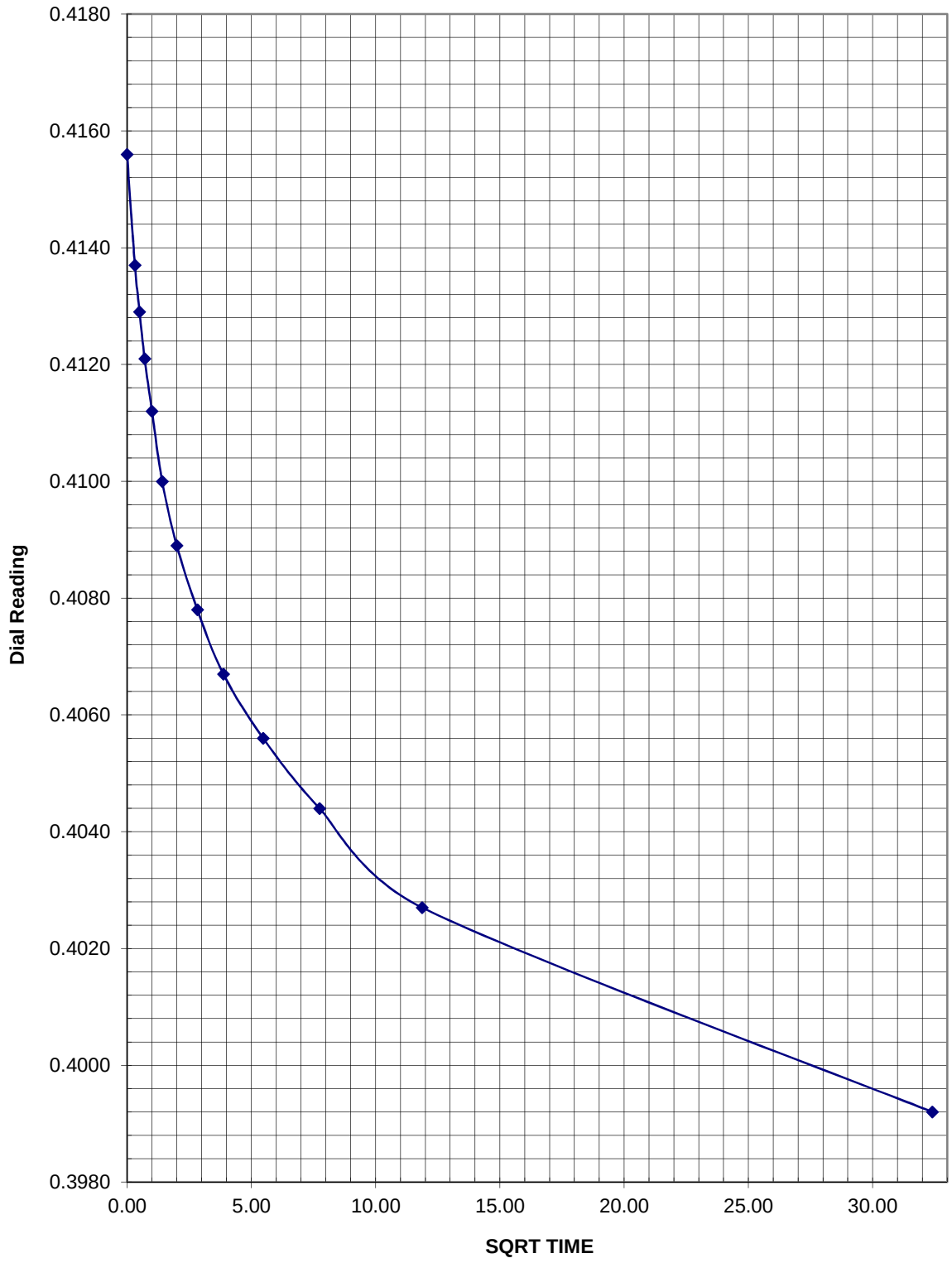
LOAD INCREMENT WORK SHEET

Project: 107510 **Sample:** SPT2
Date: 11/24/2009 **Depth (ft):** 22.5

Load Increment (psf):	700

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.4156***
6s		0.1	0.32	0.4137
15s		0.25	0.50	0.4129
30s		0.5	0.71	0.4121
1 min		1	1.00	0.4112
2 min		2	1.41	0.4100
4 min		4	2.00	0.4089
8 min		8	2.83	0.4078
15 min		15	3.87	0.4067
30 min		30	5.48	0.4056
1hr		60	7.75	0.4044
2 hr		141	11.87	0.4027
4 hr		1050	32.40	0.3992
8 hr			0.00	
16 hr			0.00	
24 hr			0.00	

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.4129	0.4121	0.4112
D:4	0.4112	0.41	0.4089
Delta 1:4	0.0017	0.0021	0.0023
D_o (calc)	0.4146	0.4142	0.4135



Project: 107510 **Sample:** SPT2

Date: 11/24/2009 **Depth (ft):** 22.5

Load Increment (psf): 700

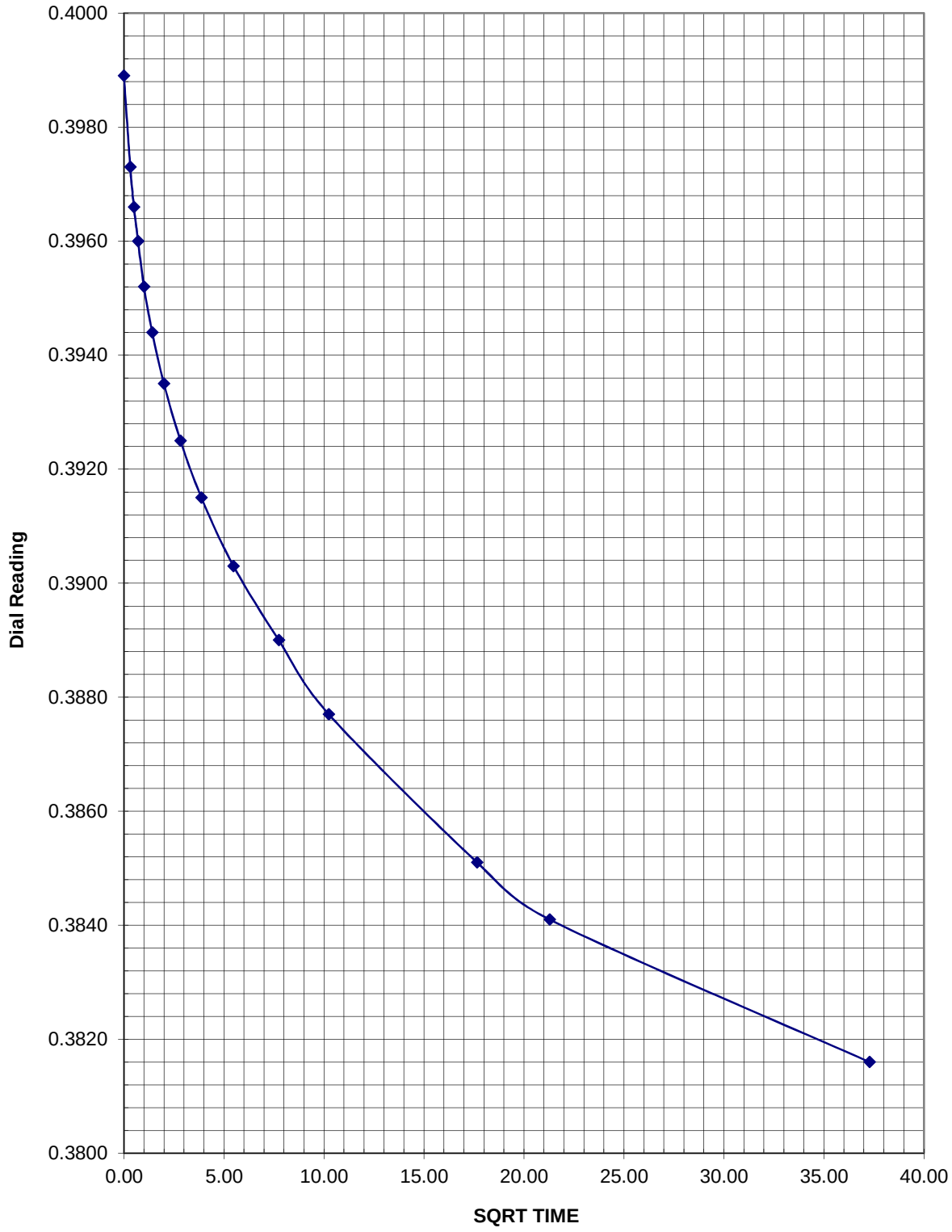
LOAD INCREMENT WORK SHEET

Project: 107510 **Sample:** SPT2
Date: 11/25/2009 **Depth (ft):** 22.5

Load Increment (psf):	1050

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.3989***
6s		0.1	0.32	0.3973
15s		0.25	0.50	0.3966
30s		0.5	0.71	0.3960
1 min		1	1.00	0.3952
2 min		2	1.41	0.3944
4 min		4	2.00	0.3935
8 min		8	2.83	0.3925
15 min		15	3.87	0.3915
30 min		30	5.48	0.3903
1hr		60	7.75	0.3890
2 hr		105	10.25	0.3877
4 hr		312	17.66	0.3851
8 hr		453	21.28	0.3841
16 hr		1390	37.28	0.3816
24 hr			0.00	

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.3966	0.396	0.3952
D:4	0.3952	0.3944	0.3935
Delta 1:4	0.0014	0.0016	0.0017
D_o (calc)	0.3980	0.3976	0.3969



Project: 107510 **Sample:** SPT2

Date: 11/25/2009 **Depth (ft):** 22.5

Load Increment (psf): 1050

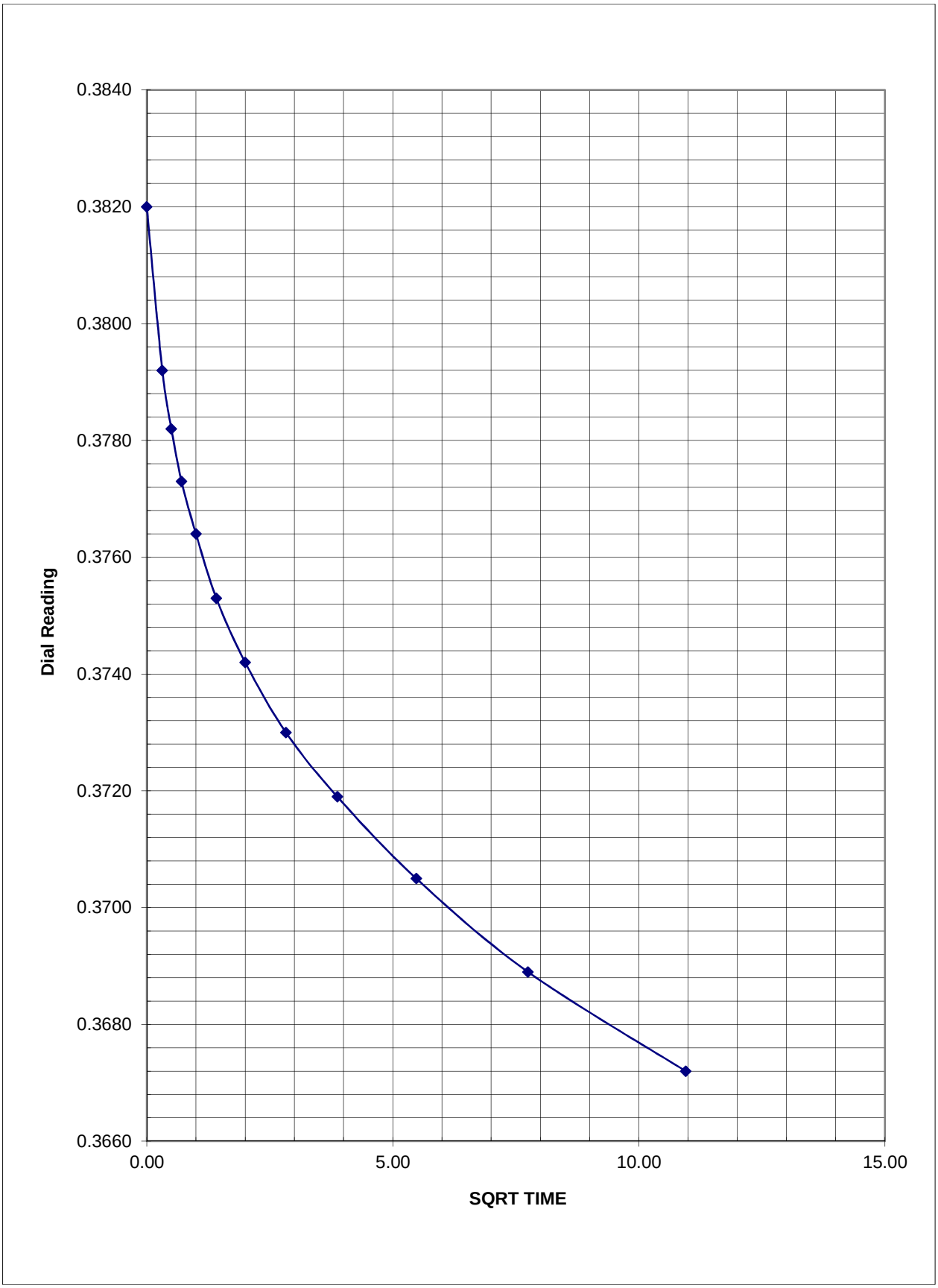
LOAD INCREMENT WORK SHEET

Project: 107510 **Sample:** SPT2
Date: 11/30/2009 **Depth (ft):** 22.5

Load Increment (psf):	1625

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.3820***
6s		0.1	0.32	0.3792
15s		0.25	0.50	0.3782
30s		0.5	0.71	0.3773
1 min		1	1.00	0.3764
2 min		2	1.41	0.3753
4 min		4	2.00	0.3742
8 min		8	2.83	0.3730
15 min		15	3.87	0.3719
30 min		30	5.48	0.3705
1hr		60	7.75	0.3689
2 hr		120	10.95	0.3672
4 hr			0.00	
8 hr			0.00	
16 hr			0.00	
24 hr			0.00	

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.3782	0.3773	0.3764
D:4	0.3764	0.3753	0.3742
Delta 1:4	0.0018	0.002	0.0022
D_o (calc)	0.3800	0.3793	0.3786



Project:	**107510**	**Sample:**	**SPT2**
Date:	**11/30/2009**	**Depth (ft):**	**22.5**
		Load Increment (psf):	**1625**

LOAD INCREMENT WORK SHEET

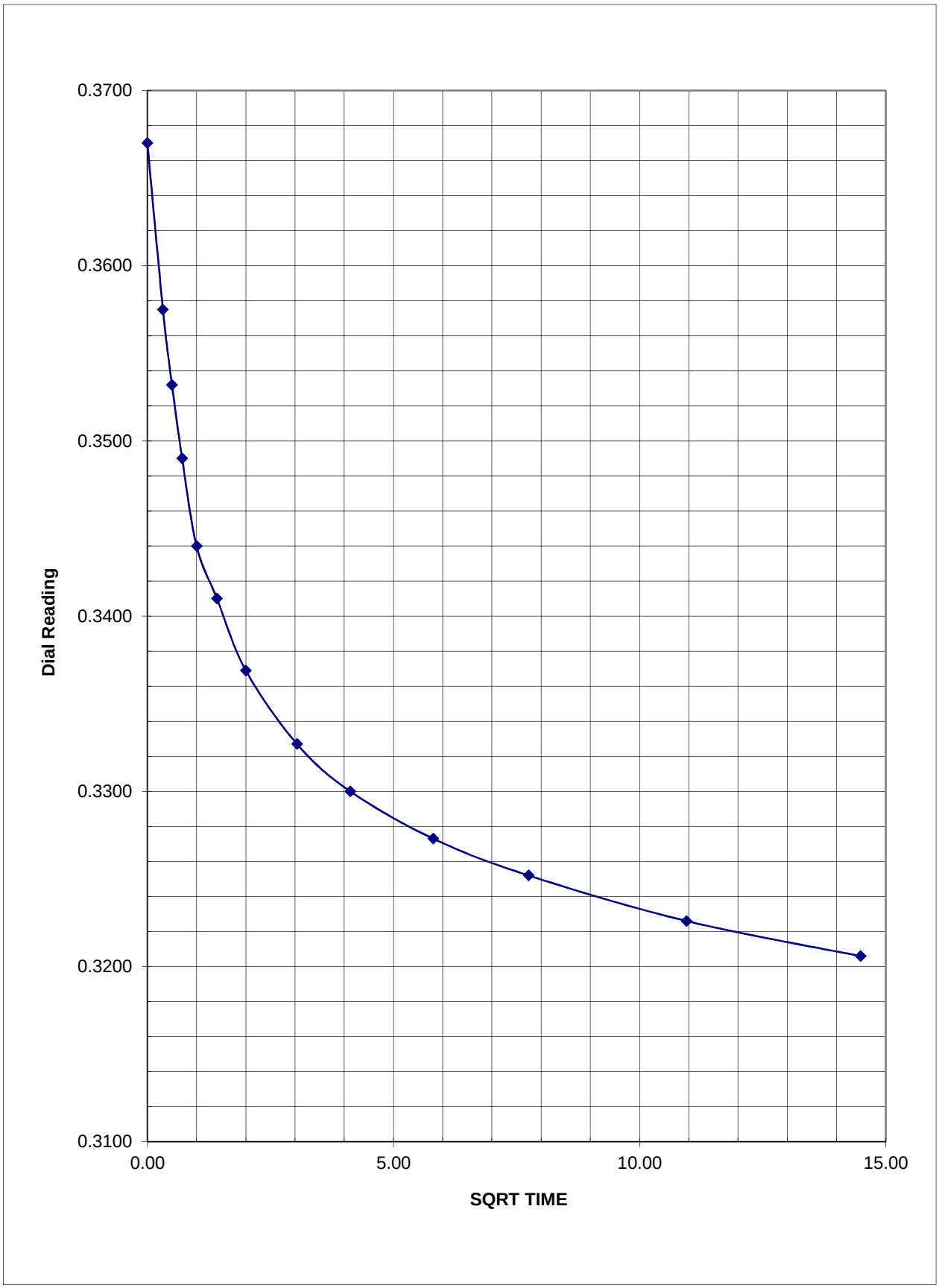
Project: 107510 **Sample:** SPT2
Date: 11/30/2009 **Depth (ft):** 22.5

Load Increment (psf): 3200

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.0001	0.00	***0.3670***
6s		0.1	0.32	0.3575
15s		0.25	0.50	0.3532
30s		0.5	0.71	0.3490
1 min		1	1.00	0.3440
2 min		2	1.41	0.3410
4 min		4	2.00	0.3369
8 min	9:15	9.25	3.04	0.3327
15 min	17:00	17	4.12	0.3300
30 min		33.75	5.81	0.3273
1hr		60	7.75	0.3252
2 hr		120	10.95	0.3226
4 hr		210	14.49	0.3206
8 hr			0.00	
16 hr			0.00	
24 hr			0.00	

Log-Time D_o Calculation

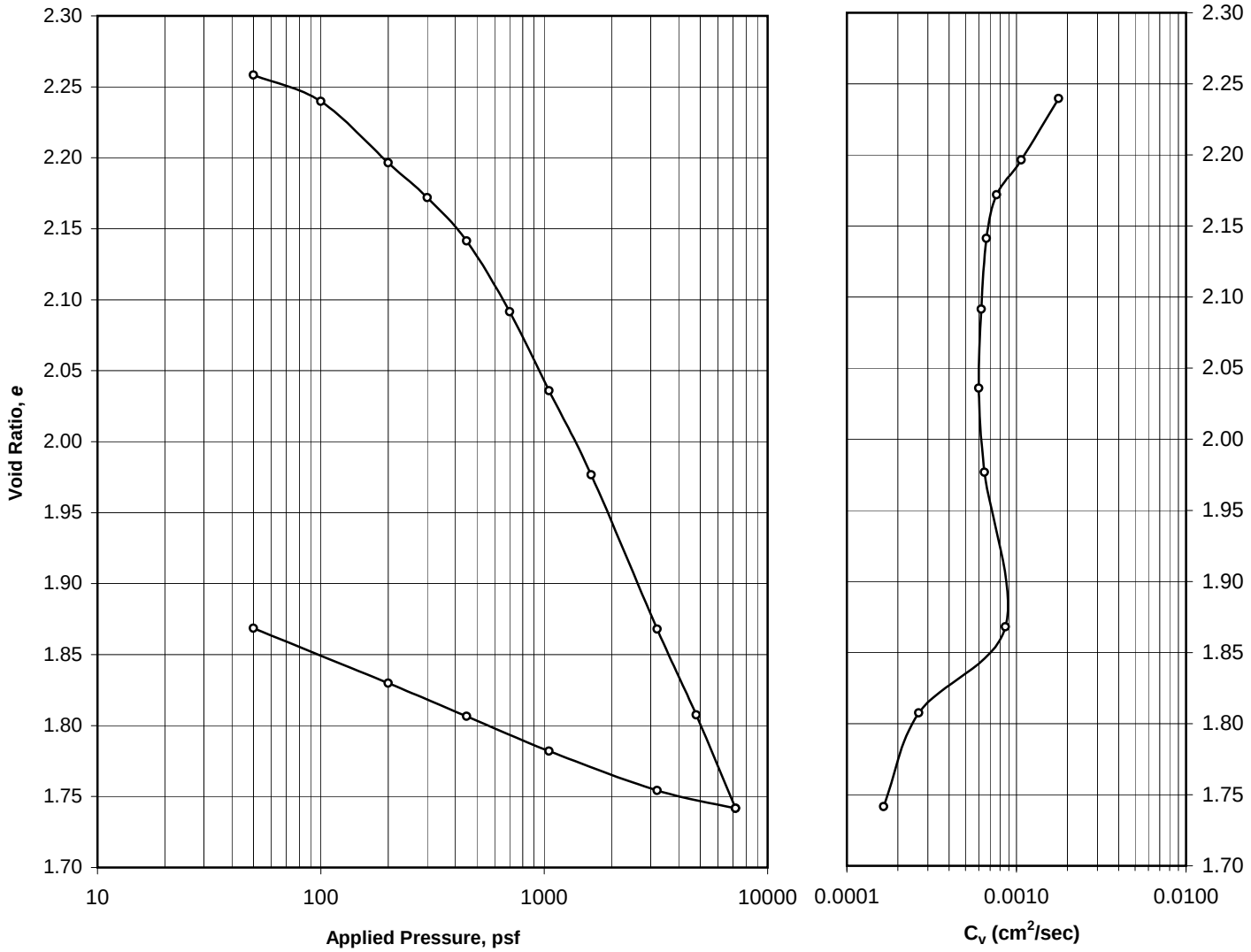
Time Ratio	$(1:4)_{@0.25}$	$(1:4)_{@0.5}$	$(1:4)_{@1.0}$
D:1	0.3532	0.349	0.3440
D:4	0.3440	0.341	0.3369
Delta 1:4	0.0092	0.008	0.0071
D_o (calc)	0.3624	0.3570	0.3511



Project: 107510 **Sample:** SPT2

Date: 11/30/2009 **Depth (ft):** 22.5

Load Increment (psf): 3200



Boring	Sample	Depth (ft)	LL	PL	Spec Grav	Sample Description
SPT-3	SPT-3	10.9'-11'	63	36	2.7	Dark Brown SILT (MH)

	Moisture Content (%)	Dry Density (pcf)	Void Ratio	Satruation (%)
INITIAL	80.4	51.7	2.258	96.1
FINAL	55.6	58.7	1.869	100.00

Recompresion Index $Cr^{(1)}$	Compression Index $Cc^{(1)}$	Est$^{(1)}$ Preconsolidation Pressure, Po' (pcf)
n/a	n/a	n/a

SAMPLE PREPARATION: Wet Method

(1) Estimated preconsilidation pressure and index values (Cr/Cc) generally based on Casaegrade Method.

KLEINFELDER
Bright People. Right Solutions.

Test Date:	7-Jan-10
Tested By:	RG
Checked By:	SAS
File:	SPT-3@11.0'
PROJECT NO.: 107510	Lab No.: 2592

CONSOLIDATION TEST

Arkema Early Action
Portland, Oregon

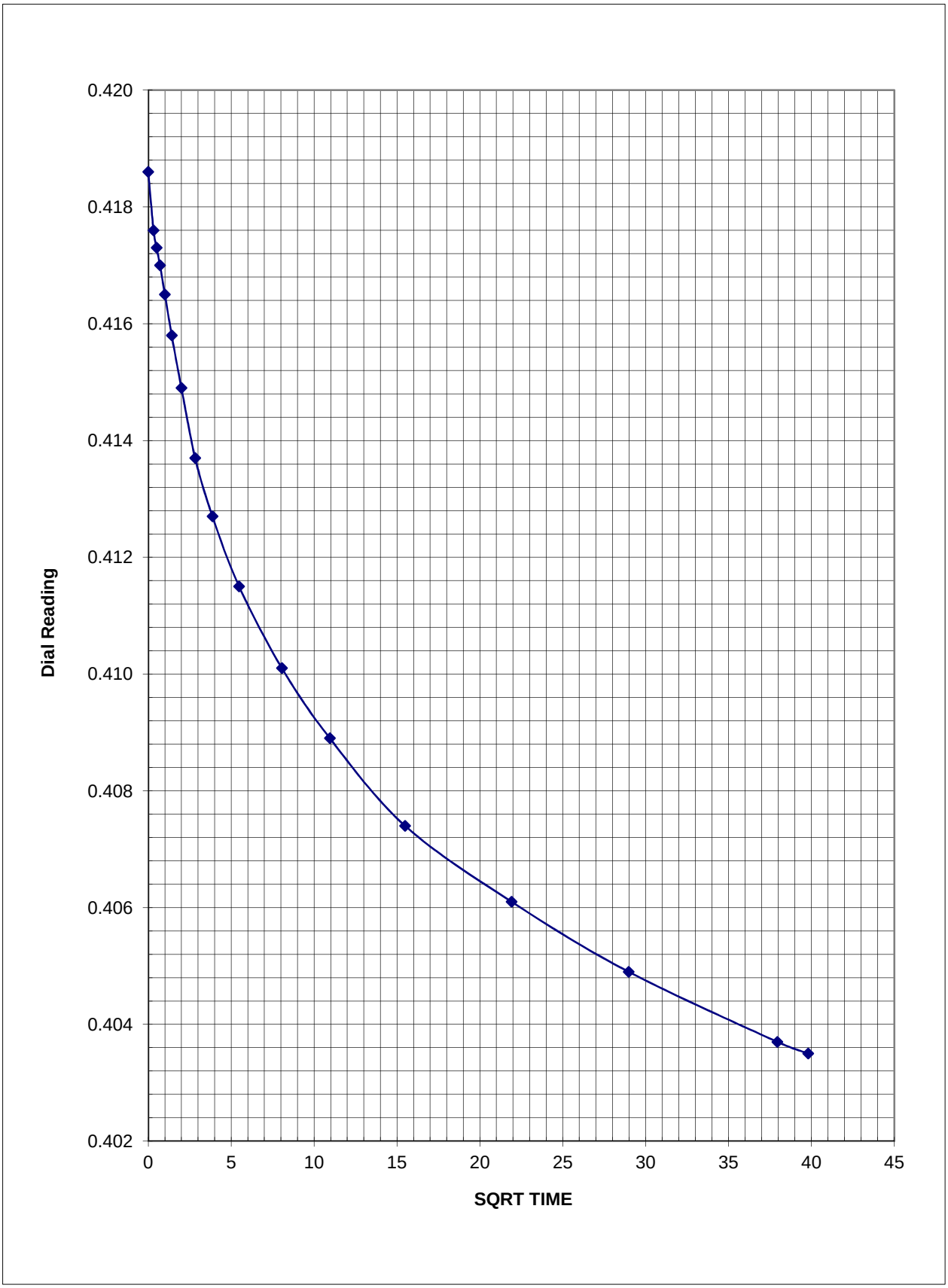
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**

Load Increment (psf):	**100**

Target Time sec/min/hr	**Recorded Time**	**Actual Time (min)**	**SQRT TIME (min)**	**Dial Reading**
Start		0.01	0.00	***0.4186***
6s		0.1	0.32	0.4176
15s		0.25	0.50	0.4173
30s		0.5	0.71	0.4170
1 min		1	1.00	0.4165
2 min		2	1.41	0.4158
4 min		4	2.00	0.4149
8 min		8	2.83	0.4137
15 min		15	3.87	0.4127
30 min		30	5.48	0.4115
1hr		65	8.06	0.4101
2 hr		120	10.95	0.4089
4 hr		240	15.49	0.4074
8 hr		480	21.91	0.4061
16 hr		840	28.98	0.4049
24 hr		1440	37.95	0.4037
		1585	39.81	0.4035

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.4173	0.417	0.4165
D:4	0.4165	0.4158	0.4149
Delta 1:4	0.0008	0.0012	0.0016
D_o (calc)	0.4181	0.4182	0.4181



Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**
		Load Increment (psf):	**100**

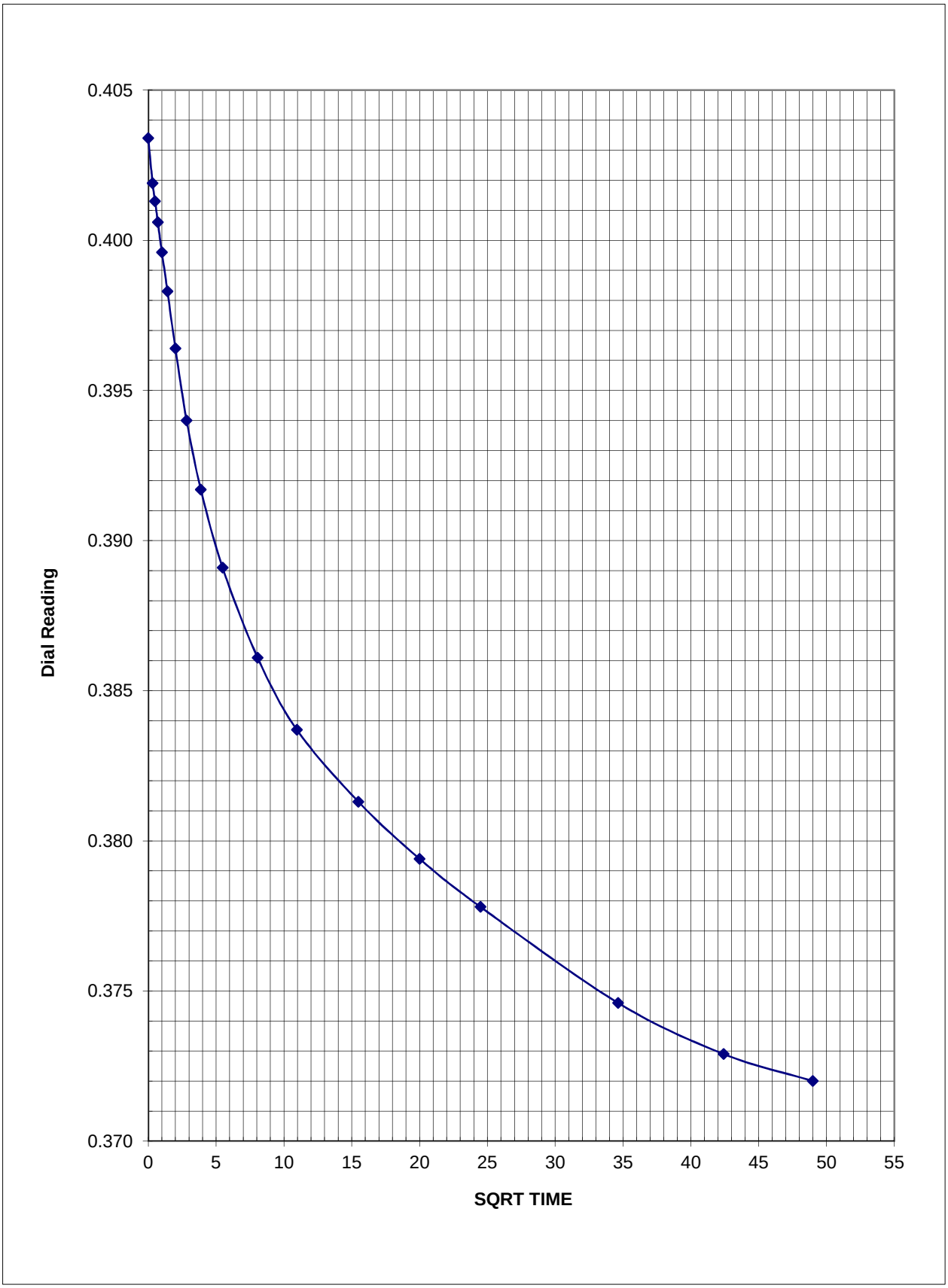
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**

Load Increment (psf):	**200**

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.01	0.00	***0.4034***
6s		0.1	0.32	0.4019
15s		0.25	0.50	0.4013
30s		0.5	0.71	0.4006
1 min		1	1.00	0.3996
2 min		2	1.41	0.3983
4 min		4	2.00	0.3964
8 min		8	2.83	0.3940
15 min		15	3.87	0.3917
30 min		30	5.48	0.3891
1hr		65	8.06	0.3861
2 hr		120	10.95	0.3837
4 hr		240	15.49	0.3813
8 hr		400	20.00	0.3794
16 hr		600	24.49	0.3778
24 hr		1200	34.64	0.3746
		1800	42.43	0.3729
		2400	48.99	0.3720

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.4013	0.4006	0.3996
D:4	0.3996	0.3983	0.3964
Delta 1:4	0.0017	0.0023	0.0032
D_o (calc)	0.4030	0.4029	0.4028



Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**
		Load Increment (psf):	**200**

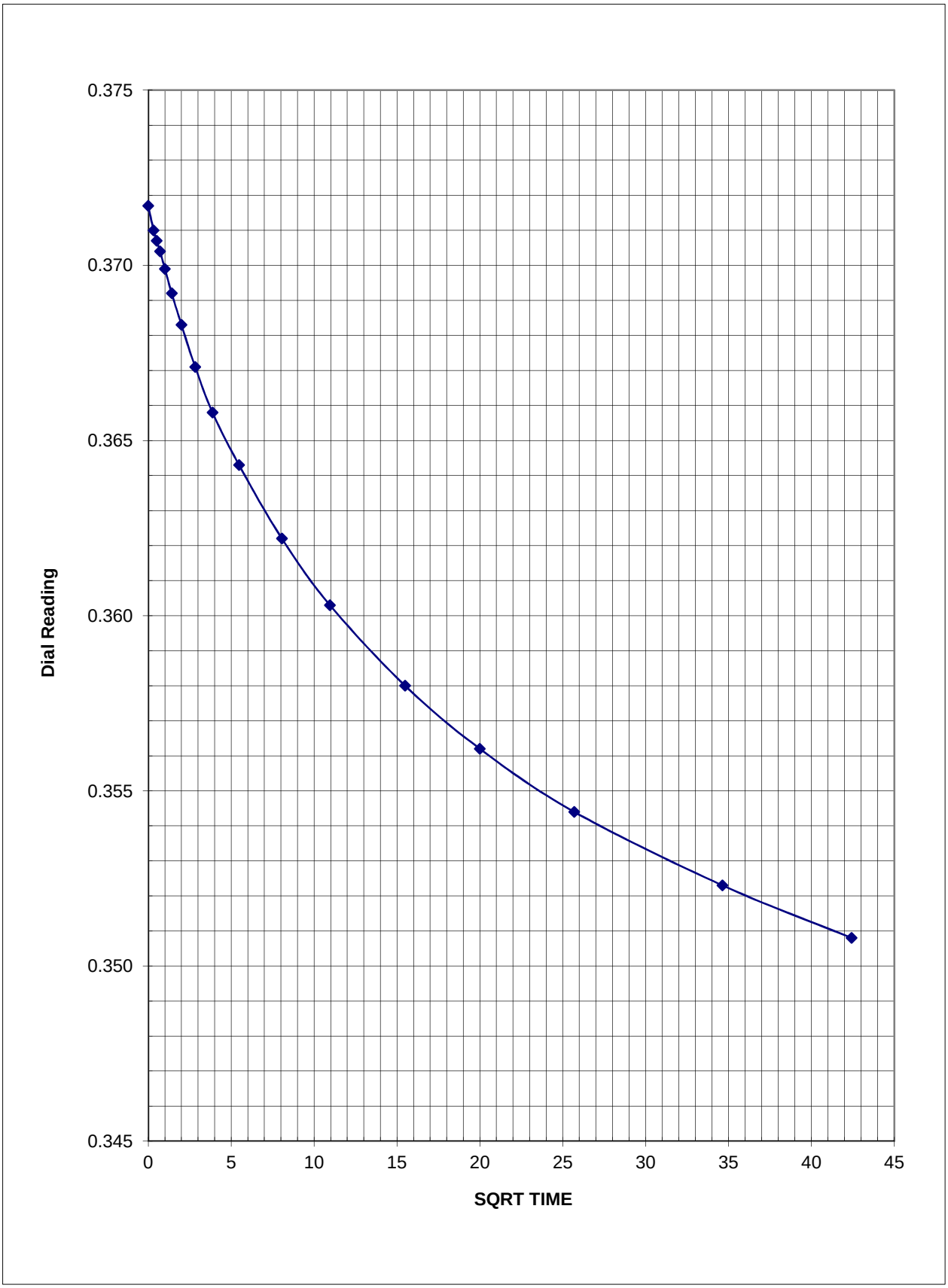
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**

Load Increment (psf):	**300**

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.01	0.00	***0.3717***
6s		0.1	0.32	0.3710
15s		0.25	0.50	0.3707
30s		0.5	0.71	0.3704
1 min		1	1.00	0.3699
2 min		2	1.41	0.3692
4 min		4	2.00	0.3683
8 min		8	2.83	0.3671
15 min		15	3.87	0.3658
30 min		30	5.48	0.3643
1hr		65	8.06	0.3622
2 hr		120	10.95	0.3603
4 hr		240	15.49	0.3580
8 hr		400	20.00	0.3562
16 hr		660	25.69	0.3544
24 hr		1200	34.64	0.3523
		1800	42.43	0.3508

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.3707	0.3704	0.3699
D:4	0.3699	0.3692	0.3683
Delta 1:4	0.0008	0.0012	0.0016
D_o (calc)	0.3715	0.3716	0.3715



Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**
		Load Increment (psf):	**300**

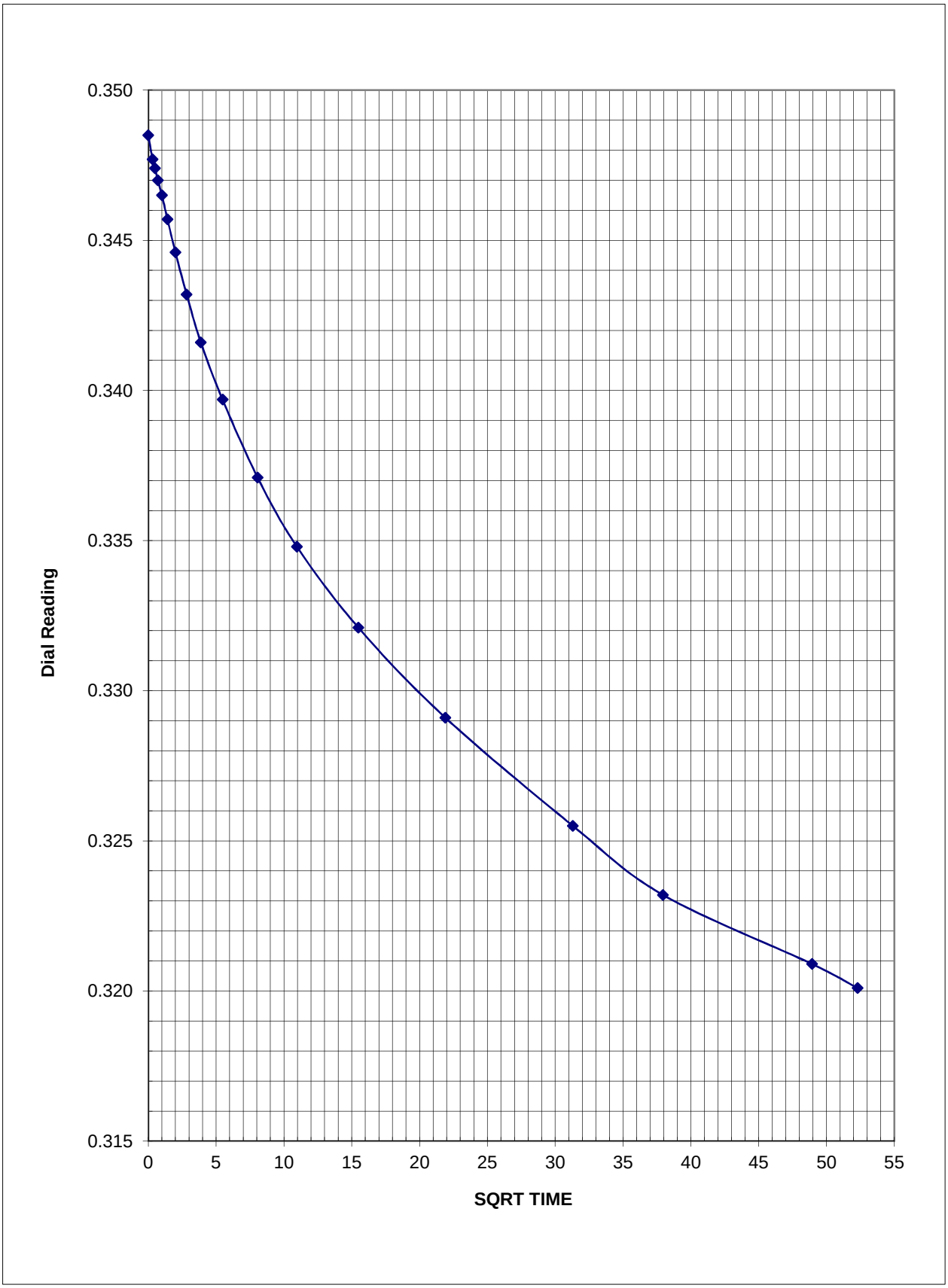
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**

Load Increment (psf):	**450**

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.01	0.00	***0.3485***
6s		0.1	0.32	0.3477
15s		0.25	0.50	0.3474
30s		0.5	0.71	0.3470
1 min		1	1.00	0.3465
2 min		2	1.41	0.3457
4 min		4	2.00	0.3446
8 min		8	2.83	0.3432
15 min		15	3.87	0.3416
30 min		30	5.48	0.3397
1hr		65	8.06	0.3371
2 hr		120	10.95	0.3348
4 hr		240	15.49	0.3321
8 hr		480	21.91	0.3291
16 hr		980	31.30	0.3255
24 hr		1440	37.95	0.3232
		2395	48.94	0.3209
		2735	52.30	0.3201

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.3474	0.347	0.3465
D:4	0.3465	0.3457	0.3446
Delta 1:4	0.0009	0.0013	0.0019
D_o (calc)	0.3483	0.3483	0.3484



Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**
		Load Increment (psf):	**450**

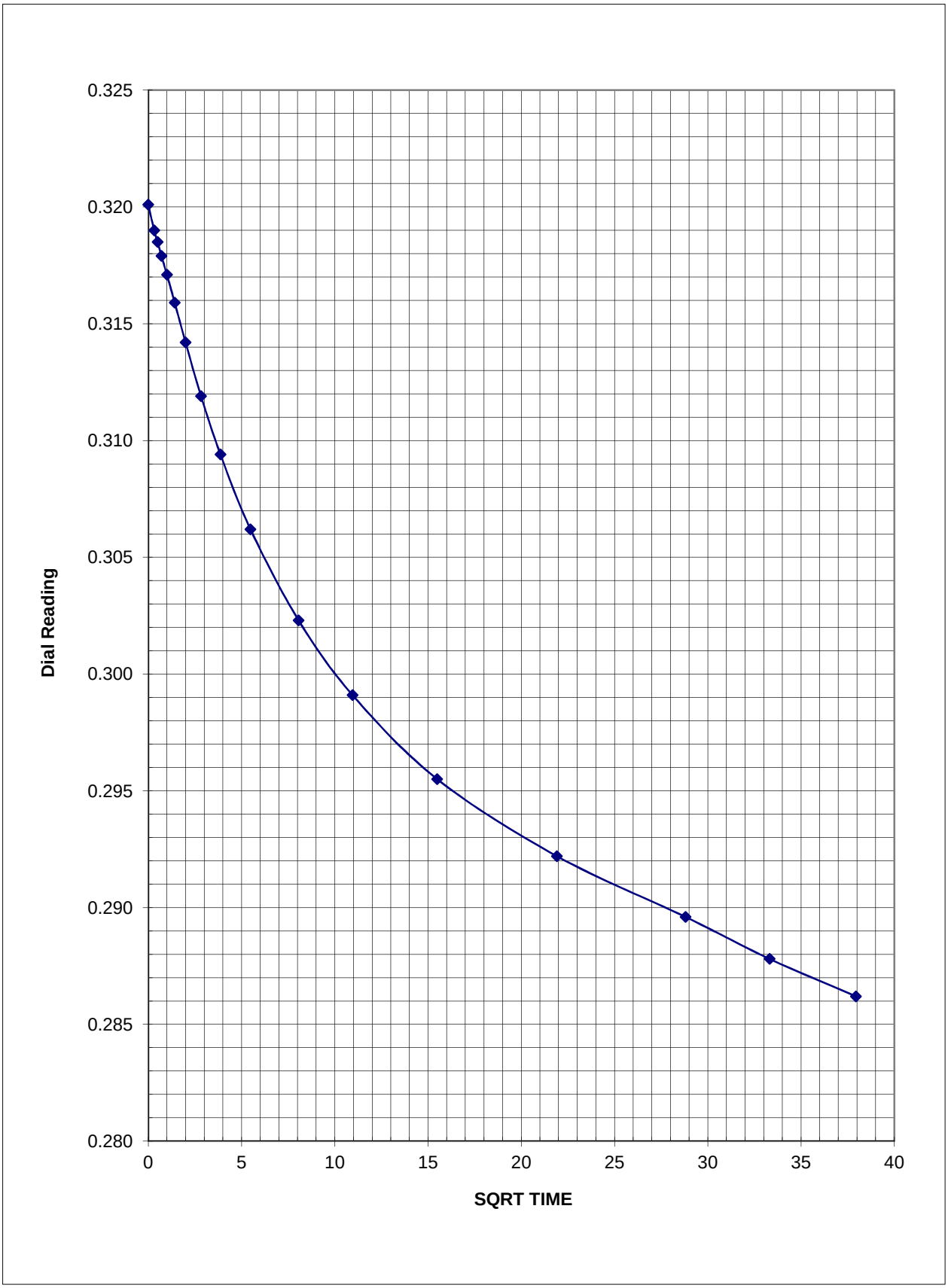
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**

Load Increment (psf):	**700**

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.01	0.00	***0.3201***
6s		0.1	0.32	0.3190
15s		0.25	0.50	0.3185
30s		0.5	0.71	0.3179
1 min		1	1.00	0.3171
2 min		2	1.41	0.3159
4 min		4	2.00	0.3142
8 min		8	2.83	0.3119
15 min		15	3.87	0.3094
30 min		30	5.48	0.3062
1hr		65	8.06	0.3023
2 hr		120	10.95	0.2991
4 hr		240	15.49	0.2955
8 hr		480	21.91	0.2922
16 hr		830	28.81	0.2896
24 hr		1110	33.32	0.2878
		1440	37.95	0.2862

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.3185	0.3179	0.3171
D:4	0.3171	0.3159	0.3142
Delta 1:4	0.0014	0.002	0.0029
D_o (calc)	0.3199	0.3199	0.3200



Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**
		Load Increment (psf):	**700**

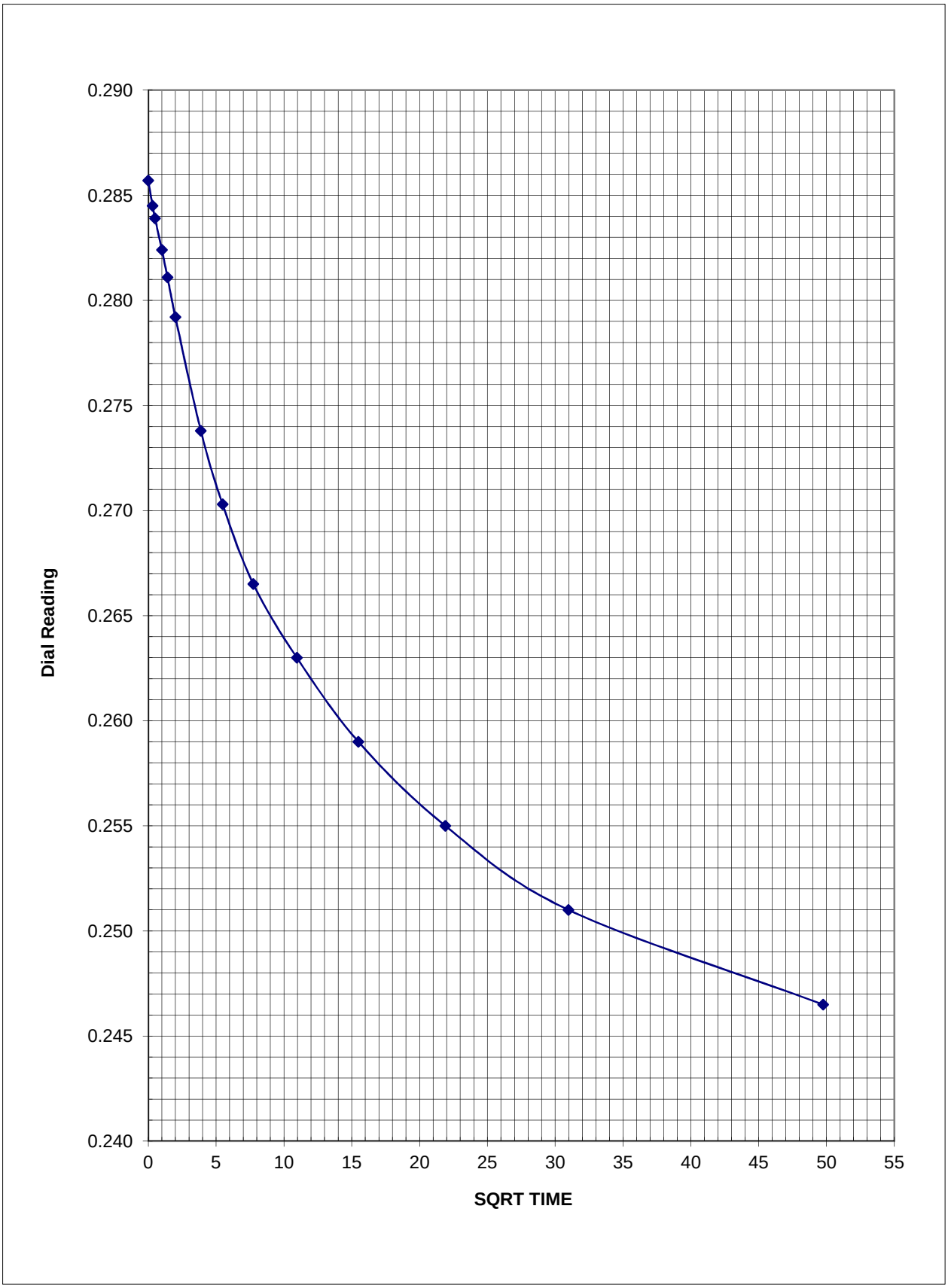
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**

Load Increment (psf):	**1050**

Target Time sec/min/hr	**Recorded Time**	**Actual Time (min)**	**SQRT TIME (min)**	**Dial Reading**
Start		0.01	0.00	***0.2857***
6s		0.1	0.32	0.2845
15s		0.25	0.50	0.2839
30s		1	1.00	0.2824
1 min		2	1.41	0.2811
2 min		4	2.00	0.2792
4 min		15	3.87	0.2738
8 min		30	5.48	0.2703
15 min		60	7.75	0.2665
30 min		120	10.95	0.2630
1hr		240	15.49	0.2590
2 hr		480	21.91	0.2550
4 hr		960	30.98	0.2510
8 hr		2475	49.75	0.2465
16 hr				
24 hr				

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.2839	0.2824	0.2811
D:4	0.2811	0.2792	0.2738
Delta 1:4	0.0028	0.0032	0.0073
D_o (calc)	0.2867	0.2856	0.2884



Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**
		Load Increment (psf):	**1050**

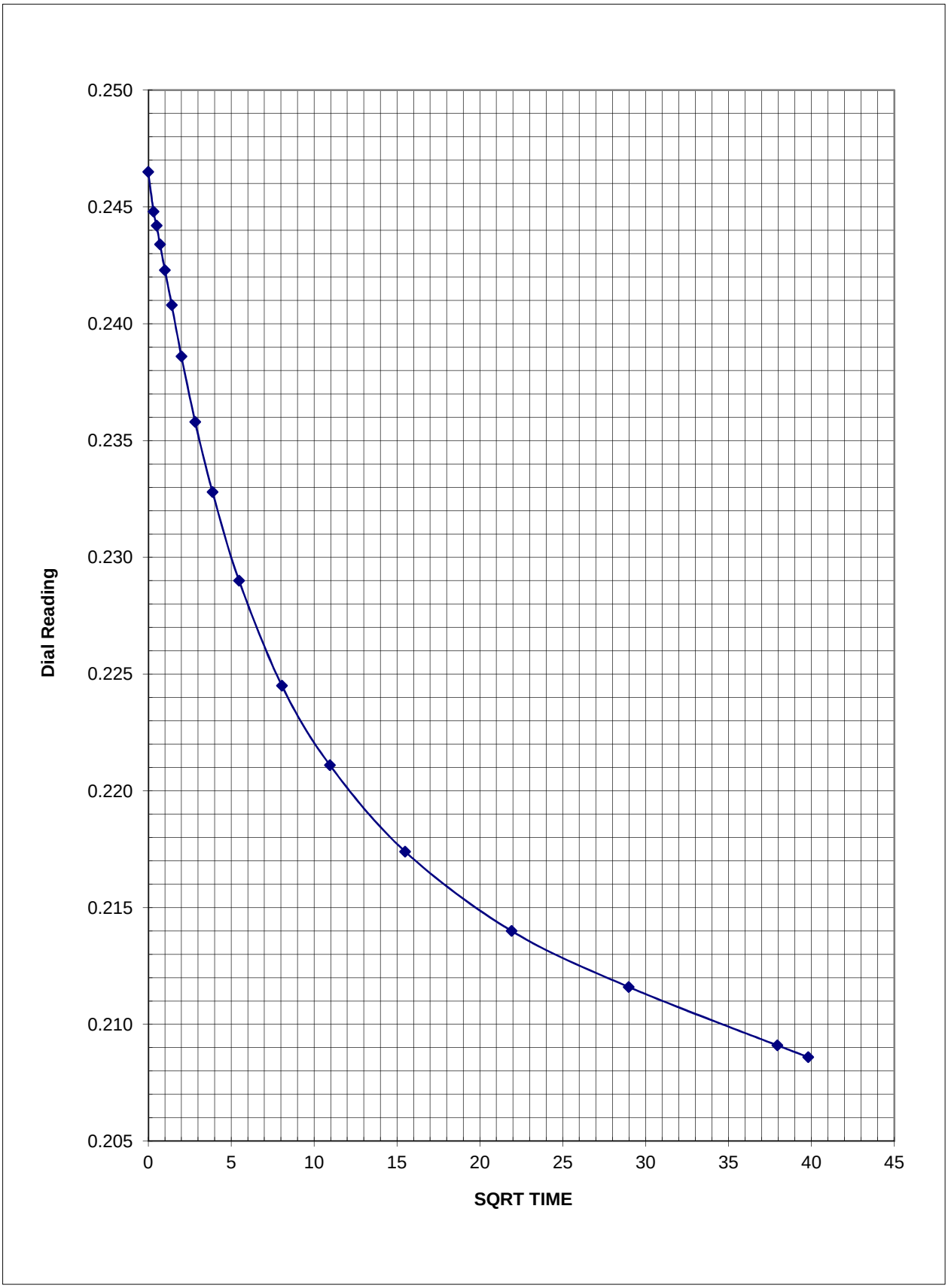
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**

Load Increment (psf):	**1625**

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.01	0.00	***0.2465***
6s		0.1	0.32	0.2448
15s		0.25	0.50	0.2442
30s		0.5	0.71	0.2434
1 min		1	1.00	0.2423
2 min		2	1.41	0.2408
4 min		4	2.00	0.2386
8 min		8	2.83	0.2358
15 min		15	3.87	0.2328
30 min		30	5.48	0.2290
1hr		65	8.06	0.2245
2 hr		120	10.95	0.2211
4 hr		240	15.49	0.2174
8 hr		480	21.91	0.2140
16 hr		840	28.98	0.2116
24 hr		1440	37.95	0.2091
		1585	39.81	0.2086

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.2442	0.2434	0.2423
D:4	0.2423	0.2408	0.2386
Delta 1:4	0.0019	0.0026	0.0037
D_o (calc)	0.2461	0.2460	0.2460



Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**
		Load Increment (psf):	**1625**

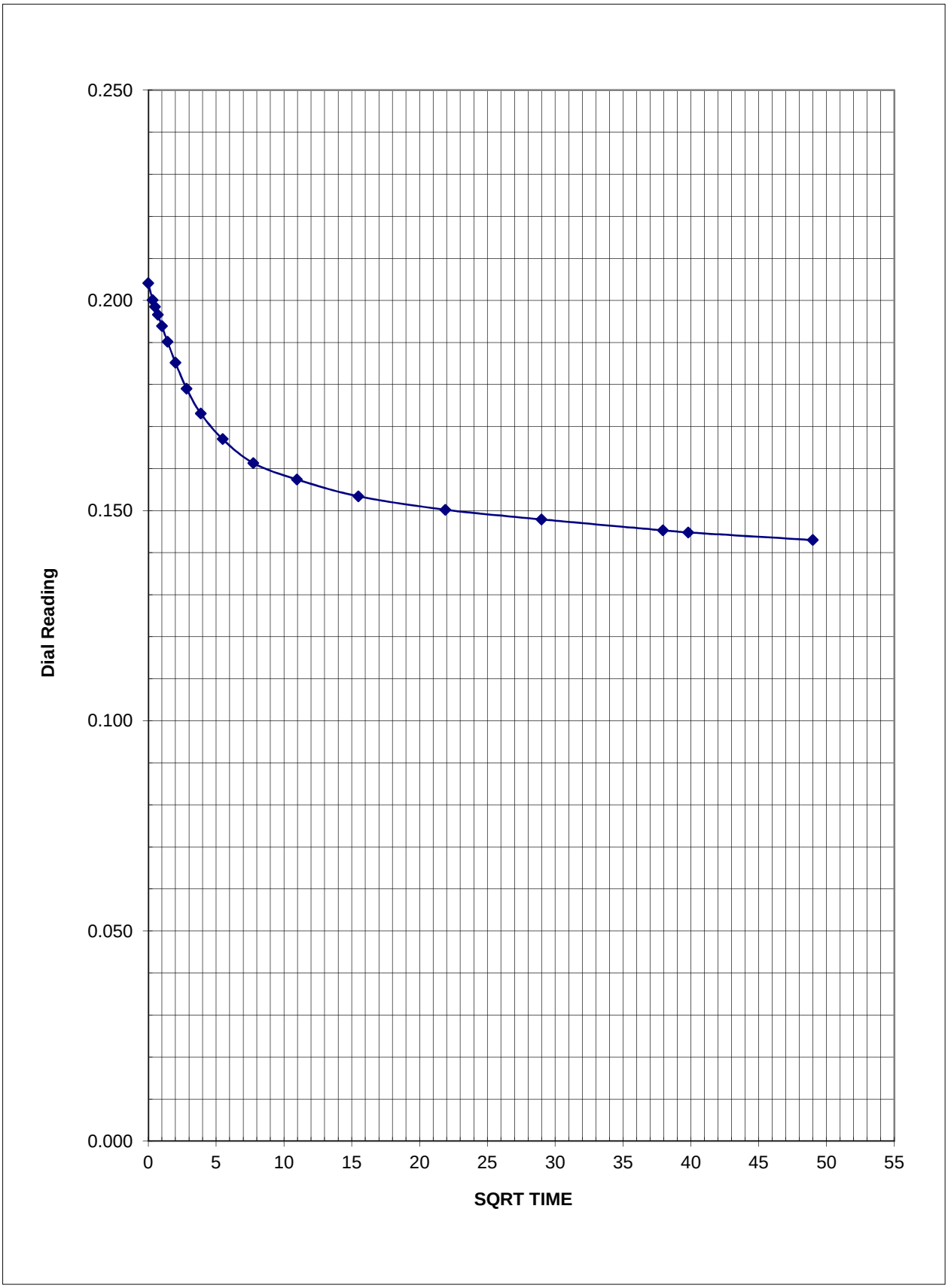
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**

Load Increment (psf):	**3200**

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.01	0.00	***0.2041***
6s		0.1	0.32	0.2001
15s		0.25	0.50	0.1985
30s		0.5	0.71	0.1966
1 min		1	1.00	0.1939
2 min		2	1.41	0.1902
4 min		4	2.00	0.1852
8 min		8	2.83	0.1790
15 min		15	3.87	0.1731
30 min		30	5.48	0.1670
1hr		60	7.75	0.1613
2 hr		120	10.95	0.1574
4 hr		240	15.49	0.1534
8 hr		480	21.91	0.1502
16 hr		840	28.98	0.1479
24 hr		1440	37.95	0.1453
		1585	39.81	0.1448
		2400	48.99	0.1430

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.1985	0.1966	0.1939
D:4	0.1939	0.1902	0.1852
Delta 1:4	0.0046	0.0064	0.0087
D_o (calc)	0.2031	0.2030	0.2026



Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**
		Load Increment (psf):	**3200**

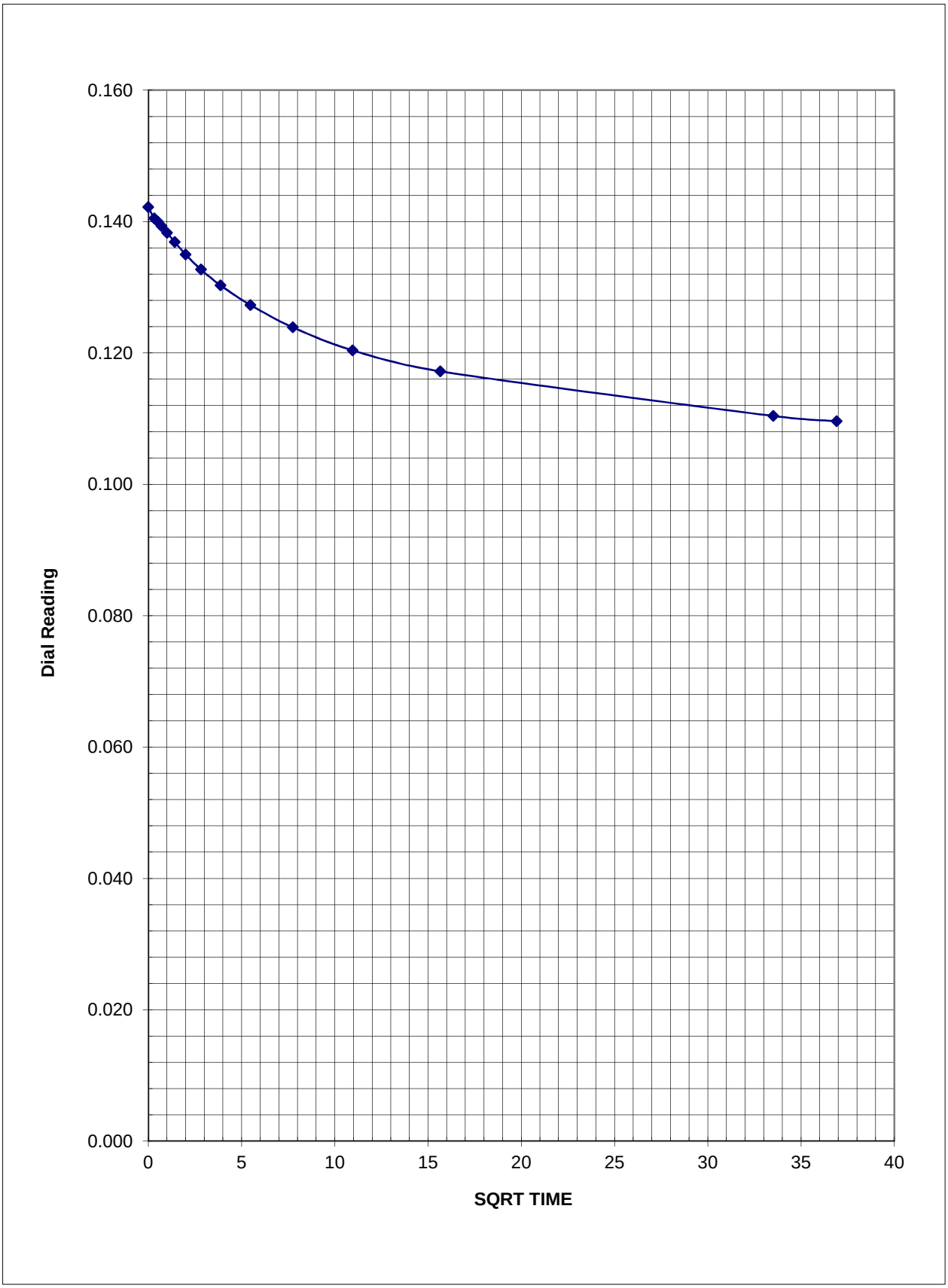
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**

Load Increment (psf):	**4800**

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.01	0.00	***0.1422***
6s		0.1	0.32	0.1405
15s		0.25	0.50	0.1400
30s		0.5	0.71	0.1393
1 min		1	1.00	0.1383
2 min		2	1.41	0.1369
4 min		4	2.00	0.1350
8 min		8	2.83	0.1327
15 min		15	3.87	0.1303
30 min		30	5.48	0.1273
1hr		60	7.75	0.1239
2 hr		120	10.95	0.1204
4 hr		245	15.65	0.1172
8 hr		1123	33.51	0.1104
16 hr		1362	36.91	0.1096
24 hr				

Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.1400	0.1393	0.1383
D:4	0.1383	0.1369	0.1350
Delta 1:4	0.0017	0.0024	0.0033
D_o (calc)	0.1417	0.1417	0.1416



Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**
		Load Increment (psf):	**4800**

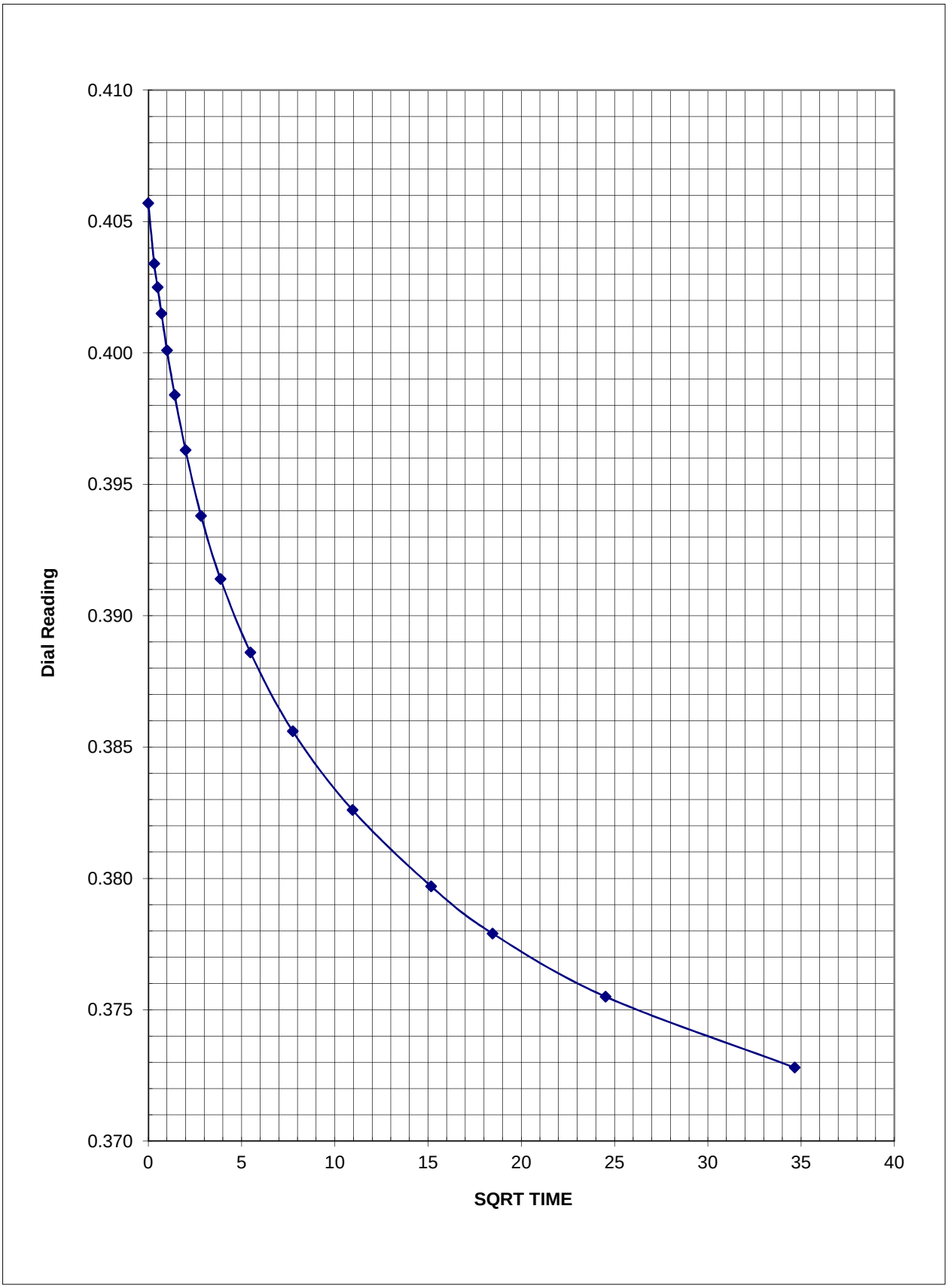
LOAD INCREMENT WORK SHEET

Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**

Load Increment (psf):	**7200**

Target Time sec/min/hr	Recorded Time	Actual Time (min)	SQRT TIME (min)	Dial Reading
Start		0.01	0.00	***0.4057***
6s		0.1	0.32	0.4034
15s		0.25	0.50	0.4025
30s		0.5	0.71	0.4015
1 min		1	1.00	0.4001
2 min		2	1.41	0.3984
4 min		4	2.00	0.3963
8 min		8	2.83	0.3938
15 min		15	3.87	0.3914
30 min		30	5.48	0.3886
1hr		60	7.75	0.3856
2 hr		120	10.95	0.3826
4 hr		230	15.17	0.3797
8 hr		341	18.47	0.3779
16 hr		601	24.52	0.3755
24 hr		1201	34.66	0.3728

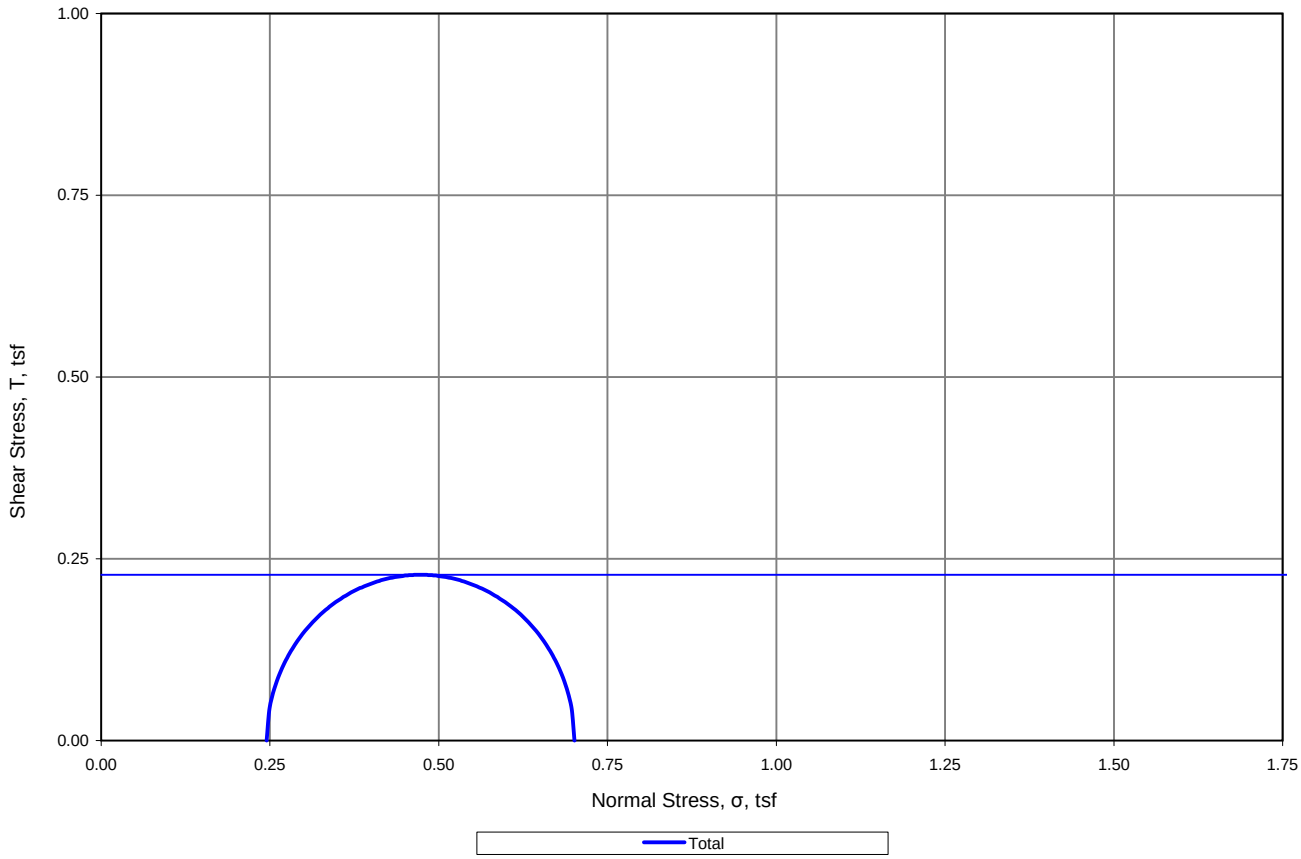
Log-Time D_o Calculation			
Time Ratio	**$(1:4)_{@0.25}$**	**$(1:4)_{@0.5}$**	**$(1:4)_{@1.0}$**
D:1	0.4025	0.4015	0.4001
D:4	0.4001	0.3984	0.3963
Delta 1:4	0.0024	0.0031	0.0038
D_o (calc)	0.4049	0.4046	0.4039

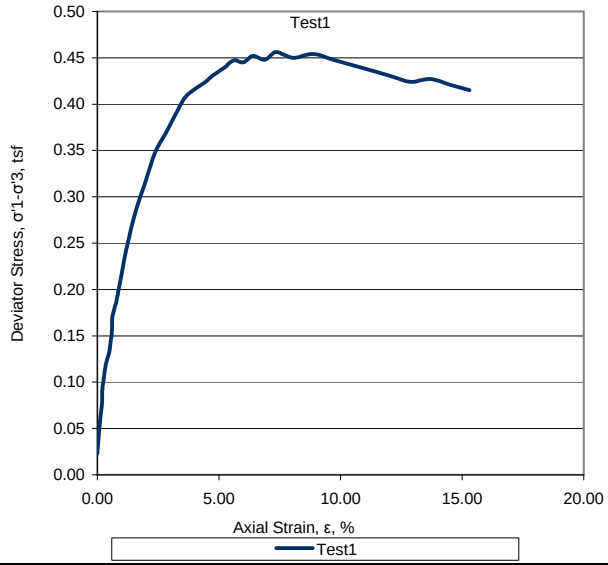


Project:	**107510**	**Sample:**	**SPT3**
Date:	**1/7/2010**	**Depth (ft):**	**11**
		Load Increment (psf):	**7200**

Triaxial Unconsolidated Undrained (UU) Test Report

Total	
c = 0.23	tsf





Initial	Water Content, %	ω_O	81.4
	Dry Density, lbs/ft^3	$^{\gamma}d_o$	50.3
	Saturation, %	S_O	95
	Void Ratio	e_O	2.230
Minor Principal Stress, tsf		σ_3	0.25
Maximum Deviator Stress, tsf	$(\sigma_1-\sigma_3)_{max}$		0.46
Time to $(\sigma_1-\sigma_3)_{max}$, min		t_f	15.0
Deviator Stress at 15% Axial Strain, tsf	$(\sigma_1-\sigma_3)_{15\%}$		0.42
Axial Strain at failure, %		ε	7.3
Initial Diameter in		D_O	2.841
Initial Height, in		H_O	6.204
Rate of strain, %/min: 1.0			

Description of Specimen: Dark Gray SILT (MH) | Amount of Material Passing the No. 200, %: 86.9

LL: 81 | PL: 39 | PI: 42 | G_S: 2.60 Measured | Type of Specimens: Undisturbed | Type of Test: ASTM D-2850

Remarks: Membrane correction applied. Scattered wood debris observed in sample.

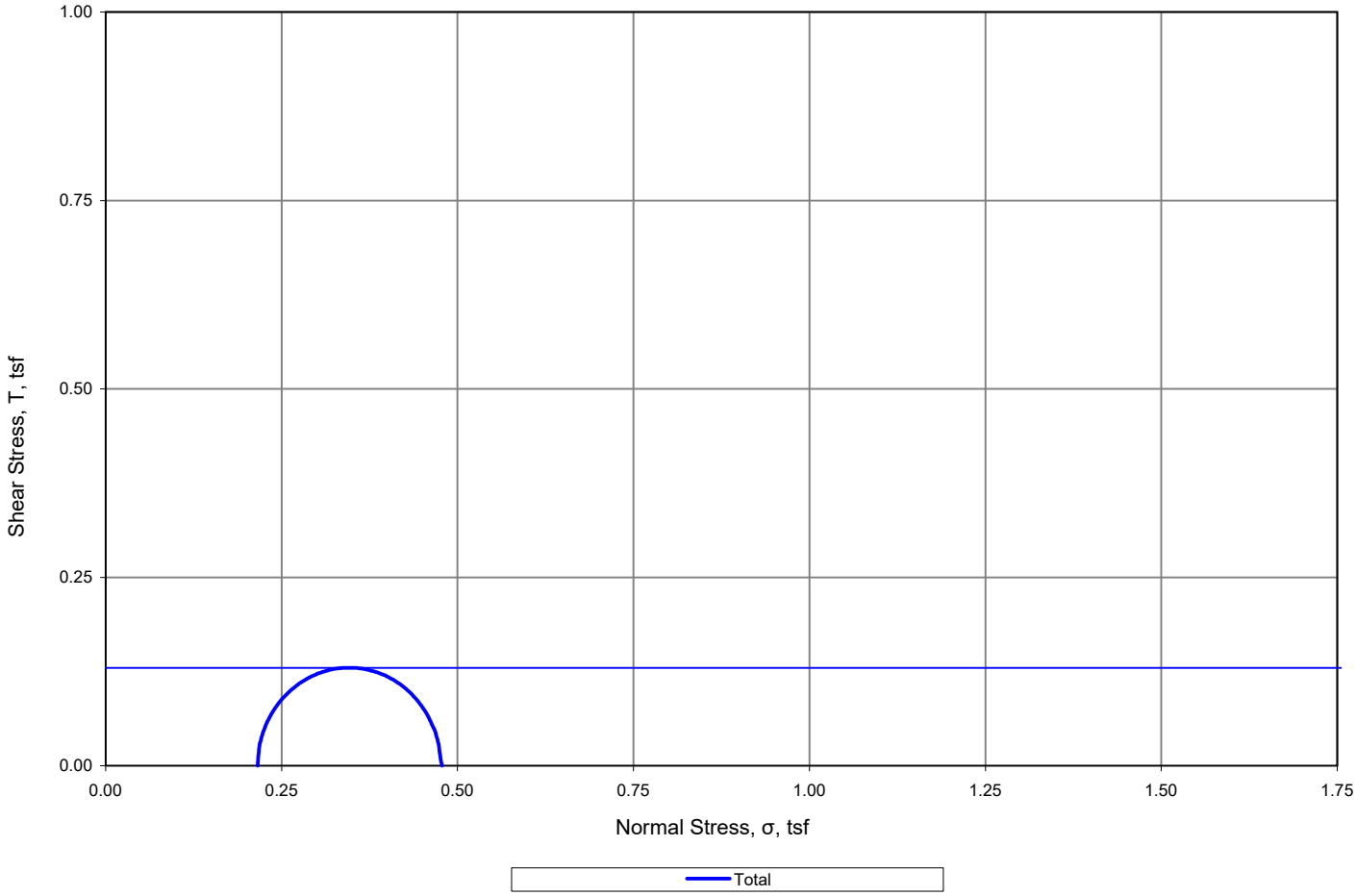
KLEINFELDER
Bright People. Right Solutions.

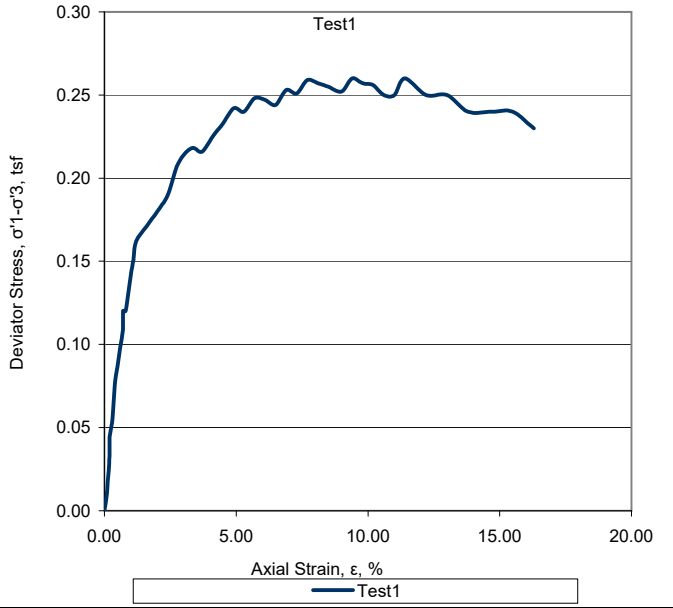
9200 SW Nimbus Avenue
Beaverton, Oregon 97008
p| 503.644.9447
f| 503.643.1905
kleinfelder.com

Project No.:	107510
Boring:	SPT-1
Sample:	ARK-SPT-1
Depth, ft:	15-17'
Date:	December 15, 2009

Triaxial Unconsolidated Undrained (UU) Test Report

Total		
c =	0.13	tsf





Initial	Water Content, %	ω_O	57.0
	Dry Density, lbs/ft^3	$^{\gamma}d_o$	62.8
	Saturation, %	S_O	93.8
	Void Ratio	e_O	1.582
Minor Principal Stress, tsf		σ_3	0.22
Maximum Deviator Stress, tsf	$(\sigma_1-\sigma_3)_{max}$		0.26
Time to $(\sigma_1-\sigma_3)_{max}$, min		t_f	15.0
Deviator Stress at 15% Axial Strain, tsf	$(\sigma_1-\sigma_3)_{15\%}$		0.24
Axial Strain at failure, %		ε	9.4
Initial Diameter in		D_O	2.870
Initial Height, in		H_O	6.143
Rate of strain, %/min: 1.0			

Description of Specimen: Gray SILT (MH)

Amount of Material Passing the No. 200, %: 98.9

LL: 53 | PL: 36 | PI: 17 | G_S: 2.60 Assumed

Type of Specimens: Undisturbed

Type of Test: ASTM D-2850

Remarks: Membrane correction applied.

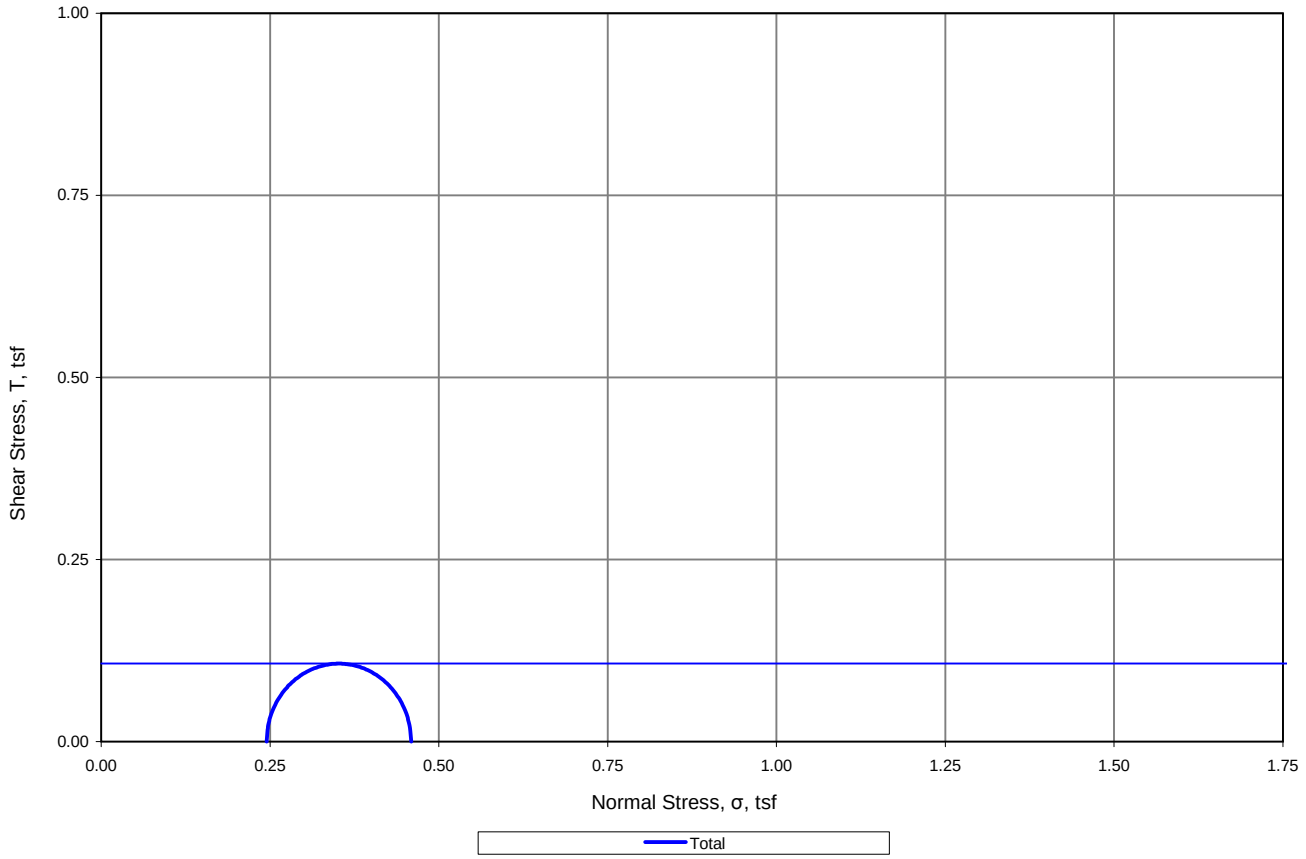
KLEINFELDER
Bright People. Right Solutions.

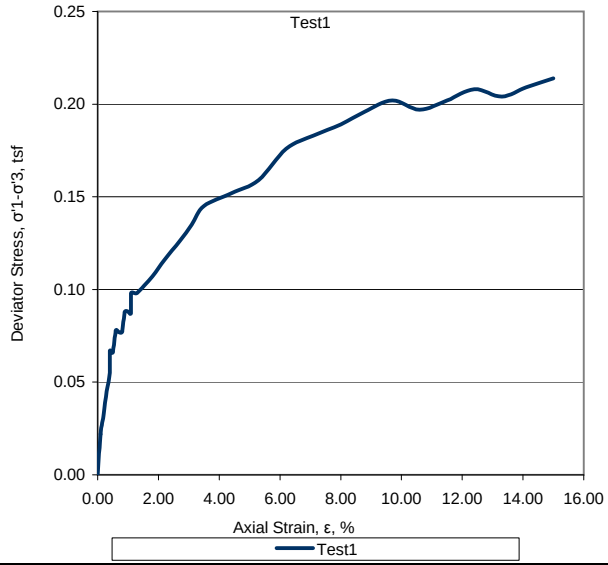
9200 SW Nimbus Avenue
Beaverton, Oregon 97008
p| 503.644.9447
f| 503.643.1905
kleinfelder.com

Project No.:	107510
Boring:	SPT-1
Sample:	ARK-SPT-1
Depth, ft:	18-20.5'
Date:	February 25, 2010

Triaxial Unconsolidated Undrained (UU) Test Report

Total	
c = 0.11	tsf





Initial	Water Content, %	ω_O	79.6
	Dry Density, lbs/ft^3	γd_o	53.4
	Saturation, %	S_O	100.6
	Void Ratio	e_O	2.103
Minor Principal Stress, tsf		σ_3	0.25
Maximum Deviator Stress, tsf	$(\sigma_1-\sigma_3)_{max}$		0.21
Time to $(\sigma_1-\sigma_3)_{max}$, min		t_f	15.0
Deviator Stress at 15% Axial Strain, tsf	$(\sigma_1-\sigma_3)_{15\%}$		0.21
Axial Strain at failure, %		ε	15.0
Initial Diameter in		D_O	2.844
Initial Height, in		H_O	5.660
Rate of strain, %/min: 1.0			

Description of Specimen: Dark Gray SILT (MH) | Amount of Material Passing the No. 200, %: 94.5

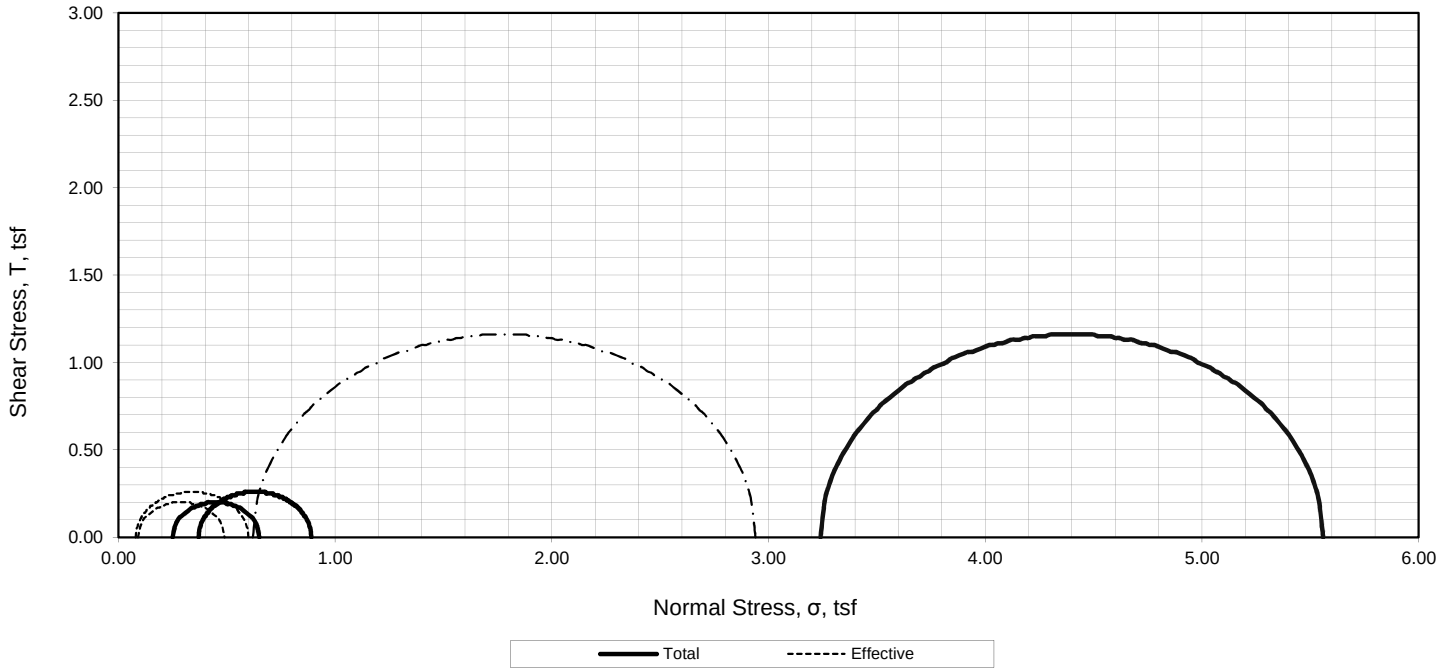
LL: 68 | PL: 33 | PI: 35 | G_S: 2.66 Measured | Type of Specimens: Undisturbed | Type of Test: ASTM D-2850

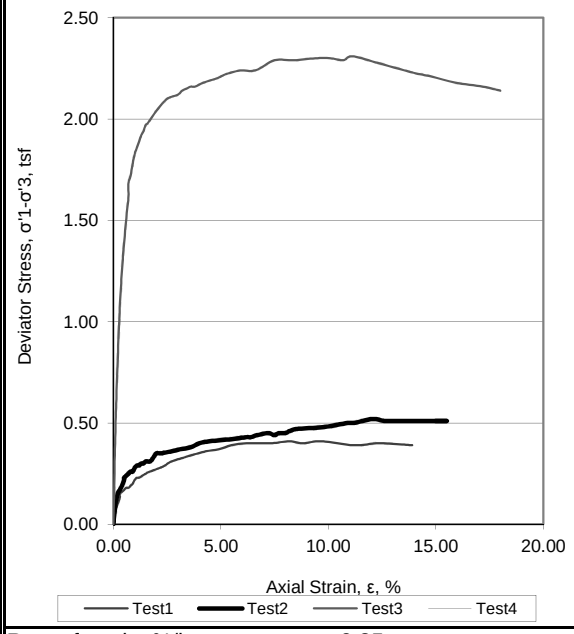
Remarks: Membrane correction applied.

KLEINFELDER
Bright People. Right Solutions.

9200 SW Nimbus Avenue
Beaverton, Oregon 97008
p| 503.644.9447
f| 503.643.1905
kleinfelder.com

Project No.:	107510
Boring:	SPT-3
Sample:	ARK-SPT-3
Depth, ft:	9.5-11.5'
Date:	December 15, 2009





Specimen No.			1	2	3	
Initial	Water Content, %	ω_O	75.8	75.6	71.9	
	Dry Density, lbs/ft^3	γd_o	53.7	53.8	55.5	
	Saturation, %	S_O	97.4	97.7	97.3	
	Void Ratio	e_O	2.02	2.02	1.92	
Before Shear	Water Content, %	ω_f	68.4	66.2	49.7	
	Dry Density, lbs/ft^3	γd_c	55.6	60.1	66.0	
	Saturation, %	S_C	100.0	100.0	100.0	
	Void Ratio	e_C	1.92	1.70	1.46	
	Final Back Pressure, tsf	U_O	2.9	2.9	2.9	
Minor Principal Stress, tsf		σ_3	0.25	0.37	3.25	
Maximum Deviator Stress, tsf	$(\sigma_1-\sigma_3)_{max}$		0.40	0.51	2.31	
Time to $(\sigma_1-\sigma_3)_{max}$, min		t_f				
Deviator Stress @ 15% Axial Strain, tsf	$(\sigma_1-\sigma_3)_{15\%}$		0.39	0.51	2.21	
Axial Strain at failure, %		ε	7.0	11.6	11.1	
Peak Pore Pressure at failure, tsf		U	3.046	3.168	5.501	
Δ Pore Pressure at failure (ΔU), tsf		ΔU	0.166	0.288	2.621	
Initial Diameter, in		D_O	2.833	2.853	2.855	
Initial Height, in		H_O	5.945	5.779	5.905	

Rate of strain, %/hr: 0.25

Description of Specimen 1: Dark Gray SILT (MH)

Description of Specimen 2: Dark Gray SILT (MH)

Description of Specimen 3: Dark Gray SILT (MH)

Amount of Material Finer than the No. 200, %: 95.0

LL: 76 | PL: 38 | PI: 38 | G_S: 2.60 Measured

Type of Specimens: Undisturbed | Type of Test: ASTM D-4767

Remarks: B Parameter >/= 0.99

Peak Strength selected at maximum effective stress ratio (obliquity)

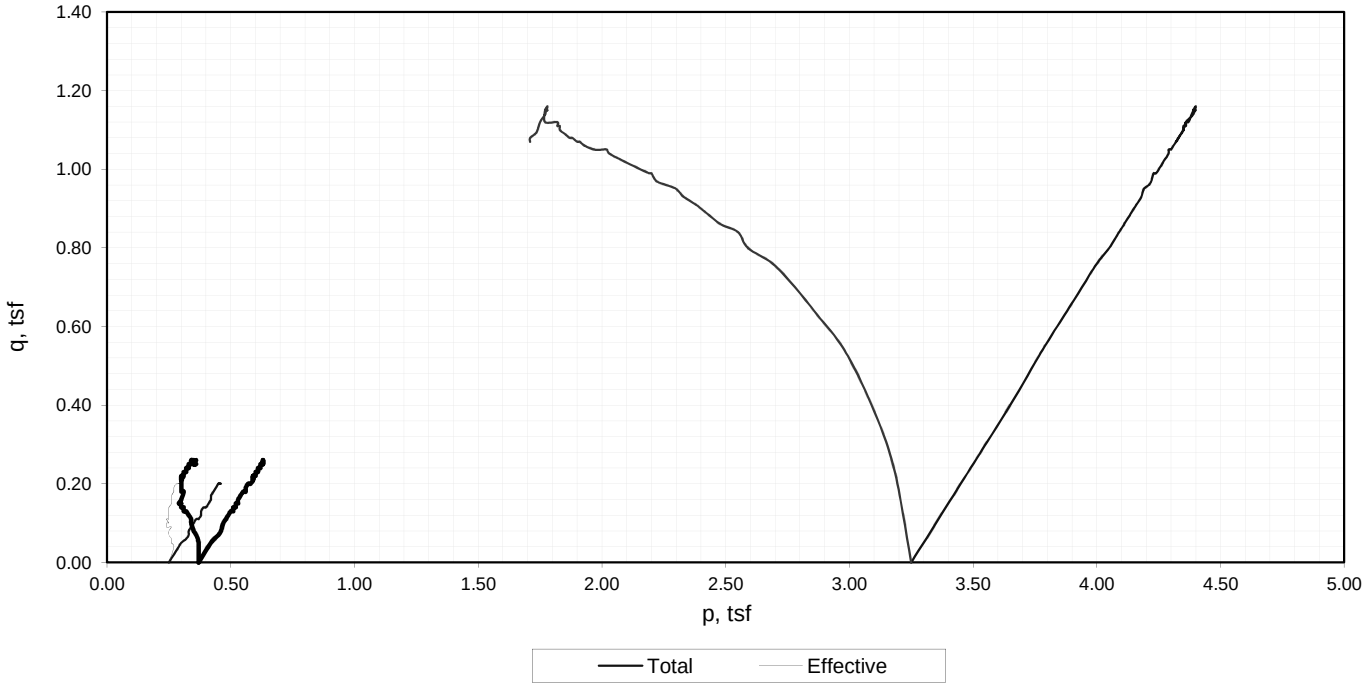
Scattered wood debris observed in samples

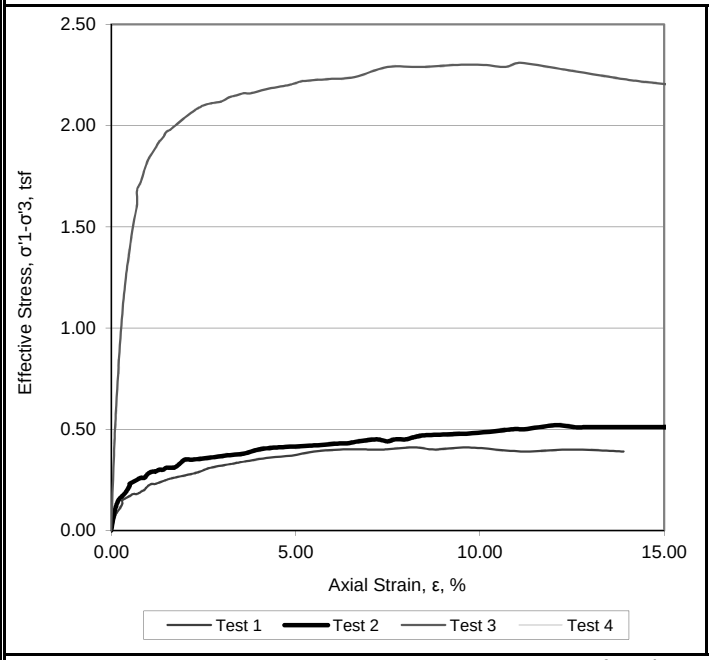
Method of Saturation: Wet Mounted

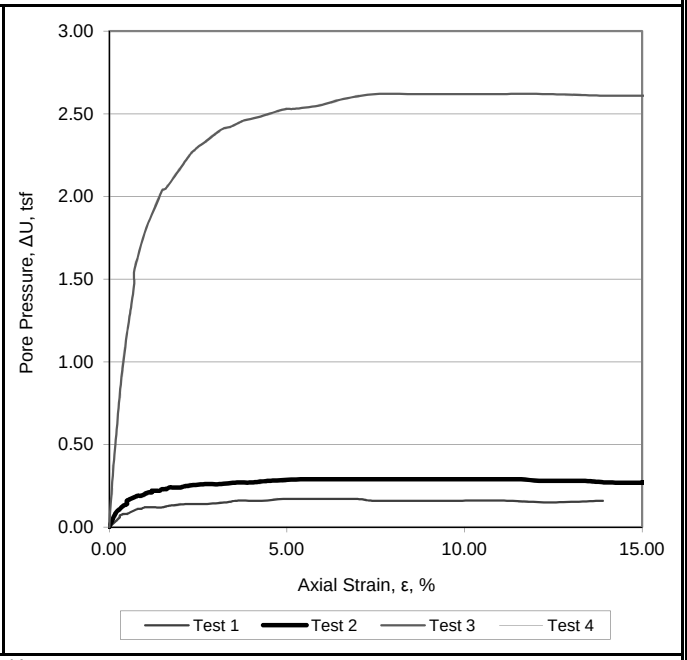
KLEINFELDER
Bright People. Right Solutions.

9200 SW Nimbus Ave
Beaverton, Oregon
p| 503-644-9447
f| 916.3643-1701
kleinfelder.com

Project Name:	Arkema Early Action
Project Number:	107510
Boring Number:	SPT-1
Sample ID:	ARK-SPT-1
Sample Depth, ft.:	13'-17'
Report Date:	December 15, 2009







Rate of strain, % / hr: 0.25

Description of Specimen 1 Dark Gray SILT (MH)

Description of Specimen 2 Dark Gray SILT (MH)

Description of Specimen 3 Dark Gray SILT (MH)

Amount of Material Finer than the No. 200, % 95.0

LL: 76	PL: 38	PI: 38	G_S: 2.60 Measured	Type of Specimen: Undisturbed	Type of Test: ASTM D-4767

Remarks: B Parameter >/= 0.99

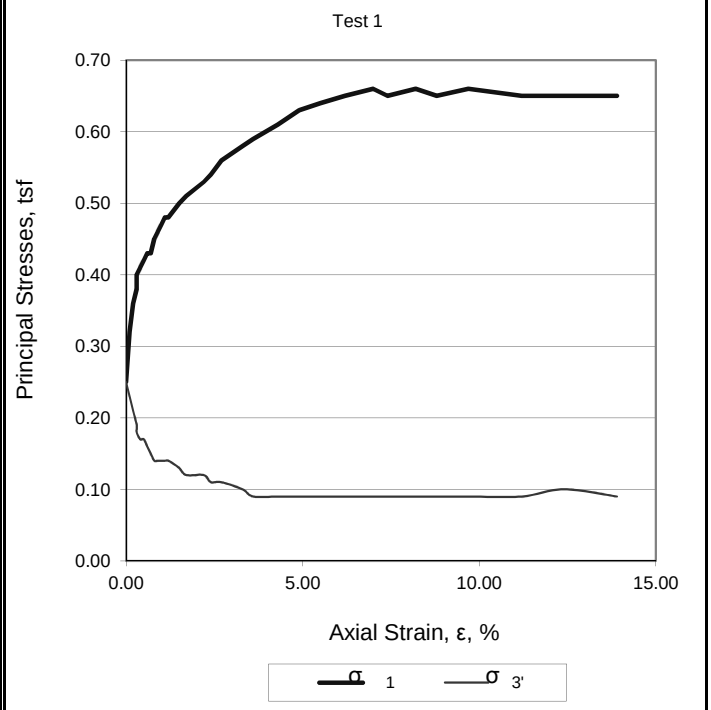
Peak Strength selected at maximum effective stress ratio (obliquity)

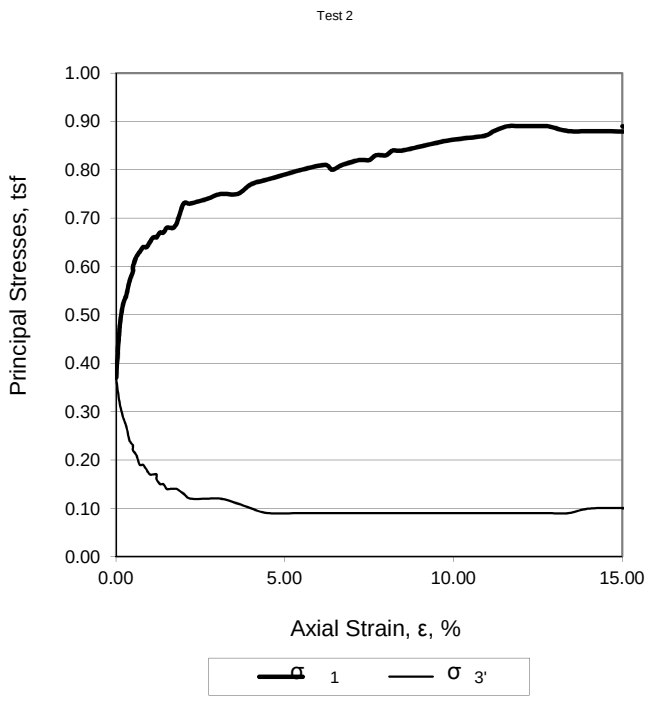
Scattered wood debris observed in samples

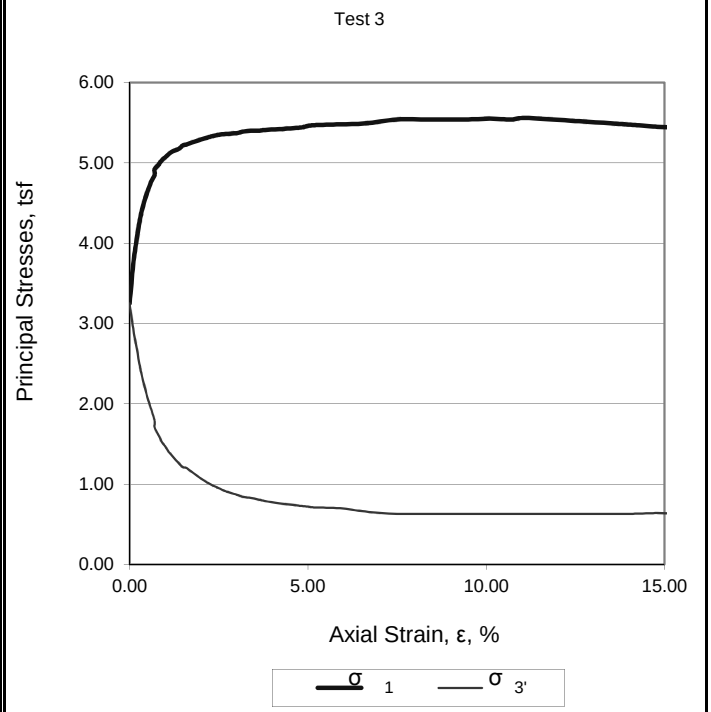
Method of Saturation: Wet Mounted

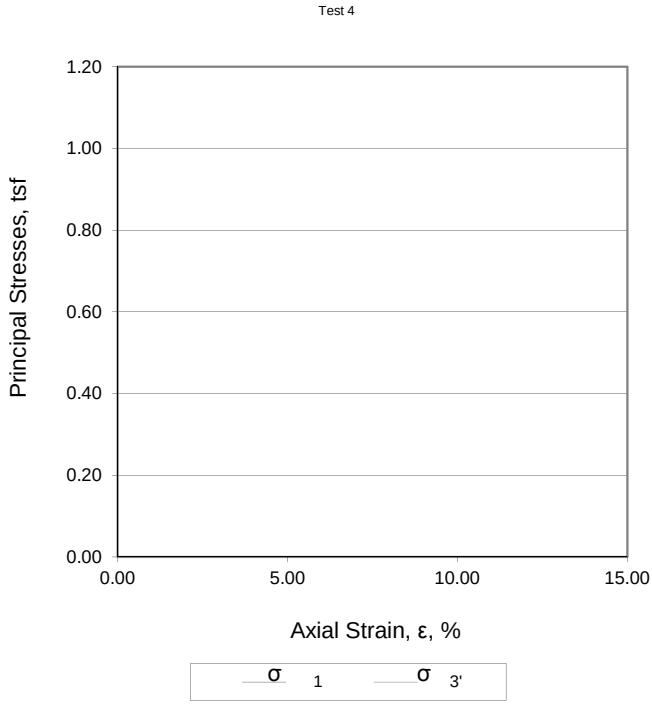
KLEINFELDER
Bright People. Right Solutions.
9200 SW Nimbus Ave
Beaverton, Oregon
p| 503-644-9447
f| 916.3643-1701
kleinfelder.com

Project Name:	Arkema Early Action
Project Number:	107510
Boring Number:	SPT-1
Sample ID:	ARK-SPT-1
Sample Depth, ft.:	13'-17'
Report Date:	December 15, 2009









Rate of strain, % / hr: 0.25

Description of Specimen 1 Dark Gray SILT (MH)

Description of Specimen 2 Dark Gray SILT (MH)

Description of Specimen 3 Dark Gray SILT (MH)

Amount of Material Finer than the No. 200, %: 95.0

LL: 76	PL: 38	PI: 38	G_S: 2.60 Measured	Type of Specimen: Undisturbed	Type of Test: ASTM D-4767

Remarks: B Parameter >/= 0.99

Peak Strength selected at maximum effective stress ratio (obliquity)

Scattered wood debris observed in samples

Method of Saturation: Wet Mounted

KLEINFELDER
Bright People. Right Solutions.

9200 SW Nimbus Ave
Beaverton, Oregon
p| 503-644-9447
f| 916.3643-1701
kleinfelder.com

Project Name:	Arkema Early Action
Project Number:	107510
Boring Number:	SPT-1
Sample ID:	ARK-SPT-1
Sample Depth, ft.:	13'-17'
Report Date:	December 15, 2009

Arkema Early Action ARK-SPT-1 13'-17'

Axial Loading Data

Triaxial Compression R-bar (CU) Tests

Selected for Calculations (**X**)

	Max Deviator Stress	5.63																						
	Selected Row for Deviator Stress				Selected Deviator Stress																			
x	Max Obliquity	5.67			Deviator Stress at Max Obliquity	5.60																		

Consolidation Pressure(psi/tsf) 3.5 / 0.25

H_O (in) 5.945 D_O (in) 2.833 A_O (in^2) 6.304

H_C (in) 5.827 D_C (in) 2.812 A_C (in^2) 6.209

Membrane Thickness: 0.012

Selected Row for Ultimate Deviator Stress (Based on Deviator Stress vs. % Axial Strian Graph) Ultimate Deviator Stress

Row Number	Elapsed Time	Dial Indicator Reading 0.0001 in	Cumulative Change (ΔH) 0.0001 in	P Axial Load lbs	Axial Strain $\varepsilon = \Delta H_C/H_C$	1-ε	Corrected Area $A_{Corr} = A_C/1-\varepsilon$ in^2	Deviator Stress $\sigma_1-\sigma_3 = P/A_C$ lbs/in^2	Membrane Correction Factor (MF) lbs/in^2	Corrected Deviator Stress $((\sigma_1-\sigma_3)$ - MF-FC)	Pore Pressure (U) lbs/in^2	Δ Pore Pressure (ΔU) lbs/in^2	σ_3 lbs/in^2	σ_3' lbs/in^2	σ_1 lbs/in^2	σ_1' lbs/in^2	p $(\sigma_1+\sigma_3)/2$ lbs/in^2	p' $(\sigma'_1+\sigma'_3)/2$ lbs/in^2	q $(\sigma_1.\sigma_3)/2$ lbs/in^2	Obliquity σ_1'/σ_3' lbs/in^2	Filter Strip Correction Factor (FC) lbs/in^2
1		0.0000	0.0000	0.00	0.0000	1.000	6.209	0.00	0.000	0.00	40.00	0.00	3.50	3.50	3.50	3.50	3.50	3.50	0.00	1.00	0
2		0.0050	0.0050	6.00	0.0010	0.999	6.216	0.97	0.003	0.97	40.30	0.30	3.50	3.20	4.47	4.17	3.99	3.69	0.49	1.30	0
3		0.0100	0.0100	9.00	0.0020	0.998	6.222	1.45	0.007	1.44	40.60	0.60	3.50	2.90	4.94	4.34	4.22	3.62	0.72	1.50	0
4		0.0150	0.0150	11.00	0.0030	0.997	6.228	1.77	0.010	1.76	40.80	0.80	3.50	2.70	5.26	4.46	4.38	3.58	0.88	1.65	0
5		0.0200	0.0200	13.00	0.0030	0.997	6.228	2.09	0.010	2.08	41.00	1.00	3.50	2.50	5.58	4.58	4.54	3.54	1.04	1.83	0
6		0.0250	0.0250	14.00	0.0040	0.996	6.234	2.25	0.014	2.24	41.10	1.10	3.50	2.40	5.74	4.64	4.62	3.52	1.12	1.93	0
7		0.0300	0.0300	15.00	0.0050	0.995	6.241	2.40	0.017	2.38	41.10	1.10	3.50	2.40	5.88	4.78	4.69	3.59	1.19	1.99	0
8		0.0350	0.0350	16.00	0.0060	0.994	6.247	2.56	0.020	2.54	41.30	1.30	3.50	2.20	6.04	4.74	4.77	3.47	1.27	2.15	0
9		0.0400	0.0400	16.00	0.0070	0.993	6.253	2.56	0.024	2.54	41.40	1.40	3.50	2.10	6.04	4.64	4.77	3.37	1.27	2.21	0
10		0.0450	0.0450	17.00	0.0080	0.992	6.259	2.72	0.027	2.69	41.50	1.50	3.50	2.00	6.19	4.69	4.85	3.35	1.35	2.35	0
11		0.0500	0.0500	18.00	0.0090	0.991	6.266	2.87	0.031	2.84	41.50	1.50	3.50	2.00	6.34	4.84	4.92	3.42	1.42	2.42	0
12		0.0550	0.0550	18.00	0.0090	0.991	6.266	2.87	0.031	2.84	41.50	1.50	3.50	2.00	6.34	4.84	4.92	3.42	1.42	2.42	0
13		0.0600	0.0600	19.00	0.0100	0.990	6.272	3.03	0.034	3.00	41.60	1.60	3.50	1.90	6.50	4.90	5.00	3.40	1.50	2.58	0
14		0.0650	0.0650	20.00	0.0110	0.989	6.278	3.19	0.038	3.15	41.60	1.60	3.50	1.90	6.65	5.05	5.08	3.48	1.58	2.66	0
15		0.0700	0.0700	20.00	0.0120	0.988	6.285	3.18	0.041	3.14	41.60	1.60	3.50	1.90	6.64	5.04	5.07	3.47	1.57	2.65	0
16		0.0900	0.0900	22.00	0.0150	0.985	6.304	3.49	0.051	3.44	41.70	1.70	3.50	1.80	6.94	5.24	5.22	3.52	1.72	2.91	0
17		0.1000	0.1000	23.00	0.0170	0.983	6.317	3.64	0.058	3.58	41.80	1.80	3.50	1.70	7.08	5.28	5.29	3.49	1.79	3.11	0
18		0.1300	0.1300	25.00	0.0220	0.978	6.349	3.94	0.075	3.87	41.90	1.90	3.50	1.60	7.37	5.47	5.43	3.53	1.93	3.42	0
19		0.1400	0.1400	26.00	0.0240	0.976	6.362	4.09	0.082	4.01	42.00	2.00	3.50	1.50	7.51	5.51	5.50	3.50	2.00	3.67	0
20		0.1600	0.1600	28.00	0.0270	0.973	6.382	4.39	0.092	4.30	42.00	2.00	3.50	1.50	7.80	5.80	5.65	3.65	2.15	3.87	0
21		0.1900	0.1900	30.00	0.0330	0.967	6.421	4.67	0.113	4.56	42.10	2.10	3.50	1.40	8.06	5.96	5.78	3.68	2.28	4.26	0
22		0.2100	0.2100	31.00	0.0360	0.964	6.441	4.81	0.123	4.69	42.20	2.20	3.50	1.30	8.19	5.99	5.84	3.64	2.34	4.61	0
23		0.2500	0.2500	33.00	0.0430	0.957	6.488	5.09	0.147	4.94	42.20	2.20	3.50	1.30	8.44	6.24	5.97	3.77	2.47	4.80	0
24		0.2850	0.2850	35.00	0.0490	0.951	6.529	5.36	0.167	5.19	42.30	2.30	3.50	1.20	8.69	6.39	6.10	3.80	2.60	5.33	0
25		0.3200	0.3200	37.00	0.0550	0.945	6.571	5.63	0.188	5.44	42.30	2.30	3.50	1.20	8.94	6.64	6.22	3.92	2.72	5.53	0
26		0.3600	0.3600	38.00	0.0620	0.938	6.620	5.74	0.212	5.53	42.30	2.30	3.50	1.20	9.03	6.73	6.26	3.96	2.76	5.61	0
27		0.4100	0.4100	39.00	0.0700	0.930	6.677	5.84	0.239	5.60	42.30	2.30	3.50	1.20	9.10	6.80	6.30	4.00	2.80	5.67	0
28		0.4300	0.4300	39.00	0.0740	0.926	6.706	5.82	0.253	5.57	42.20	2.20	3.50	1.30	9.07	6.87	6.28	4.08	2.78	5.28	0
29		0.4750	0.4750	40.00	0.0820	0.918	6.764	5.91	0.280	5.63	42.20	2.20	3.50	1.30	9.13	6.93	6.32	4.12	2.82	5.33	0
30		0.5100	0.5100	40.00	0.0880	0.912	6.808	5.88	0.300	5.58	42.20	2.20	3.50	1.30	9.08	6.88	6.29	4.09	2.79	5.29	0
31		0.5650	0.5650	41.00	0.0970	0.903	6.876	5.96	0.331	5.63	42.20	2.20	3.50	1.30	9.13	6.93	6.31	4.11	2.81	5.33	0
32		0.6500	0.6500	41.00	0.1120	0.888	6.992	5.86	0.382	5.48	42.20	2.20	3.50	1.30	8.98	6.78	6.24	4.04	2.74	5.21	0
33		0.7200	0.7200	42.00	0.1240	0.876	7.088	5.93	0.423	5.51	42.10	2.10	3.50	1.40	9.01	6.91	6.25	4.15	2.75	4.93	0
34		0.8100	0.8100	43.00	0.1390	0.861	7.212	5.96	0.475	5.49	42.20	2.20	3.50	1.30	8.99	6.79	6.24	4.04	2.74	5.22	0
35				44.00				#VALUE!			42.10	2.10	3.50	1.40		#######					0
36																					0
37																					0
38																					0
39																					

Calculations Based on
EM 1110-2-1906 Appendix X
ASTM D 4767-04

Arkema Early Action ARK-SPT-1 13'-17'

Axial Loading Data
Triaxial Compression R-bar (CU) Tests

Selected for Calculations (**X**)

Max Deviator Stress 7.19

Selected Row for Deviator Stress ____ Selected Deviator Stress ____

x Max Obliquity 6.91 Deviator Stress at Max Obliquity 7.09

H_O (in) 5.779 D_O (in) 2.853 A_O (in^2) 6.392

H_C (in) 5.614 D_C (in) 2.740 A_C (in^2) 5.895

Consolidation Pressure(psi/tsf) 5.2 / 0.37

Membrane Thickness: 0.012

Selected Row for Ultimate Deviator Stress (Based on Deviator Stress vs. % Axial Strian Graph) ____ Ultimate Deviator Stress ____

Row Number	Elapsed Time	Dial Indicator Reading 0.0001 in	Cumulative Change (ΔH) 0.0001 in	P Axial Load lbs	Axial Strain $\varepsilon = \Delta H_C/H_C$	1-ε	Corrected Area $A_{Corr} = A_C/1-\varepsilon$ in^2	Deviator Stress $\sigma_1-\sigma_3 = P/A_C$ lbs/in^2	Membrane Correction Factor (MF) lbs/in^2	Corrected Deviator Stress $((\sigma_1-\sigma_3)$ - MF-FC)	Pore Pressure (U) lbs/in^2	Δ Pore Pressure (ΔU) lbs/in^2	σ_3 lbs/in^2	σ_3' lbs/in^2	σ_1 lbs/in^2	σ_1' lbs/in^2	p $(\sigma_1+\sigma_3)/2$ lbs/in^2	p' $(\sigma'_1+\sigma'_3)/2$ lbs/in^2	q $(\sigma_1-\sigma_3)/2$ lbs/in^2	Obliquity σ_1'/σ_3' lbs/in^2	Filter Strip Correction Factor (FC) lbs/in^2
1		0.0000	0.0000	0.00	0.0000	1.000	5.895	0.00	0.000	0.00	40.00	0.00	5.20	5.20	5.20	5.20	5.20	5.20	0.00	1.00	0
2		0.0050	0.0050	8.00	0.0010	0.999	5.901	1.36	0.004	1.36	40.70	0.70	5.20	4.50	6.56	5.86	5.88	5.18	0.68	1.30	0
3		0.0100	0.0100	12.00	0.0020	0.998	5.906	2.03	0.007	2.02	41.23	1.23	5.20	3.97	7.22	5.99	6.21	4.98	1.01	1.51	0
4		0.0150	0.0150	14.00	0.0030	0.997	5.912	2.37	0.011	2.36	41.50	1.50	5.20	3.70	7.56	6.06	6.38	4.88	1.18	1.64	0
5		0.0200	0.0200	16.00	0.0040	0.996	5.918	2.70	0.014	2.69	41.80	1.80	5.20	3.40	7.89	6.09	6.54	4.74	1.34	1.79	0
6		0.0255	0.0255	18.00	0.0050	0.995	5.924	3.04	0.018	3.02	42.00	2.00	5.20	3.20	8.22	6.22	6.71	4.71	1.51	1.94	0
7		0.0300	0.0300	19.00	0.0050	0.995	5.924	3.21	0.018	3.19	42.20	2.20	5.20	3.00	8.39	6.19	6.80	4.60	1.60	2.06	0
8		0.0350	0.0350	20.00	0.0060	0.994	5.930	3.37	0.021	3.35	42.30	2.30	5.20	2.90	8.55	6.25	6.87	4.57	1.67	2.15	0
9		0.0400	0.0400	21.00	0.0070	0.993	5.936	3.54	0.025	3.52	42.50	2.50	5.20	2.70	8.72	6.22	6.96	4.46	1.76	2.30	0
10		0.0450	0.0450	22.00	0.0080	0.992	5.942	3.70	0.028	3.67	42.60	2.60	5.20	2.60	8.87	6.27	7.04	4.44	1.84	2.41	0
11		0.0500	0.0500	22.00	0.0090	0.991	5.948	3.70	0.032	3.67	42.70	2.70	5.20	2.50	8.87	6.17	7.03	4.33	1.83	2.47	0
12		0.0550	0.0550	23.00	0.0100	0.990	5.954	3.86	0.035	3.83	42.80	2.80	5.20	2.40	9.03	6.23	7.11	4.31	1.91	2.59	0
13		0.0600	0.0600	24.00	0.0110	0.989	5.960	4.03	0.039	3.99	42.90	2.90	5.20	2.30	9.19	6.29	7.20	4.30	2.00	2.74	0
14		0.0650	0.0650	24.00	0.0120	0.988	5.966	4.02	0.042	3.98	42.90	2.90	5.20	2.30	9.18	6.28	7.19	4.29	1.99	2.73	0
15		0.0700	0.0700	24.00	0.0120	0.988	5.966	4.02	0.042	3.98	43.00	3.00	5.20	2.20	9.18	6.18	7.19	4.19	1.99	2.81	0
16		0.0750	0.0750	25.00	0.0130	0.987	5.972	4.19	0.046	4.14	43.10	3.10	5.20	2.10	9.34	6.24	7.27	4.17	2.07	2.97	0
17		0.0800	0.0800	25.00	0.0140	0.986	5.978	4.18	0.049	4.13	43.10	3.10	5.20	2.10	9.33	6.23	7.27	4.17	2.07	2.97	0
18		0.0850	0.0850	26.00	0.0150	0.985	5.984	4.34	0.053	4.29	43.20	3.20	5.20	2.00	9.49	6.29	7.34	4.14	2.14	3.14	0
19		0.0900	0.0900	26.00	0.0160	0.984	5.991	4.34	0.056	4.28	43.20	3.20	5.20	2.00	9.48	6.28	7.34	4.14	2.14	3.14	0
20		0.0950	0.0950	26.00	0.0170	0.983	5.997	4.34	0.060	4.28	43.30	3.30	5.20	1.90	9.48	6.18	7.34	4.04	2.14	3.25	0
21		0.1000	0.1000	27.00	0.0180	0.982	6.003	4.50	0.063	4.44	43.30	3.30	5.20	1.90	9.64	6.34	7.42	4.12	2.22	3.34	0
22		0.1150	0.1150	30.00	0.0200	0.980	6.015	4.99	0.070	4.92	43.40	3.40	5.20	1.80	10.12	6.72	7.66	4.26	2.46	3.73	0
23		0.1250	0.1250	30.00	0.0220	0.978	6.027	4.98	0.077	4.90	43.50	3.50	5.20	1.70	10.10	6.60	7.65	4.15	2.45	3.88	0
24		0.1500	0.1500	31.00	0.0270	0.973	6.058	5.12	0.095	5.03	43.60	3.60	5.20	1.60	10.23	6.63	7.71	4.11	2.51	4.14	0
25		0.1750	0.1750	32.00	0.0310	0.969	6.083	5.26	0.109	5.15	43.60	3.60	5.20	1.60	10.35	6.75	7.78	4.18	2.58	4.22	0
26		0.2000	0.2000	33.00	0.0360	0.964	6.115	5.40	0.126	5.27	43.70	3.70	5.20	1.50	10.47	6.77	7.84	4.14	2.64	4.52	0
27		0.2250	0.2250	35.00	0.0400	0.960	6.140	5.70	0.140	5.56	43.80	3.80	5.20	1.40	10.76	6.96	7.98	4.18	2.78	4.97	0
28		0.2500	0.2500	36.00	0.0450	0.955	6.172	5.83	0.158	5.67	43.90	3.90	5.20	1.30	10.87	6.97	8.04	4.14	2.84	5.36	0
29		0.3100	0.3100	38.00	0.0550	0.945	6.238	6.09	0.193	5.90	44.00	4.00	5.20	1.20	11.10	7.10	8.15	4.15	2.95	5.91	0
30		0.3500	0.3500	39.00	0.0620	0.938	6.284	6.21	0.217	5.99	44.00	4.00	5.20	1.20	11.19	7.19	8.20	4.20	3.00	5.99	0
31		0.3600	0.3600	39.00	0.0640	0.936	6.298	6.19	0.224	5.97	44.00	4.00	5.20	1.20	11.17	7.17	8.18	4.18	2.98	5.97	0
32		0.3750	0.3750	40.00	0.0670	0.933	6.318	6.33	0.235	6.10	44.00	4.00	5.20	1.20	11.30	7.30	8.25	4.25	3.05	6.08	0
33		0.4050	0.4050	41.00	0.0720	0.928	6.352	6.45	0.252	6.20	44.00	4.00	5.20	1.20	11.40	7.40	8.30	4.30	3.10	6.17	0
34		0.4200	0.4200	41.00	0.0750	0.925	6.373	6.43	0.263	6.17	44.00	4.00	5.20	1.20	11.37	7.37	8.28	4.28	3.08	6.14	0
35		0.4300	0.4300	42.00	0.0770	0.923	6.386	6.58	0.270	6.31	44.00	4.00	5.20	1.20	11.51	7.51	8.36	4.36	3.16	6.26	0
36		0.4500	0.4500	42.00	0.0800	0.920	6.407	6.56	0.280	6.28	44.00	4.00	5.20	1.20	11.48	7.48	8.34	4.34	3.14	6.23	0
37		0.4600	0.4600	43.00	0.0820	0.918	6.421	6.70	0.287	6.41	44.00	4.00	5.20	1.20	11.61	7.61	8.41	4.41	3.21	6.34	0
38		0.4800	0.4800	44.00	0.0850	0.915	6.442	6.83	0.298	6.53	44.00	4.00	5.20	1.20	11.73	7.73	8.47	4.47	3.27	6.44	0
39		0.5500	0.5500	46.00	0.0980	0.902	6.535	7.04	0.343	6.70	44.00	4.00	5.20	1.20	11.90	7.90	8.55	4.55	3.35	6.58	0
40		0.6100	0.6100	48.00	0.1090	0.891	6.616	7.26	0.382	6.88	44.00	4.00	5.20	1.20	12.08	8.08	8.64	4.64	3.44	6.73	0
41		0.6300	0.6300	49.00	0.1120	0.888	6.638	7.38	0.392	6.99	44.00	4.00	5.20	1.20	12.19	8.19	8.69	4.69	3.49	6.82	0
42		0.6500	0.6500	50.00	0.1160	0.884	6.668	7.50	0.406	7.09	44.00	4.00	5.20	1.20	12.29	8.29	8.75	4.75	3.55	6.91	0
43		0.6800	0.6800	51.00	0.1210	0.879	6.706	7.61	0.424	7.19	43.90	3.90	5.20	1.30	12.39	8.49	8.79	4.89	3.59	6.53	0
44		0.7100	0.7100	51.00	0.1260	0.874	6.744	7.56	0.441	7.12	43.90	3.90	5.20	1.30	12.32	8.42	8.76	4.86	3.56	6.48	0
45		0.7200	0.7200	51.00	0.1280	0.872	6.760	7.54	0.448	7.09	43.90	3.90	5.20	1.30	12.29	8.39	8.75	4.85	3.55	6.46	0
46		0.7500	0.7500	51.00	0.1340	0.866	6.807	7.49	0.469	7.02	43.90	3.90	5.20	1.30	12.22	8.32	8.71	4.81	3.51	6.40	0
47		0.7900	0.7900	52.00	0.1410	0.859	6.862	7.58	0.494	7.09	43.80	3.80	5.20	1.40	12.29	8.49	8.74	4.94	3.54	6.06	0
48		0.8700	0.8700	53.00	0.1550	0.845	6.976	7.60	0.543	7.06	43.80	3.80	5.20	1.40	12.26	8.46	8.73	4.93	3.53	6.04	0
49		0.8400	0.8400	53.00	0.1500	0.850	6.935	7.64	0.526	7.11	43.80	3.80	5.20	1.40	12.31	8.51	8.76	4.96	3.56	6.08	0

Calculations Based on
EM 1110-2-1906 Appendix X
ASTM D 4767-04

Arkema Early Action ARK-SPT-1 13'-17'

Axial Loading Data
Triaxial Compression R-bar (CU) Tests

Selected for Calculations (**X**)

Max Deviator Stress 32.12 | Selected Deviator Stress | H_O (in) 5.905 D_O (in) 2.855 A_O (in^2) 6.402 | Consolidation Pressure(psi/tsf) 45.1 / 3.25

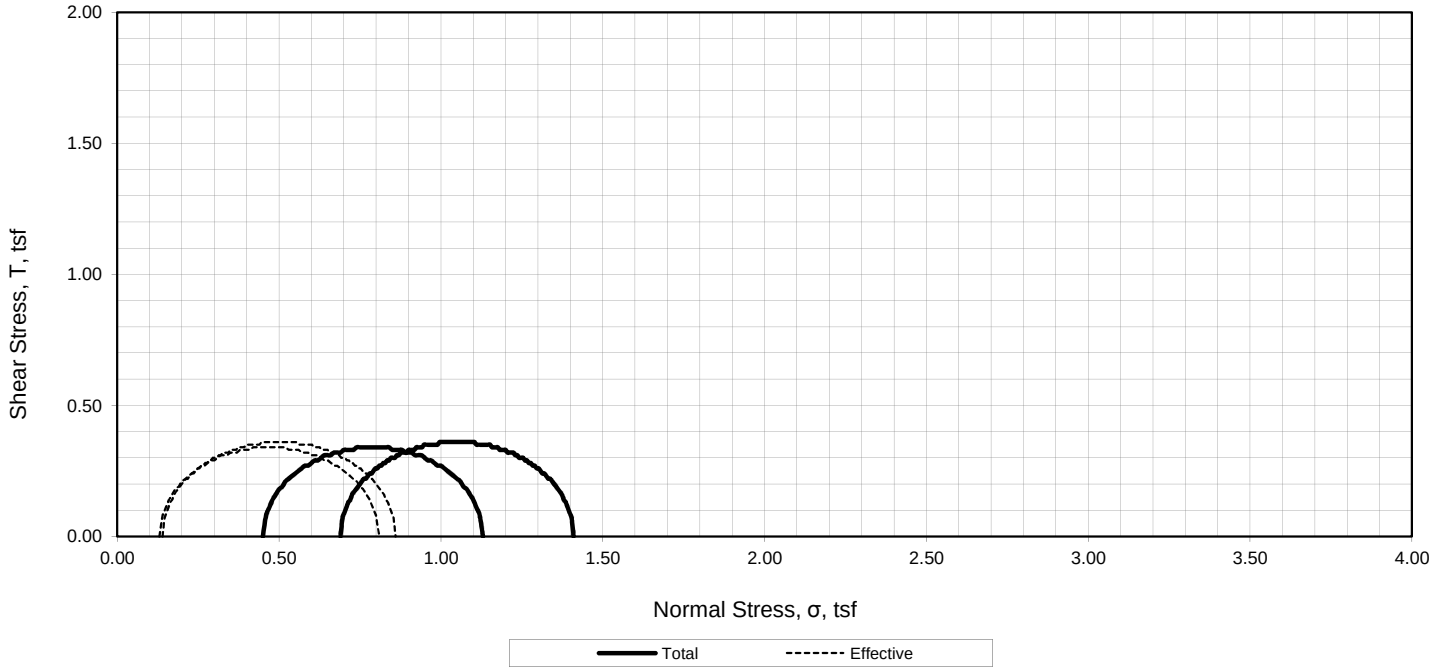
Selected Row for Deviator Stress | H_C (in) 5.339 D_C (in) 2.755 A_C (in^2) 5.961 | Membrane Thickness: 0.012

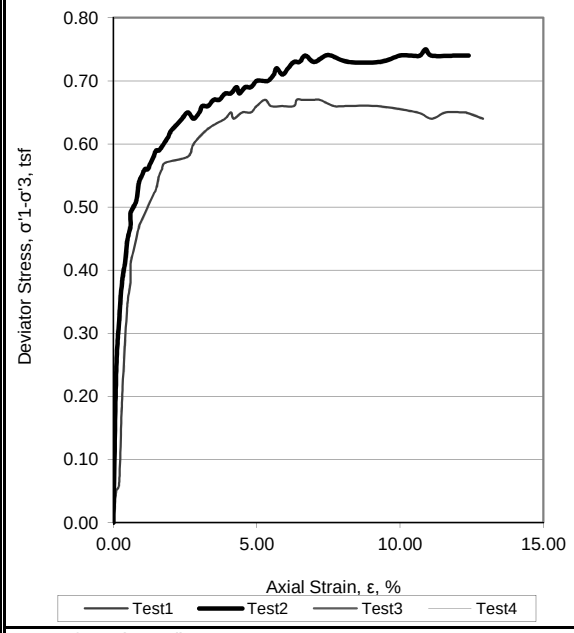
x Max Obliquity 4.69 | Deviator Stress at Max Obliquity 32.12

Selected Row for Ultimate Deviator Stress (Based on Deviator Stress vs. % Axial Strian Graph) | Ultimate Deviator Stress

Row Number	Elapsed Time	Dial Indicator Reading 0.0001 in	Cumulative Change (ΔH) 0.0001 in	P Axial Load lbs	Axial Strain $\varepsilon = \Delta H_C/H_C$	1-ε	Corrected Area $A_{Corr} = A_C/1-\varepsilon$ in^2	Deviator Stress $\sigma_1-\sigma_3 = P/A_C$ lbs/in^2	Membrane Correction Factor (MF) lbs/in^2	Corrected Deviator Stress $((\sigma_1-\sigma_3) - MF-FC)$	Pore Pressure (U) lbs/in^2	Δ Pore Pressure (ΔU) lbs/in^2	σ_3 lbs/in^2	σ_3' lbs/in^2	σ_1 lbs/in^2	σ_1' lbs/in^2	p $(\sigma_1+\sigma_3)/2$ lbs/in^2	p' $(\sigma'_1+\sigma'_3)/2$ lbs/in^2	q $(\sigma_1-\sigma_3)/2$ lbs/in^2	Obliquity σ_1'/σ_3' lbs/in^2	Filter Strip Correction Factor (FC) lbs/in^2
1		0.0000	0.0000	0.00	0.0000	1.000	5.961	0.00	0.000	0.00	40.00	0.00	45.10	45.10	45.10	45.10	45.10	45.10	0.00	1.00	0
2		0.0050	0.0050	40.00	0.0010	0.999	5.967	6.70	0.003	6.70	44.30	4.30	45.10	40.80	51.80	47.50	48.45	44.15	3.35	1.16	0
3		0.0100	0.0100	67.00	0.0020	0.998	5.973	11.22	0.007	11.21	47.80	7.80	45.10	37.30	56.31	48.51	50.71	42.91	5.61	1.30	0
4		0.0150	0.0150	89.00	0.0030	0.997	5.979	14.89	0.010	14.88	51.20	11.20	45.10	33.90	59.98	48.78	52.54	41.34	7.44	1.44	0
5		0.0200	0.0200	104.00	0.0040	0.996	5.985	17.38	0.014	17.37	53.90	13.90	45.10	31.20	62.47	48.57	53.79	39.89	8.69	1.56	0
6		0.0255	0.0255	116.00	0.0050	0.995	5.991	19.36	0.017	19.34	56.20	16.20	45.10	28.90	64.44	48.24	54.77	38.57	9.67	1.67	0
7		0.0300	0.0300	126.00	0.0060	0.994	5.997	21.01	0.021	20.99	58.20	18.20	45.10	26.90	66.09	47.89	55.60	37.40	10.50	1.78	0
8		0.0350	0.0350	134.00	0.0070	0.993	6.003	22.32	0.024	22.30	60.30	20.30	45.10	24.80	67.40	47.10	56.25	35.95	11.15	1.90	0
9		0.0400	0.0400	140.00	0.0070	0.993	6.003	23.32	0.024	23.30	61.40	21.40	45.10	23.70	68.40	47.00	56.75	35.35	11.65	1.98	0
10		0.0450	0.0450	144.00	0.0080	0.992	6.009	23.96	0.028	23.93	62.60	22.60	45.10	22.50	69.03	46.43	57.07	34.47	11.97	2.06	0
11		0.0500	0.0500	149.00	0.0090	0.991	6.015	24.77	0.031	24.74	63.80	23.80	45.10	21.30	69.84	46.04	57.47	33.67	12.37	2.16	0
12		0.0550	0.0550	153.00	0.0100	0.990	6.022	25.41	0.035	25.38	64.70	24.70	45.10	20.40	70.48	45.78	57.79	33.09	12.69	2.24	0
13		0.0600	0.0600	156.00	0.0110	0.989	6.028	25.88	0.038	25.84	65.60	25.60	45.10	19.50	70.94	45.34	58.02	32.42	12.92	2.33	0
14		0.0650	0.0650	159.00	0.0120	0.988	6.034	26.35	0.042	26.31	66.30	26.30	45.10	18.80	71.41	45.11	58.26	31.96	13.16	2.40	0
15		0.0700	0.0700	161.00	0.0130	0.987	6.040	26.66	0.045	26.62	67.00	27.00	45.10	18.10	71.72	44.72	58.41	31.41	13.31	2.47	0
16		0.0750	0.0750	163.00	0.0140	0.986	6.046	26.96	0.049	26.91	67.70	27.70	45.10	17.40	72.01	44.31	58.56	30.86	13.46	2.55	0
17		0.0800	0.0800	166.00	0.0150	0.985	6.052	27.43	0.052	27.38	68.30	28.30	45.10	16.80	72.48	44.18	58.79	30.49	13.69	2.63	0
18		0.0850	0.0850	167.00	0.0160	0.984	6.058	27.57	0.056	27.51	68.50	28.50	45.10	16.60	72.61	44.11	58.86	30.36	13.76	2.66	0
19		0.1050	0.1050	173.00	0.0200	0.980	6.083	28.44	0.070	28.37	70.20	30.20	45.10	14.90	73.47	43.27	59.29	29.09	14.19	2.90	0
20		0.1250	0.1250	177.00	0.0230	0.977	6.102	29.01	0.080	28.93	71.40	31.40	45.10	13.70	74.03	42.63	59.57	28.17	14.47	3.11	0
21		0.1300	0.1300	178.00	0.0240	0.976	6.108	29.14	0.084	29.06	71.60	31.60	45.10	13.50	74.16	42.56	59.63	28.03	14.53	3.15	0
22		0.1350	0.1350	179.00	0.0250	0.975	6.114	29.28	0.087	29.19	71.90	31.90	45.10	13.20	74.29	42.39	59.70	27.80	14.60	3.21	0
23		0.1450	0.1450	180.00	0.0270	0.973	6.127	29.38	0.094	29.29	72.40	32.40	45.10	12.70	74.39	41.99	59.75	27.35	14.65	3.31	0
24		0.1600	0.1600	182.00	0.0300	0.970	6.146	29.61	0.105	29.51	73.00	33.00	45.10	12.10	74.61	41.61	59.86	26.86	14.76	3.44	0
25		0.1700	0.1700	184.00	0.0320	0.968	6.158	29.88	0.112	29.77	73.50	33.50	45.10	11.60	74.87	41.37	59.99	26.49	14.89	3.57	0
26		0.1800	0.1800	185.00	0.0340	0.966	6.171	29.98	0.118	29.86	73.60	33.60	45.10	11.50	74.96	41.36	60.03	26.43	14.93	3.60	0
27		0.1940	0.1940	186.00	0.0360	0.964	6.184	30.08	0.125	29.96	73.90	33.90	45.10	11.20	75.06	41.16	60.08	26.18	14.98	3.68	0
28		0.2050	0.2050	187.00	0.0380	0.962	6.197	30.18	0.132	30.05	74.10	34.10	45.10	11.00	75.15	41.05	60.13	26.03	15.03	3.73	0
29		0.2250	0.2250	189.00	0.0420	0.958	6.223	30.37	0.146	30.22	74.50	34.50	45.10	10.60	75.32	40.82	60.21	25.71	15.11	3.85	0
30		0.2550	0.2550	192.00	0.0480	0.952	6.262	30.66	0.167	30.49	75.00	35.00	45.10	10.10	75.59	40.59	60.35	25.35	15.25	4.02	0
31		0.2650	0.2650	194.00	0.0500	0.950	6.275	30.92	0.174	30.75	75.10	35.10	45.10	10.00	75.85	40.75	60.48	25.38	15.38	4.08	0
32		0.2800	0.2800	195.00	0.0520	0.948	6.288	31.01	0.181	30.83	75.20	35.20	45.10	9.90	75.93	40.73	60.52	25.32	15.42	4.11	0
33		0.3150	0.3150	198.00	0.0590	0.941	6.335	31.25	0.206	31.04	75.40	35.40	45.10	9.70	76.14	40.74	60.62	25.22	15.52	4.20	0
34		0.3500	0.3500	200.00	0.0660	0.934	6.383	31.33	0.230	31.10	76.00	36.00	45.10	9.10	76.20	40.20	60.65	24.65	15.55	4.42	0
35		0.4000	0.4000	207.00	0.0750	0.925	6.445	32.12	0.261	31.86	76.40	36.40	45.10	8.70	76.96	40.56	61.03	24.63	15.93	4.66	0
36		0.4500	0.4500	209.00	0.0840	0.916	6.508	32.11	0.293	31.82	76.40	36.40	45.10	8.70	76.92	40.52	61.01	24.61	15.91	4.66	0
37		0.5000	0.5000	212.00	0.0940	0.906	6.580	32.22	0.328	31.89	76.40	36.40	45.10	8.70	76.99	40.59	61.05	24.65	15.95	4.67	0
38		0.5400	0.5400	214.00	0.1010	0.899	6.631	32.27	0.352	31.92	76.40	36.40	45.10	8.70	77.02	40.62	61.06	24.66	15.96	4.67	0
39		0.5700	0.5700	215.00	0.1070	0.893	6.676	32.20	0.373	31.83	76.40	36.40	45.10	8.70	76.93	40.53	61.02	24.62	15.92	4.66	0
40		0.5900	0.5900	218.00	0.1110	0.889	6.706	32.51	0.387	32.12	76.40	36.40	45.10	8.70	77.22	40.82	61.16	24.76	16.06	4.69	0
41		0.6500	0.6500	218.00	0.1220	0.878	6.790	32.11	0.425	31.69	76.40	36.40	45.10	8.70	76.79	40.39	60.95	24.55	15.85	4.64	0
42		0.7400	0.7400	218.00	0.1390	0.861	6.924	31.48	0.484	31.00	76.30	36.30	45.10	8.80	76.10	39.80	60.60	24.30	15.50	4.52	0
43		0.7900	0.7900	218.00	0.1480	0.852	6.997	31.16	0.516	30.64	76.20	36.20	45.10	8.90	75.74	39.54	60.42	24.22	15.32	4.44	0
44		0.8500	0.8500	219.00	0.1590	0.841	7.088	30.90	0.554	30.35	76.30	36.30	45.10	8.80	75.45	39.15	60.28	23.98	15.18	4.45	0
45		0.9200	0.9200	220.00	0.1720	0.828	7.200	30.56	0.599	29.96	76.30	36.30	45.10	8.80	75.06	38.76	60.08	23.78	14.98	4.40	0
46		0.9600	0.9600	221.00	0.1800	0.820	7.270	30.40	0.627	29.77	76.30	36.30	45.10	8.80	74.87	38.57	59.99	23.69	14.89	4.38	0

Calculations Based on
EM 1110-2-1906 Appendix X
ASTM D 4767-04





Specimen No.			1	2	3	
Initial	Water Content, %	ω_O	58.4	56.7		
	Dry Density, lbs/ft^3	$^{\gamma}d_o$	63.7	64.1		
	Saturation, %	S_O	96.8	94.9		
	Void Ratio	e_O	1.61	1.59		
Before Shear	Water Content, %	ω_f	54.1	50.2		
	Dry Density, lbs/ft^3	$^{\gamma}d_c$	66.0	67.2		
	Saturation, %	S_C	100.0	100.0		
	Void Ratio	e_C	1.52	1.47		
	Final Back Pressure, tsf	U_O	2.9	2.9		
Minor Principal Stress, tsf		σ_3	0.45	0.69		
Maximum Deviator Stress, tsf	$(\sigma_1-\sigma_3)_{max}$		0.67	0.71		
Time to $(\sigma_1-\sigma_3)_{max}$, min		t_f				
Deviator Stress @ 15% Axial Strain, tsf	$(\sigma_1-\sigma_3)_{15\%}$		0.64	0.74		
Axial Strain at failure, %		ε	7.0	5.9		
Peak Pore Pressure at failure, tsf		U	3.247	3.449		
Δ Pore Pressure at failure (ΔU), tsf		ΔU	0.324	0.547		

Rate of strain, %/hr: 0.25

Description of Specimen 1: Dark Gray Sandy SILT (MH)

Description of Specimen 2: Dark Gray Sandy SILT (MH)

Description of Specimen 3: Dark Gray Sandy SILT (MH)

Initial Diameter, in	D_O	2.862	2.850		
Initial Height, in	H_O	5.526	5.533		

Amount of Material Finer than the No. 200, %: 66.6

LL: 73 | PL: 32 | PI: 41 | G_S: 2.66 Measured

Type of Specimens: Undisturbed

Type of Test: ASTM D-4767

Remarks: B Parameter >/= 0.99

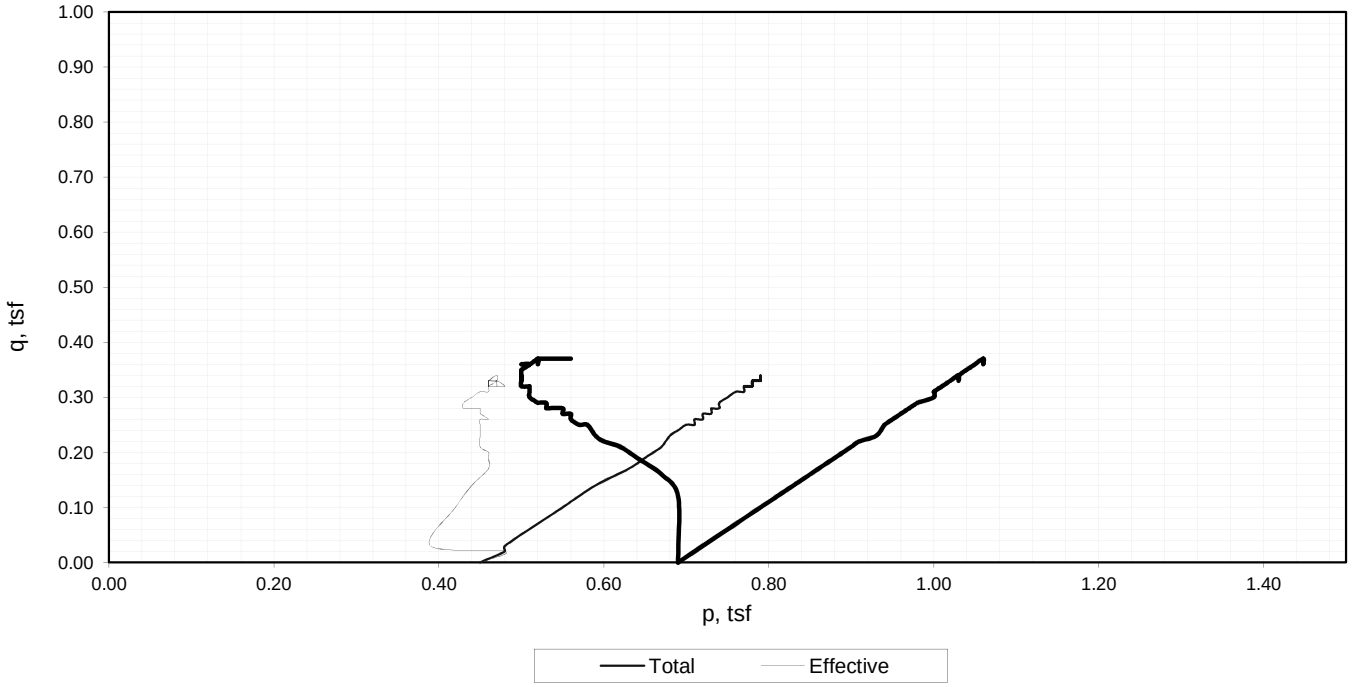
Peak Strength selected at maximum effective stress ratio (obliquity)

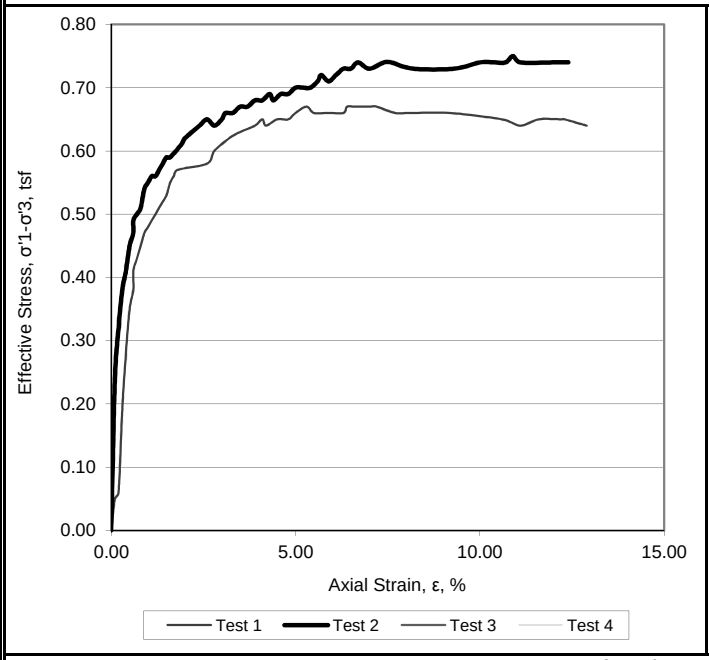
Method of Saturation: Wet Mounted

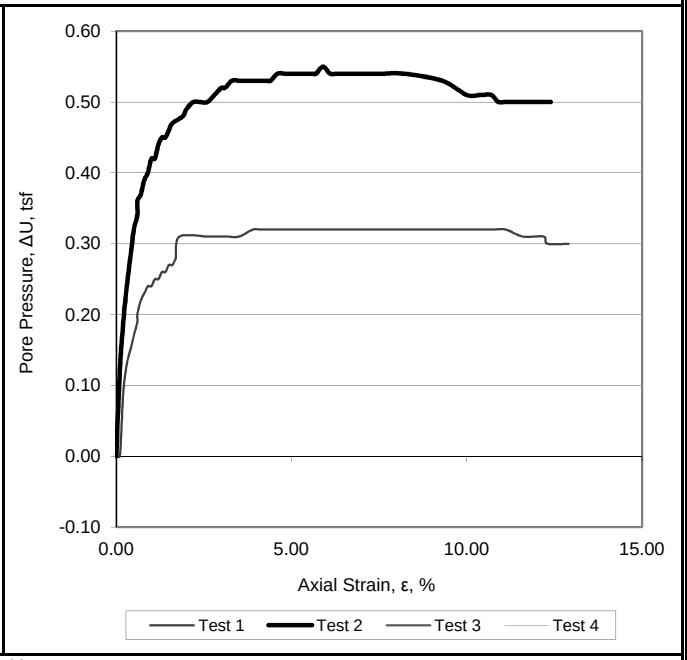
KLEINFELDER
Bright People. Right Solutions.

9200 SW Nimbus Ave
Beaverton, Oregon
p| 503-644-9447
f| 916.3643-1701
kleinfelder.com

Project Name:	Arkema Early Action
Project Number:	107510
Boring Number:	SPT-2
Sample ID:	ARK-SPT-2
Sample Depth, ft.:	20.5-22.5
Report Date:	December 15, 2009







Rate of strain, % / hr: 0.25

Description of Specimen 1 Dark Gray Sandy SILT (MH)

Description of Specimen 2 Dark Gray Sandy SILT (MH)

Description of Specimen 3 Dark Gray Sandy SILT (MH)

Amount of Material Finer than the No. 200, % 66.6

LL: 73	PL: 32	PI: 41	G_S: 2.66 Measured	Type of Specimen: Undisturbed	Type of Test: ASTM D-4767

Remarks: B Parameter >/= 0.99

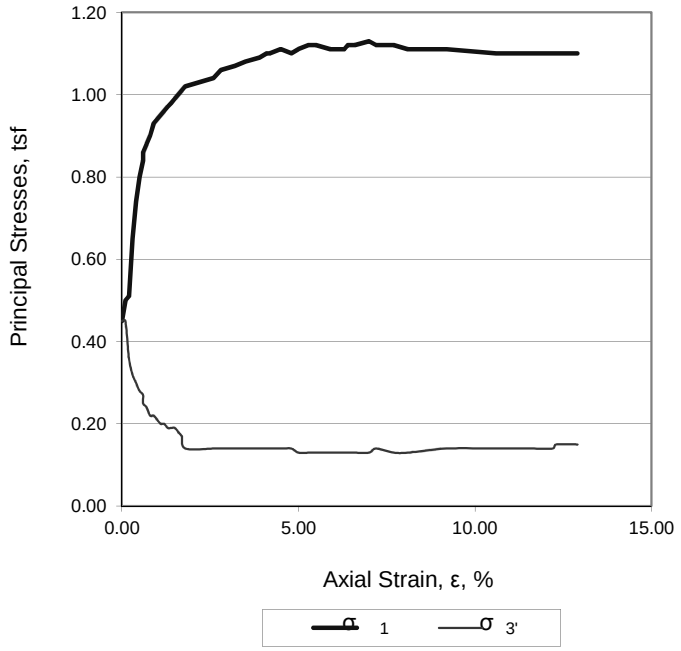
Peak Strength selected at maximum effective stress ratio (obliquity)

Method of Saturation: Wet Mounted

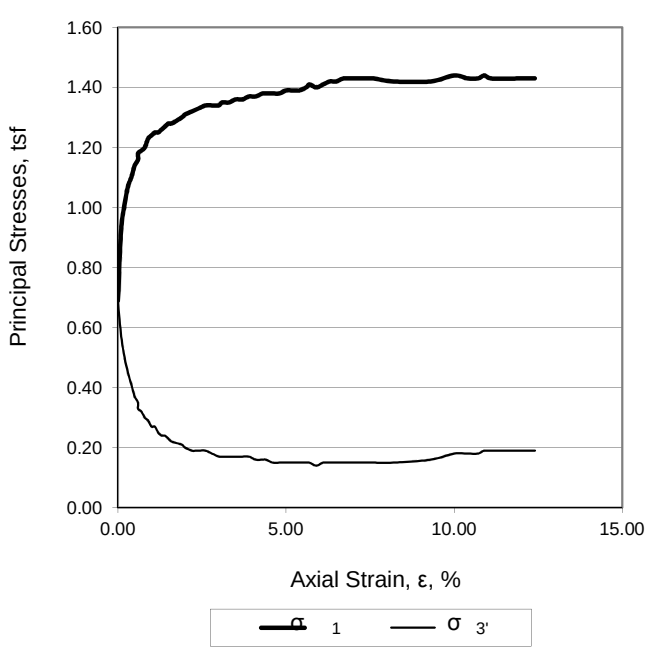
KLEINFELDER
Bright People. Right Solutions.
9200 SW Nimbus Ave
Beaverton, Oregon
p| 503-644-9447
f| 916.3643-1701
kleinfelder.com

Project Name:	Arkema Early Action
Project Number:	107510
Boring Number:	SPT-2
Sample ID:	ARK-SPT-2
Sample Depth, ft.:	20.5-22.5
Report Date:	December 15, 2009

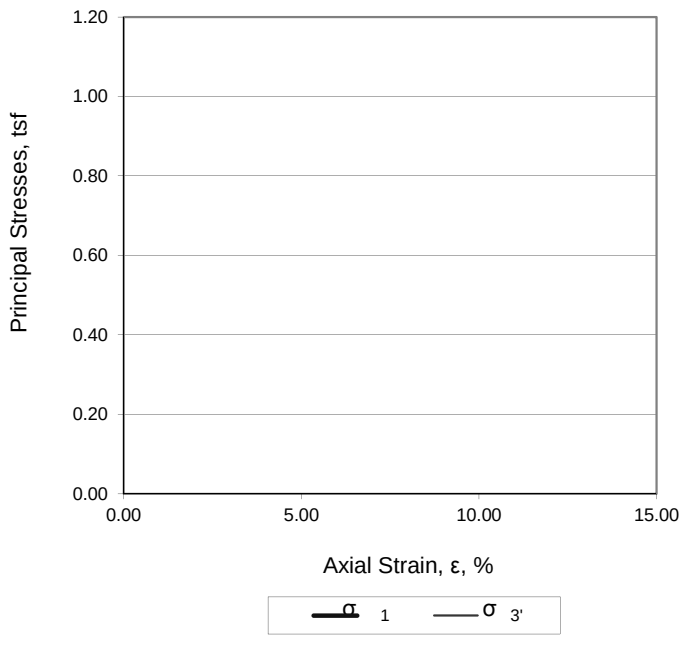
Test 1



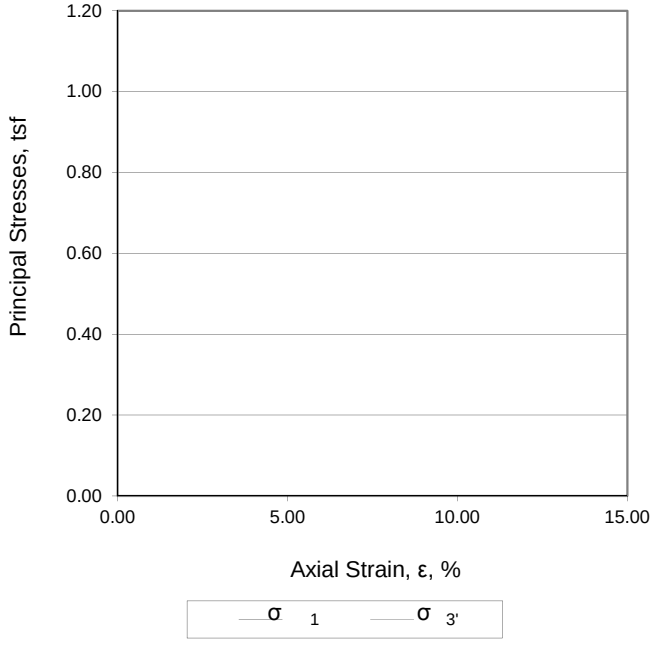
Test 2



Test 3



Test 4



Rate of strain, % / hr: 0.25

Description of Specimen 1 Dark Gray Sandy SILT (MH)

Description of Specimen 2 Dark Gray Sandy SILT (MH)

Description of Specimen 3 Dark Gray Sandy SILT (MH)

Amount of Material Finer than the No. 200, % 66.6

LL: 73	PL: 32	PI: 41	G_S: 2.66 Measured	Type of Specimen: Undisturbed	Type of Test: ASTM D-4767

Remarks: B Parameter >/= 0.99

Peak Strength selected at maximum effective stress ratio (obliquity)

Method of Saturation: Wet Mounted

KLEINFELDER
Bright People. Right Solutions.

9200 SW Nimbus Ave
Beaverton, Oregon
p| 503-644-9447
f| 916.3643-1701
kleinfelder.com

Project Name:	Arkema Early Action
Project Number:	107510
Boring Number:	SPT-2
Sample ID:	ARK-SPT-2
Sample Depth, ft.:	20.5-22.5
Report Date:	December 15, 2009

Arkema Early Action ARK-SPT-2 20.5-22.5

Axial Loading Data
Triaxial Compression R-bar (CU) Tests

Selected for Calculations (**X**)

	Max Deviator Stress	9.33															Consolidation Pressure(psi/tsf)	6.3	/	0.45
	Selected Row for Deviator Stress			Selected Deviator Stress			H_O (in)	5.526	D_O (in)	2.862	A_O (in^2)	6.433								
x	Max Obliquity	6.19		Deviator Stress at Max Obliquity	9.33		H_C (in)	5.429	D_C (in)	2.837	A_C (in^2)	6.319			Membrane Thickness:	0.012					

Selected Row for Ultimate Deviator Stress (Based on Deviator Stress vs. % Axial Strian Graph) Ultimate Deviator Stress

Row Number	Elapsed Time	Dial Indicator Reading 0.0001 in	Cumulative Change (ΔH) 0.0001 in	P Axial Load lbs	Axial Strain $\varepsilon = \Delta H_C/H_C$	1-ε	Corrected Area $A_{Corr} = A_C/1-\varepsilon$ in^2	Deviator Stress $\sigma_1-\sigma_3 = P/A_C$ lbs/in^2	Membrane Correction Factor (MF) lbs/in^2	Corrected Deviator Stress $((\sigma_1-\sigma_3)$ - MF-FC)	Pore Pressure (U) lbs/in^2	Δ Pore Pressure (ΔU) lbs/in^2	σ_3 lbs/in^2	σ_3' lbs/in^2	σ_1 lbs/in^2	σ_1' lbs/in^2	p $(\sigma_1+\sigma_3)/2$ lbs/in^2	p' $(\sigma'_1+\sigma'_3)/2$ lbs/in^2	q $(\sigma_1.\sigma_3)/2$ lbs/in^2	Obliquity σ_1'/σ_3' lbs/in^2	Filter Strip Correction Factor (FC) lbs/in^2
1		0.0000	0.0000	0.00	0.0000	1.000	6.319	0.00	0.000	0.00	40.60	0.00	6.30	6.30	6.30	6.30	6.30	6.30	0.00	1.00	0
2		0.0050	0.0050	4.00	0.0010	0.999	6.326	0.63	0.003	0.63	40.60	0.00	6.30	6.30	6.93	6.93	6.62	6.62	0.32	1.10	0
3		0.0100	0.0100	5.00	0.0020	0.998	6.332	0.79	0.007	0.78	41.90	1.30	6.30	5.00	7.08	5.78	6.69	5.39	0.39	1.16	0
4		0.0150	0.0150	17.00	0.0030	0.997	6.338	2.68	0.010	2.67	42.40	1.80	6.30	4.50	8.97	7.17	7.64	5.84	1.34	1.59	0
5		0.0200	0.0200	25.00	0.0040	0.996	6.345	3.94	0.014	3.93	42.70	2.10	6.30	4.20	10.23	8.13	8.26	6.16	1.96	1.93	0
6		0.0250	0.0250	31.00	0.0050	0.995	6.351	4.88	0.017	4.86	43.00	2.40	6.30	3.90	11.16	8.76	8.73	6.33	2.43	2.25	0
7		0.0300	0.0300	34.00	0.0060	0.994	6.358	5.35	0.020	5.33	43.20	2.60	6.30	3.70	11.63	9.03	8.97	6.37	2.67	2.44	0
8		0.0350	0.0350	36.00	0.0060	0.994	6.358	5.66	0.020	5.64	43.40	2.80	6.30	3.50	11.94	9.14	9.12	6.32	2.82	2.61	0
9		0.0400	0.0400	38.00	0.0070	0.993	6.364	5.97	0.024	5.95	43.60	3.00	6.30	3.30	12.25	9.25	9.27	6.27	2.97	2.80	0
10		0.0450	0.0450	40.00	0.0080	0.992	6.370	6.28	0.027	6.25	43.80	3.20	6.30	3.10	12.55	9.35	9.43	6.23	3.13	3.02	0
11		0.0500	0.0500	42.00	0.0090	0.991	6.377	6.59	0.030	6.56	43.90	3.30	6.30	3.00	12.86	9.56	9.58	6.28	3.28	3.19	0
12		0.0550	0.0550	43.00	0.0100	0.990	6.383	6.74	0.034	6.71	44.00	3.40	6.30	2.90	13.01	9.61	9.65	6.25	3.35	3.31	0
13		0.0600	0.0600	44.00	0.0110	0.989	6.390	6.89	0.037	6.85	44.10	3.50	6.30	2.80	13.15	9.65	9.73	6.23	3.43	3.45	0
14		0.0650	0.0650	45.00	0.0120	0.988	6.396	7.04	0.041	7.00	44.10	3.50	6.30	2.80	13.30	9.80	9.80	6.30	3.50	3.50	0
15		0.0700	0.0700	46.00	0.0130	0.987	6.403	7.18	0.044	7.14	44.20	3.60	6.30	2.70	13.44	9.84	9.87	6.27	3.57	3.64	0
16		0.0750	0.0750	47.00	0.0140	0.986	6.409	7.33	0.047	7.28	44.20	3.60	6.30	2.70	13.58	9.98	9.94	6.34	3.64	3.70	0
17		0.0800	0.0800	48.00	0.0150	0.985	6.416	7.48	0.051	7.43	44.30	3.70	6.30	2.60	13.73	10.03	10.01	6.31	3.71	3.86	0
18		0.0850	0.0850	49.00	0.0160	0.984	6.422	7.63	0.054	7.58	44.40	3.80	6.30	2.50	13.88	10.08	10.09	6.29	3.79	4.03	0
19		0.0900	0.0900	50.00	0.0170	0.983	6.429	7.78	0.058	7.72	44.50	3.90	6.30	2.40	14.02	10.12	10.16	6.26	3.86	4.22	0
20		0.0950	0.0950	50.00	0.0170	0.983	6.429	7.78	0.058	7.72	44.50	3.90	6.30	2.40	14.02	10.12	10.16	6.26	3.86	4.22	0
21		0.1000	0.1000	51.00	0.0180	0.982	6.435	7.93	0.061	7.87	44.90	4.30	6.30	2.00	14.17	9.87	10.23	5.93	3.93	4.93	0
22		0.1400	0.1400	53.00	0.0260	0.974	6.488	8.17	0.088	8.08	44.90	4.30	6.30	2.00	14.38	10.08	10.34	6.04	4.04	5.04	0
23		0.1500	0.1500	55.00	0.0280	0.972	6.501	8.46	0.095	8.37	44.90	4.30	6.30	2.00	14.67	10.37	10.48	6.18	4.18	5.18	0
24		0.1750	0.1750	57.00	0.0320	0.968	6.528	8.73	0.108	8.62	44.90	4.30	6.30	2.00	14.92	10.62	10.61	6.31	4.31	5.31	0
25		0.1900	0.1900	58.00	0.0350	0.965	6.549	8.86	0.118	8.74	44.90	4.30	6.30	2.00	15.04	10.74	10.67	6.37	4.37	5.37	0
26		0.2100	0.2100	59.00	0.0390	0.961	6.576	8.97	0.132	8.84	45.00	4.40	6.30	1.90	15.14	10.74	10.72	6.32	4.42	5.65	0
27		0.2200	0.2200	60.00	0.0410	0.959	6.590	9.10	0.139	8.96	45.00	4.40	6.30	1.90	15.26	10.86	10.78	6.38	4.48	5.72	0
28		0.2300	0.2300	60.00	0.0420	0.958	6.596	9.10	0.142	8.96	45.00	4.40	6.30	1.90	15.26	10.86	10.78	6.38	4.48	5.71	0
29		0.2450	0.2450	61.00	0.0450	0.955	6.617	9.22	0.152	9.07	45.00	4.40	6.30	1.90	15.37	10.97	10.83	6.43	4.53	5.77	0
30		0.2600	0.2600	61.00	0.0480	0.952	6.638	9.19	0.162	9.03	45.00	4.40	6.30	1.90	15.33	10.93	10.81	6.41	4.51	5.75	0
31		0.2700	0.2700	62.00	0.0500	0.950	6.652	9.32	0.169	9.15	45.10	4.50	6.30	1.80	15.45	10.95	10.88	6.38	4.58	6.08	0
32		0.2900	0.2900	63.00	0.0530	0.947	6.673	9.44	0.179	9.26	45.10	4.50	6.30	1.80	15.56	11.06	10.93	6.43	4.63	6.15	0
33		0.3000	0.3000	63.00	0.0550	0.945	6.687	9.42	0.186	9.23	45.10	4.50	6.30	1.80	15.53	11.03	10.92	6.42	4.62	6.13	0
34		0.3200	0.3200	63.00	0.0590	0.941	6.716	9.38	0.200	9.18	45.10	4.50	6.30	1.80	15.48	10.98	10.89	6.39	4.59	6.10	0
35		0.3400	0.3400	63.00	0.0630	0.937	6.744	9.34	0.213	9.13	45.10	4.50	6.30	1.80	15.43	10.93	10.86	6.36	4.56	6.07	0
36		0.3500	0.3500	64.00	0.0640	0.936	6.751	9.48	0.217	9.26	45.10	4.50	6.30	1.80	15.56	11.06	10.93	6.43	4.63	6.15	0
37		0.3600	0.3600	64.00	0.0660	0.934	6.766	9.46	0.223	9.24	45.10	4.50	6.30	1.80	15.54	11.04	10.92	6.42	4.62	6.13	0
38		0.3800	0.3800	65.00	0.0700	0.930	6.795	9.57	0.237	9.33	45.10	4.50	6.30	1.80	15.63	11.13	10.97	6.47	4.67	6.19	0
39		0.3900	0.3900	65.00	0.0720	0.928	6.810	9.54	0.244	9.30	45.00	4.40	6.30	1.90	15.60	11.20	10.95	6.55	4.65	5.89	0
40		0.4200	0.4200	65.00	0.0770	0.923	6.847	9.49	0.261	9.23	45.10	4.50	6.30	1.80	15.53	11.03	10.91	6.41	4.61	6.13	0
41		0.4400	0.4400	65.00	0.0810	0.919	6.876	9.45	0.274	9.18	45.10	4.50	6.30	1.80	15.48	10.98	10.89	6.39	4.59	6.10	0

Calculations Based on
EM 1110-2-1906 Appendix X
ASTM D 4767-04

Axial Loading Data
Triaxial Compression R-bar (CU) Tests

Selected for Calculations (**X**)

	Max Deviator Stress	9.33						Consolidation Pressure(psi/tsf)	6.3 / 0.45
	Selected Row for Deviator Stress		Selected Deviator Stress		H_O (in)	5.526	D_O (in) 2.862	A_O (in^2)	6.433
x	Max Obliquity	6.19	Deviator Stress at Max Obliquity	9.33	H_C (in)	5.429	D_C (in) 2.837	A_C (in^2)	6.319

Membrane Thickness: 0.012

Selected Row for Ultimate Deviator Stress (Based on Deviator Stress vs. % Axial Strian Graph) _____ Ultimate Deviator Stress _____

Row Number	Elapsed Time	Dial Indicator Reading 0.0001 in	Cumulative Change (ΔH) 0.0001 in	P Axial Load lbs	Axial Strain $\varepsilon = \Delta H_C/H_C$	1-ε	Corrected Area $A_{Corr} = A_C/1-\varepsilon$ in^2	Deviator Stress $\sigma_1-\sigma_3 = P/A_C$ lbs/in^2	Membrane Correction Factor (MF) lbs/in^2	Corrected Deviator Stress $((\sigma_1-\sigma_3)$ - MF-FC)	Pore Pressure (U) lbs/in^2	Δ Pore Pressure (ΔU) lbs/in^2	σ_3 lbs/in^2	σ_3' lbs/in^2	σ_1 lbs/in^2	σ_1' lbs/in^2	p $(\sigma_1+\sigma_3)/2$ lbs/in^2	p' $(\sigma'_1+\sigma'_3)/2$ lbs/in^2	q $(\sigma_1.\sigma_3)/2$ lbs/in^2	Obliquity σ_1'/σ_3' lbs/in^2	Filter Strip Correction Factor (FC) lbs/in^2
42		0.5000	0.5000	66.00	0.0920	0.908	6.960	9.48	0.311	9.17	45.00	4.40	6.30	1.90	15.47	11.07	10.88	6.48	4.58	5.83	0
43		0.5750	0.5750	66.00	0.1060	0.894	7.069	9.34	0.359	8.98	45.00	4.40	6.30	1.90	15.28	10.88	10.79	6.39	4.49	5.73	0
44		0.6000	0.6000	66.00	0.1110	0.889	7.108	9.29	0.376	8.91	45.00	4.40	6.30	1.90	15.21	10.81	10.76	6.36	4.46	5.69	0
45		0.6300	0.6300	67.00	0.1160	0.884	7.149	9.37	0.393	8.98	44.90	4.30	6.30	2.00	15.28	10.98	10.79	6.49	4.49	5.49	0
46		0.6600	0.6600	68.00	0.1220	0.878	7.197	9.45	0.413	9.04	44.90	4.30	6.30	2.00	15.34	11.04	10.82	6.52	4.52	5.52	0
47		0.6700	0.6700	68.00	0.1230	0.877	7.206	9.44	0.416	9.02	44.80	4.20	6.30	2.10	15.32	11.12	10.81	6.61	4.51	5.30	0
48		0.7000	0.7000	68.00	0.1290	0.871	7.255	9.37	0.437	8.93	44.80	4.20	6.30	2.10	15.23	11.03	10.77	6.57	4.47	5.25	0
49																					0
50																					0
51																					0
52																					

Calculations Based on
EM 1110-2-1906 Appendix X
ASTM D 4767-04

Arkema Early Action ARK-SPT-2 20.5-22.5

Axial Loading Data

Triaxial Compression R-bar (CU) Tests

Selected for Calculations (**X**)

	Max Deviator Stress	10.35																					
	Selected Row for Deviator Stress			Selected Deviator Stress																			
x	Max Obliquity	5.95		Deviator Stress at Max Obliquity	9.91																		

Consolidation Pressure(psi/tsf) 9.6 / 0.69

H_O (in) 5.533 D_O (in) 2.850 A_O (in^2) 6.380

H_C (in) 5.398 D_C (in) 2.818 A_C (in^2) 6.236

Membrane Thickness: 0.012

Selected Row for Ultimate Deviator Stress (Based on Deviator Stress vs. % Axial Strian Graph) Ultimate Deviator Stress

Row Number	Elapsed Time	Dial Indicator Reading 0.0001 in	Cumulative Change (ΔH) 0.0001 in	P Axial Load lbs	Axial Strain $\varepsilon = \Delta H_C/H_C$	1-ε	Corrected Area $A_{Corr} = A_C/1-\varepsilon$ in^2	Deviator Stress $\sigma_1-\sigma_3 = P/A_C$ lbs/in^2	Membrane Correction Factor (MF) lbs/in^2	Corrected Deviator Stress $((\sigma_1-\sigma_3)$ - MF-FC)	Pore Pressure (U) lbs/in^2	Δ Pore Pressure (ΔU) lbs/in^2	σ_3 lbs/in^2	σ_3' lbs/in^2	σ_1 lbs/in^2	σ_1' lbs/in^2	p $(\sigma_1+\sigma_3)/2$ lbs/in^2	p' $(\sigma'_1+\sigma'_3)/2$ lbs/in^2	q $(\sigma_1.\sigma_3)/2$ lbs/in^2	Obliquity σ_1'/σ_3' lbs/in^2	Filter Strip Correction Factor (FC) lbs/in^2
1		0.0000	0.0000	0.00	0.0000	1.000	6.236	0.00	0.000	0.00	40.30	0.00	9.60	9.60	9.60	9.60	9.60	9.60	0.00	1.00	0
2		0.0050	0.0050	21.00	0.0010	0.999	6.242	3.36	0.003	3.36	42.00	1.70	9.60	7.90	12.96	11.26	11.28	9.58	1.68	1.43	0
3		0.0100	0.0100	28.00	0.0020	0.998	6.248	4.48	0.007	4.47	42.90	2.60	9.60	7.00	14.07	11.47	11.84	9.24	2.24	1.64	0
4		0.0150	0.0150	33.00	0.0030	0.997	6.254	5.28	0.010	5.27	43.70	3.40	9.60	6.20	14.87	11.47	12.24	8.83	2.64	1.85	0
5		0.0200	0.0200	36.00	0.0040	0.996	6.261	5.75	0.014	5.74	44.20	3.90	9.60	5.70	15.34	11.44	12.47	8.57	2.87	2.01	0
6		0.0255	0.0255	39.00	0.0050	0.995	6.267	6.22	0.017	6.20	44.70	4.40	9.60	5.20	15.80	11.40	12.70	8.30	3.10	2.19	0
7		0.0300	0.0300	41.00	0.0060	0.994	6.273	6.54	0.020	6.52	45.00	4.70	9.60	4.90	16.12	11.42	12.86	8.16	3.26	2.33	0
8		0.0350	0.0350	43.00	0.0060	0.994	6.273	6.85	0.020	6.83	45.30	5.00	9.60	4.60	16.43	11.43	13.02	8.02	3.42	2.48	0
9		0.0400	0.0400	44.00	0.0070	0.993	6.280	7.01	0.024	6.99	45.50	5.20	9.60	4.40	16.59	11.39	13.09	7.89	3.49	2.59	0
10		0.0450	0.0450	45.00	0.0080	0.992	6.286	7.16	0.027	7.13	45.70	5.40	9.60	4.20	16.73	11.33	13.17	7.77	3.57	2.70	0
11		0.0500	0.0500	47.00	0.0090	0.991	6.292	7.47	0.031	7.44	45.90	5.60	9.60	4.00	17.04	11.44	13.32	7.72	3.72	2.86	0
12		0.0550	0.0550	48.00	0.0100	0.990	6.299	7.62	0.034	7.59	46.10	5.80	9.60	3.80	17.19	11.39	13.39	7.59	3.79	3.00	0
13		0.0600	0.0600	49.00	0.0110	0.989	6.305	7.77	0.037	7.73	46.20	5.90	9.60	3.70	17.33	11.43	13.47	7.57	3.87	3.09	0
14		0.0650	0.0650	49.00	0.0120	0.988	6.311	7.76	0.041	7.72	46.40	6.10	9.60	3.50	17.32	11.22	13.46	7.36	3.86	3.21	0
15		0.0700	0.0700	50.00	0.0130	0.987	6.318	7.91	0.044	7.87	46.50	6.20	9.60	3.40	17.47	11.27	13.53	7.33	3.93	3.31	0
16		0.0750	0.0750	51.00	0.0140	0.986	6.324	8.06	0.048	8.01	46.60	6.30	9.60	3.30	17.61	11.31	13.61	7.31	4.01	3.43	0
17		0.0800	0.0800	52.00	0.0150	0.985	6.331	8.21	0.051	8.16	46.70	6.40	9.60	3.20	17.76	11.36	13.68	7.28	4.08	3.55	0
18		0.0850	0.0850	52.00	0.0160	0.984	6.337	8.21	0.055	8.16	46.80	6.50	9.60	3.10	17.76	11.26	13.68	7.18	4.08	3.63	0
19		0.1000	0.1000	54.00	0.0190	0.981	6.356	8.50	0.065	8.44	47.00	6.70	9.60	2.90	18.04	11.34	13.82	7.12	4.22	3.91	0
20		0.1100	0.1100	55.00	0.0200	0.980	6.363	8.64	0.068	8.57	47.10	6.80	9.60	2.80	18.17	11.37	13.89	7.09	4.29	4.06	0
21		0.1200	0.1200	56.00	0.0220	0.978	6.376	8.78	0.075	8.71	47.20	6.90	9.60	2.70	18.31	11.41	13.95	7.05	4.35	4.22	0
22		0.1300	0.1300	57.00	0.0240	0.976	6.389	8.92	0.082	8.84	47.30	7.00	9.60	2.60	18.44	11.44	14.02	7.02	4.42	4.40	0
23		0.1430	0.1430	58.00	0.0260	0.974	6.402	9.06	0.089	8.97	47.30	7.00	9.60	2.60	18.57	11.57	14.09	7.09	4.49	4.45	0
24		0.1500	0.1500	58.00	0.0280	0.972	6.415	9.04	0.095	8.95	47.40	7.10	9.60	2.50	18.55	11.45	14.07	6.97	4.47	4.58	0
25		0.1600	0.1600	59.00	0.0300	0.970	6.429	9.18	0.102	9.08	47.50	7.20	9.60	2.40	18.68	11.48	14.14	6.94	4.54	4.78	0
26		0.1700	0.1700	60.00	0.0310	0.969	6.435	9.32	0.106	9.21	47.50	7.20	9.60	2.40	18.81	11.61	14.21	7.01	4.61	4.84	0
27		0.1800	0.1800	60.00	0.0330	0.967	6.448	9.31	0.112	9.20	47.60	7.30	9.60	2.30	18.80	11.50	14.20	6.90	4.60	5.00	0
28		0.1900	0.1900	61.00	0.0350	0.965	6.462	9.44	0.119	9.32	47.60	7.30	9.60	2.30	18.92	11.62	14.26	6.96	4.66	5.05	0
29		0.2000	0.2000	61.00	0.0370	0.963	6.475	9.42	0.126	9.29	47.60	7.30	9.60	2.30	18.89	11.59	14.25	6.95	4.65	5.04	0
30		0.2100	0.2100	62.00	0.0390	0.961	6.489	9.55	0.133	9.42	47.60	7.30	9.60	2.30	19.02	11.72	14.31	7.01	4.71	5.09	0
31		0.2200	0.2200	62.00	0.0410	0.959	6.502	9.54	0.140	9.40	47.70	7.40	9.60	2.20	19.00	11.60	14.30	6.90	4.70	5.27	0
32		0.2300	0.2300	63.00	0.0430	0.957	6.516	9.67	0.146	9.52	47.70	7.40	9.60	2.20	19.12	11.72	14.36	6.96	4.76	5.33	0
33		0.2400	0.2400	63.00	0.0440	0.956	6.523	9.66	0.150	9.51	47.70	7.40	9.60	2.20	19.11	11.71	14.36	6.95	4.76	5.32	0
34		0.2500	0.2500	64.00	0.0460	0.954	6.536	9.79	0.157	9.63	47.80	7.50	9.60	2.10	19.23	11.73	14.42	6.92	4.82	5.59	0
35		0.2600	0.2600	64.00	0.0480	0.952	6.550	9.77	0.164	9.61	47.80	7.50	9.60	2.10	19.21	11.71	14.40	6.90	4.80	5.57	0
36		0.2700	0.2700	65.00	0.0500	0.950	6.564	9.90	0.170	9.73	47.80	7.50	9.60	2.10	19.33	11.83	14.47	6.97	4.87	5.63	0
37		0.2800	0.2800	65.00	0.0520	0.948	6.578	9.88	0.177	9.70	47.80	7.50	9.60	2.10	19.30	11.80	14.45	6.95	4.85	5.62	0
38		0.2900	0.2900	65.00	0.0540	0.946	6.592	9.86	0.184	9.68	47.80	7.50	9.60	2.10	19.28	11.78	14.44	6.94	4.84	5.61	0
39		0.3000	0.3000	66.00	0.0560	0.944	6.606	9.99	0.191	9.80	47.80	7.50	9.60	2.10	19.40	11.90	14.50	7.00	4.90	5.67	0
40		0.3100	0.3100	67.00	0.0570	0.943	6.613	10.13	0.194	9.94	47.80	7.50	9.60	2.10	19.54	12.04	14.57	7.07	4.97	5.73	0
41		0.3200	0.3200	67.00	0.0590	0.941	6.627	10.11	0.201	9.91	47.90	7.60	9.60	2.00	19.51	11.91	14.55	6.95	4.95	5.95	0
42		0.3300	0.3300	68.00	0.0610	0.939	6.641	10.24	0.208	10.03	47.80	7.50	9.60	2.10	19.63	12.13	14.62	7.12	5.02	5.78	0
43		0.3400	0.3400	69.00	0.0630	0.937	6.655	10.37	0.215	10.16	47.80	7.50	9.60	2.10	19.76	12.26	14.68	7.18	5.08	5.84	0
44		0.3500	0.3500	69.00	0.0650	0.935	6.669	10.35	0.221	10.13	47.80	7.50	9.60	2.10	19.73	12.23	14.66	7.16	5.06	5.82	0
45		0.3600	0.3600	70.00	0.0670	0.933	6.683	10.47	0.228	10.24	47.80	7.50	9.60	2.10	19.84	12.34	14.72	7.22	5.12	5.88	0

Calculations Based on
EM 1110-2-1906 Appendix X
ASTM D 4767-04

Axial Loading Data
Triaxial Compression R-bar (CU) Tests

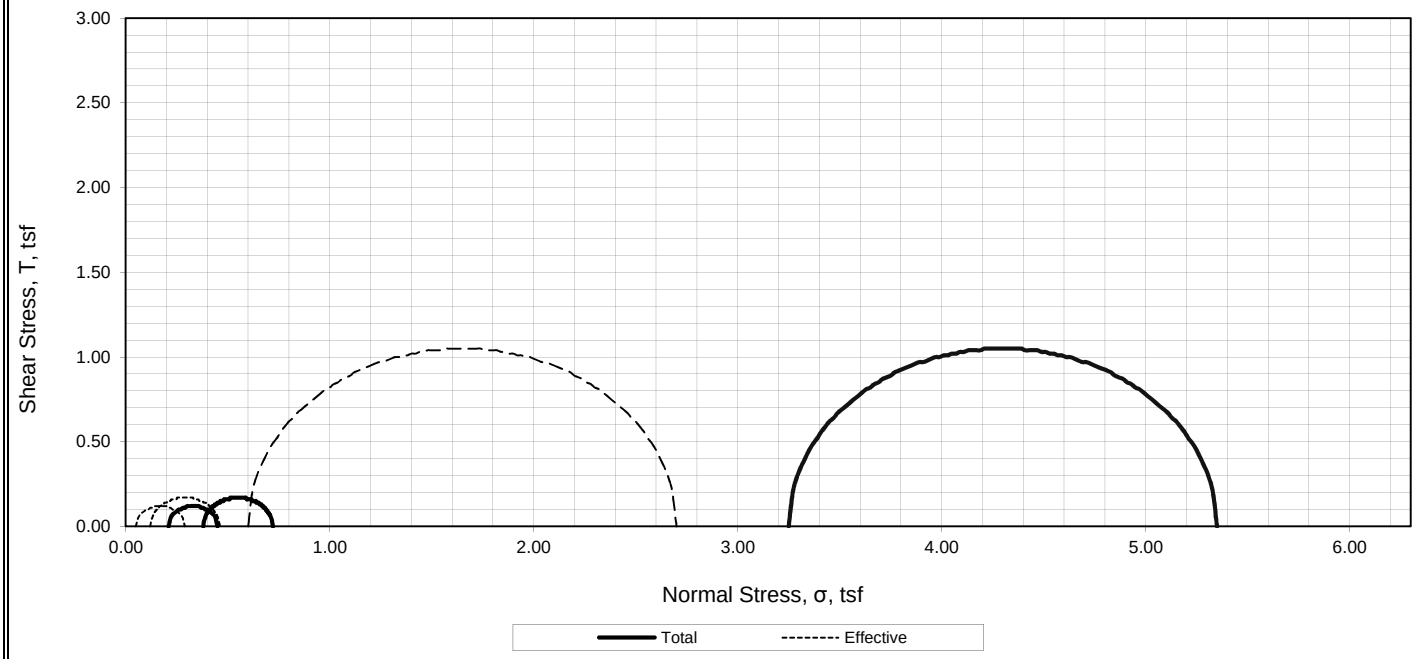
Selected for Calculations (**X**)

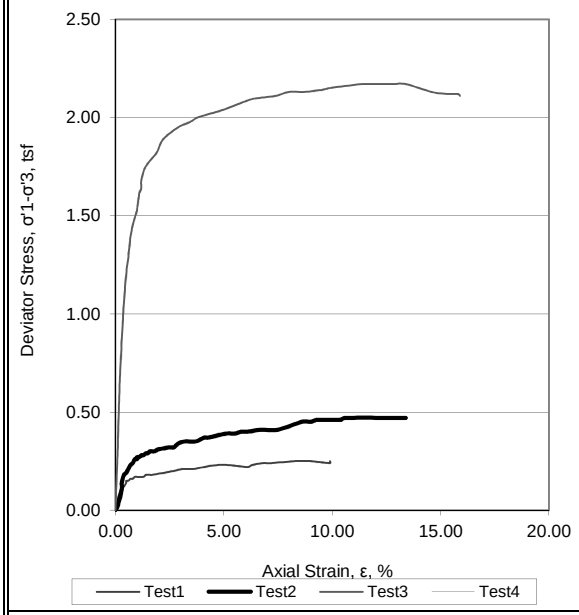
	Max Deviator Stress	10.35														Consolidation Pressure(psi/tsf)	9.6	/	0.69		
	Selected Row for Deviator Stress			Selected Deviator Stress			H_O (in)	5.533	D_O (in)	2.850	A_O (in^2)	6.380									
x	Max Obliquity	5.95		Deviator Stress at Max Obliquity	9.91		H_C (in)	5.398	D_C (in)	2.818	A_C (in^2)	6.236			Membrane Thickness:	0.012					

Selected Row for Ultimate Deviator Stress (Based on Deviator Stress vs. % Axial Strian Graph) | Ultimate Deviator Stress

Row Number	Elapsed Time	Dial Indicator Reading 0.0001 in	Cumulative Change (ΔH) 0.0001 in	P Axial Load lbs	Axial Strain $\varepsilon = \Delta H_C/H_C$	1-ε	Corrected Area $A_{Corr} = A_C/1-\varepsilon$ in^2	Deviator Stress $\sigma_1-\sigma_3 = P/A_C$ lbs/in^2	Membrane Correction Factor (MF) lbs/in^2	Corrected Deviator Stress ($(\sigma_1-\sigma_{3)}$ - MF-FC)	Pore Pressure (U) lbs/in^2	Δ Pore Pressure (ΔU) lbs/in^2	σ_3 lbs/in^2	σ_3' lbs/in^2	σ_1 lbs/in^2	σ_1' lbs/in^2	p $(\sigma_1+\sigma_3)/2$ lbs/in^2	p' $(\sigma'_1+\sigma'_3)/2$ lbs/in^2	q $(\sigma_1.\sigma_3)/2$ lbs/in^2	Obliquity σ_1'/σ_3' lbs/in^2	Filter Strip Correction Factor (FC) lbs/in^2
46		0.3800	0.3800	70.00	0.0700	0.930	6.705	10.44	0.238	10.20	47.80	7.50	9.60	2.10	19.80	12.30	14.70	7.20	5.10	5.86	0
47		0.4000	0.4000	71.00	0.0740	0.926	6.734	10.54	0.252	10.29	47.80	7.50	9.60	2.10	19.89	12.39	14.74	7.24	5.14	5.90	0
48		0.4100	0.4100	71.00	0.0760	0.924	6.749	10.52	0.259	10.26	47.80	7.50	9.60	2.10	19.86	12.36	14.73	7.23	5.13	5.89	0
49		0.4400	0.4400	71.00	0.0820	0.918	6.793	10.45	0.279	10.17	47.80	7.50	9.60	2.10	19.77	12.27	14.69	7.19	5.09	5.84	0
50		0.5000	0.5000	72.00	0.0930	0.907	6.875	10.47	0.317	10.15	47.70	7.40	9.60	2.20	19.75	12.35	14.68	7.28	5.08	5.62	0
51		0.5400	0.5400	74.00	0.1000	0.900	6.929	10.68	0.341	10.34	47.40	7.10	9.60	2.50	19.94	12.84	14.77	7.67	5.17	5.14	0
52		0.5600	0.5600	74.00	0.1040	0.896	6.959	10.63	0.354	10.28	47.40	7.10	9.60	2.50	19.88	12.78	14.74	7.64	5.14	5.11	0
53		0.5800	0.5800	74.00	0.1070	0.893	6.983	10.60	0.365	10.24	47.40	7.10	9.60	2.50	19.84	12.74	14.72	7.62	5.12	5.09	0
54		0.5900	0.5900	75.00	0.1090	0.891	6.998	10.72	0.371	10.35	47.30	7.00	9.60	2.60	19.95	12.95	14.77	7.77	5.17	4.98	0
55		0.6000	0.6000	75.00	0.1110	0.889	7.014	10.69	0.378	10.31	47.30	7.00	9.60	2.60	19.91	12.91	14.76	7.76	5.16	4.97	0
56		0.6500	0.6500	76.00	0.1200	0.880	7.086	10.73	0.409	10.32	47.30	7.00	9.60	2.60	19.92	12.92	14.76	7.76	5.16	4.97	0
57		0.6700	0.6700	76.00	0.1240	0.876	7.118	10.68	0.422	10.26	47.30	7.00	9.60	2.60	19.86	12.86	14.73	7.73	5.13	4.95	0
58																					0
59																					
60																					

Calculations Based on
EM 1110-2-1906 Appendix X
ASTM D 4767-04





Specimen No.			1	2	3
Initial	Water Content, %	ω_O	71.0	74.3	72.4
	Dry Density, lbs/ft^3	$^{\gamma}d_o$	58.8	55.4	52.7
	Saturation, %	S_O	100.0	98.7	89.2
	Void Ratio	e_O	1.85	2.02	2.18
Before Shear	Water Content, %	ω_f	58.6	58.1	48.9
	Dry Density, lbs/ft^3	$^{\gamma}d_c$	63.1	60.3	65.8
	Saturation, %	S_C	100.0	100.0	100.0
	Void Ratio	e_C	1.65	1.77	1.54
	Final Back Pressure, tsf	U_O	3.6	3.6	2.9
Minor Principal Stress, tsf		σ_3	0.22	0.38	3.25
Maximum Deviator Stress, tsf	$(\sigma_1-\sigma_3)_{max}$		0.23	0.34	2.10
Time to $(\sigma_1-\sigma_3)_{max}$, min		t_f			
Deviator Stress @ 15% Axial Strain, tsf	$(\sigma_1-\sigma_3)_{15\%}$		0.24	0.47	2.13
Axial Strain at failure, %		ε	6.3	2.9	6.7
Peak Pore Pressure at failure, tsf		U	3.758	3.859	5.530
Δ Pore Pressure at failure (ΔU), tsf		ΔU	0.158	0.259	2.650
Initial Diameter, in		D_O	2.749	2.833	2.850
Initial Height, in		H_O	5.684	5.948	5.850

Rate of strain, %/hr: 0.25

Description of Specimen 1: Dark Gray SILT (MH), 10'

Description of Specimen 2: Dark Gray SILT (MH), 11'

Description of Specimen 3: Dark Gray SILT (MH), 14.5'

Amount of Material Finer than the No. 200, %: 88.8

LL: 63 PL: 38 PI: 25 G_S: 2.68 Measured

Type of Specimens: Undisturbed

Type of Test: ASTM D-4767

Remarks: B Parameter >/= 0.97

Peak Strength selected at maximum effective stress ratio (obliquity)

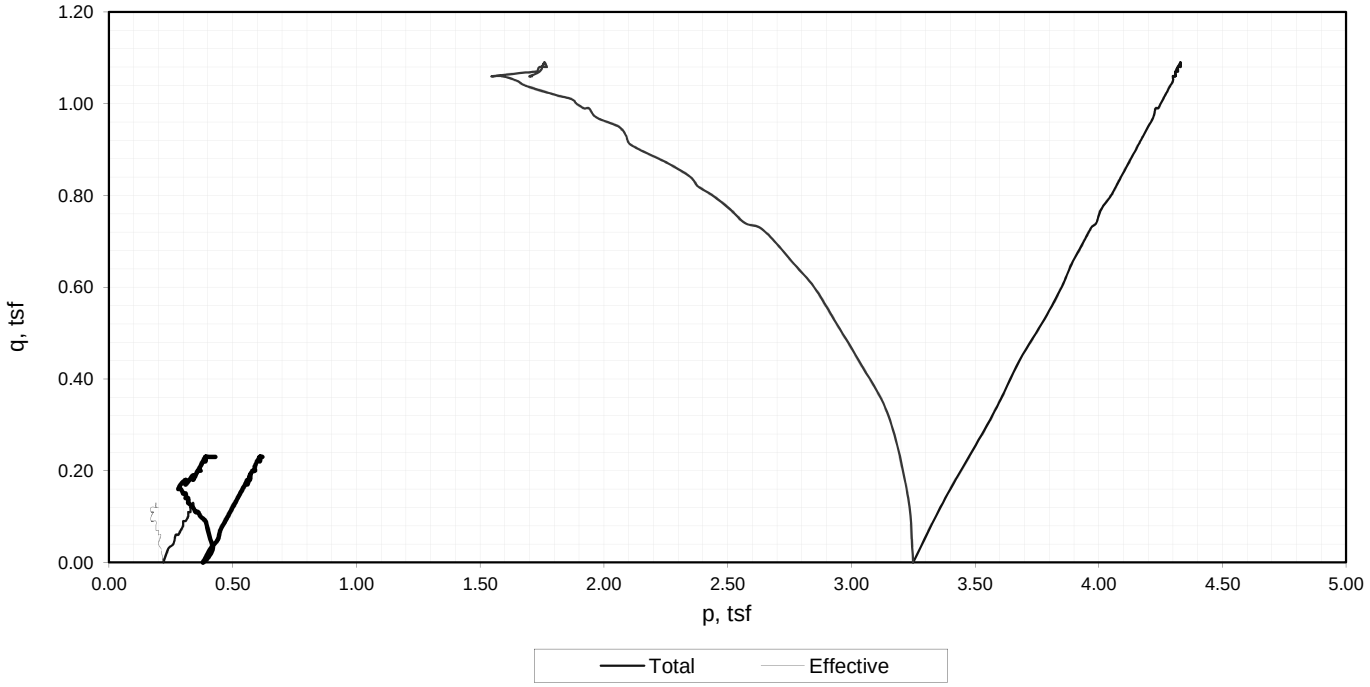
Some scattered wood debris observed in samples

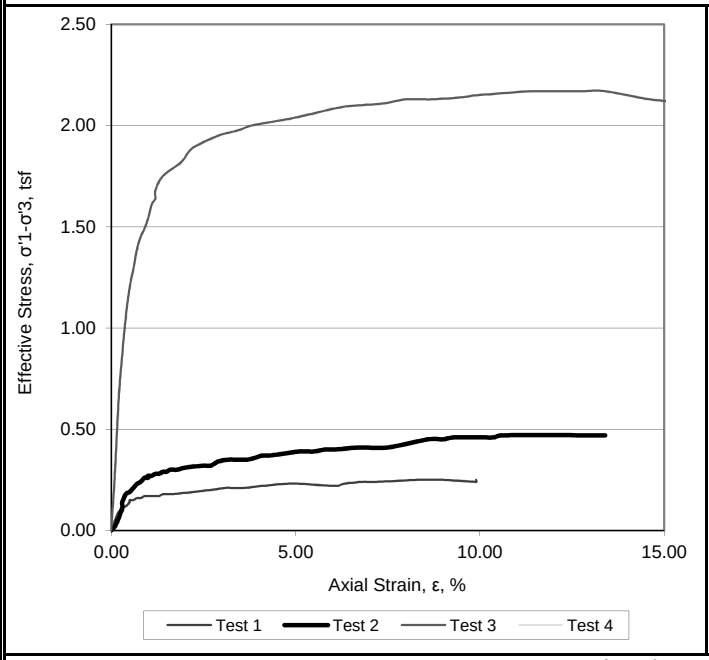
Method of Saturation: Wet Mounted

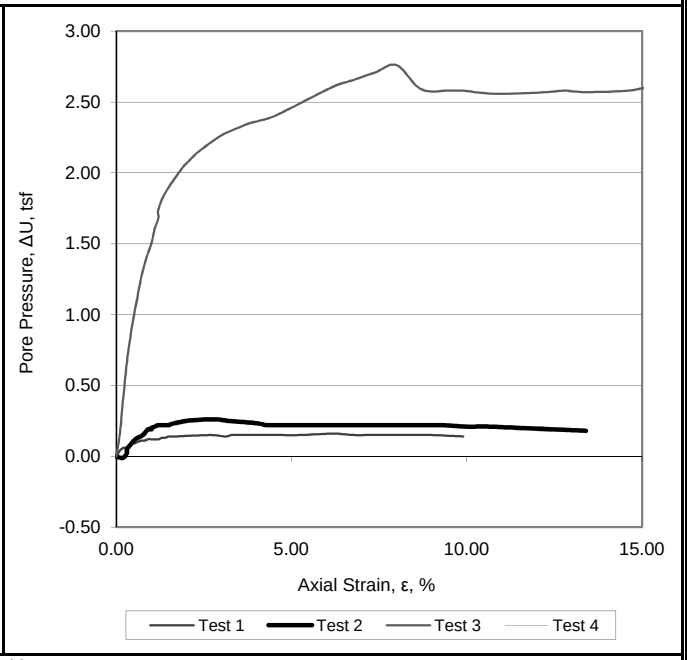
KLEINFELDER
Bright People. Right Solutions.

9200 SW Nimbus Ave
Beaverton, Oregon
p| 503-644-9447
f| 916.3643-1701
kleinfelder.com

Project Name:	Arkema Early Action
Project Number:	107510
Boring Number:	SPT-3
Sample ID:	ARK-SPT-3
Sample Depth, ft.:	9.5-11.5, 13-15
Report Date:	December 15, 2009







Rate of strain, % / hr: 0.25

Description of Specimen 1 Dark Gray SILT (MH), 10'

Description of Specimen 2 Dark Gray SILT (MH), 11'

Description of Specimen 3 Dark Gray SILT (MH), 14.5'

Amount of Material Finer than the No. 200, %: 88.8

LL: 63	PL: 38	PI: 25	G_S: 2.68 Measured	Type of Specimen: Undisturbed	Type of Test: ASTM D-4767

Remarks: B Parameter >/= 0.97

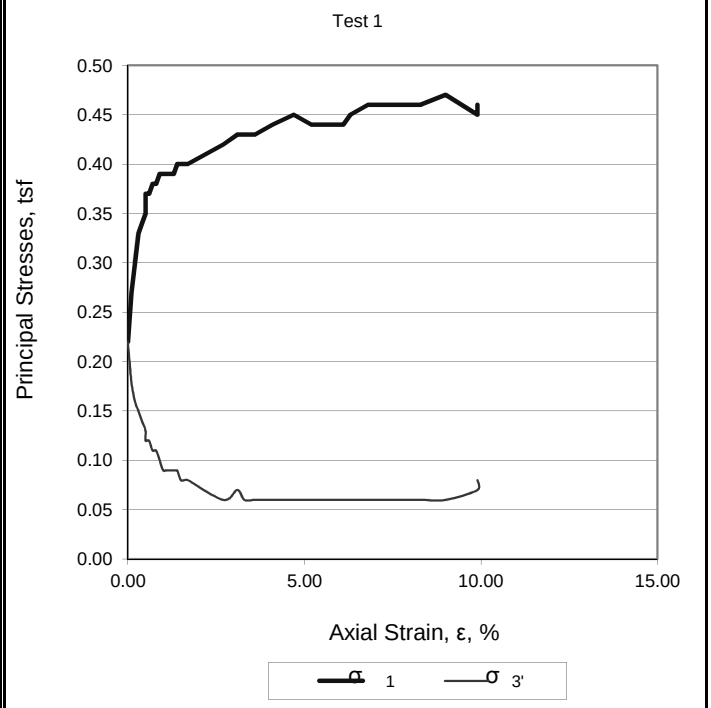
Peak Strength selected at maximum effective stress ratio (obliquity)

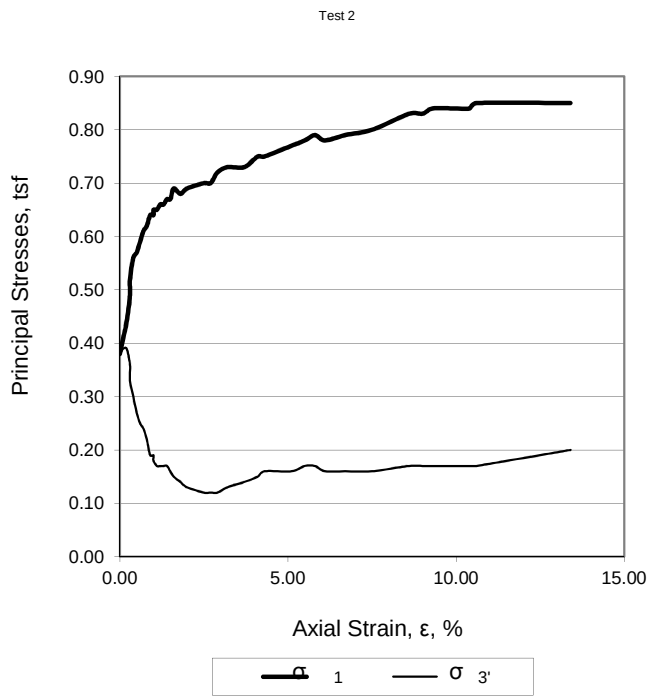
Some scattered wood debris observed in samples

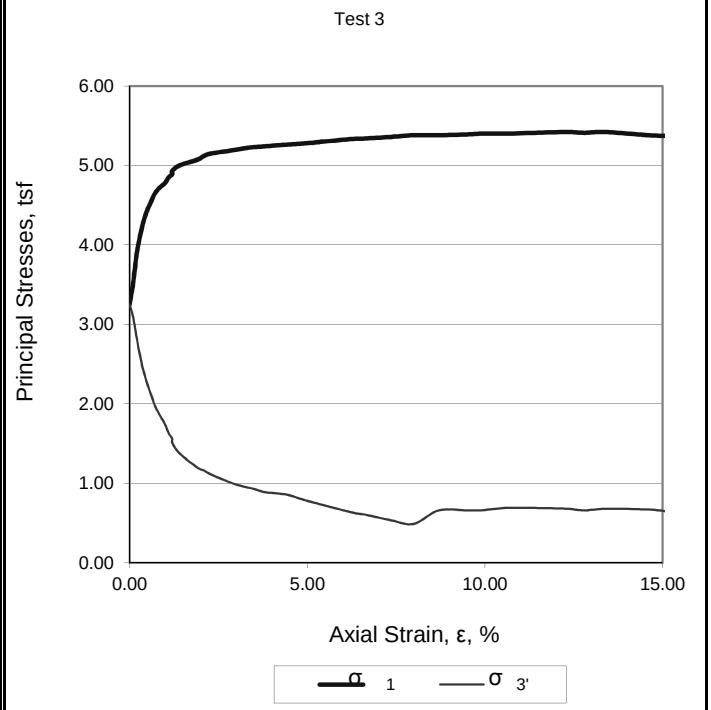
Method of Saturation: Wet Mounted

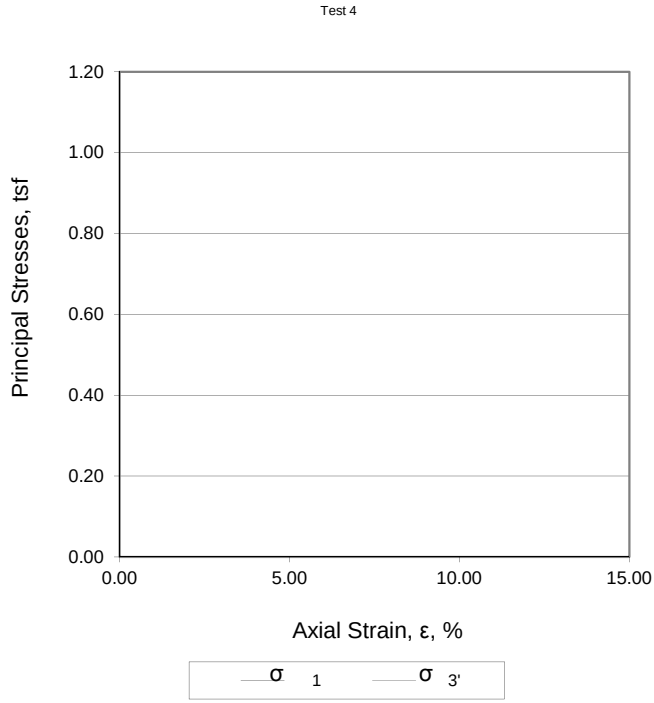
KLEINFELDER
Bright People. Right Solutions.
9200 SW Nimbus Ave
Beaverton, Oregon
p| 503-644-9447
f| 916.3643-1701
kleinfelder.com

Project Name:	Arkema Early Action
Project Number:	107510
Boring Number:	SPT-3
Sample ID:	ARK-SPT-3
Sample Depth, ft.:	9.5-11.5, 13-15
Report Date:	December 15, 2009









Rate of strain, % / hr: 0.25

Description of Specimen 1 Dark Gray SILT (MH), 10'

Description of Specimen 2 Dark Gray SILT (MH), 11'

Description of Specimen 3 Dark Gray SILT (MH), 14.5'

Amount of Material Finer than the No. 200, %: 88.8

LL: 63	PL: 38	PI: 25	G_S: 2.68 Measured	Type of Specimen: Undisturbed	Type of Test: ASTM D-4767

Remarks: B Parameter >/= 0.97

Peak Strength selected at maximum effective stress ratio (obliquity)

Some scattered wood debris observed in samples

Method of Saturation: Wet Mounted

KLEINFELDER
Bright People. Right Solutions.

9200 SW Nimbus Ave
Beaverton, Oregon
p| 503-644-9447
f| 916.3643-1701
kleinfelder.com

Project Name:	Arkema Early Action
Project Number:	107510
Boring Number:	SPT-3
Sample ID:	ARK-SPT-3
Sample Depth, ft.:	9.5-11.5, 13-15
Report Date:	December 15, 2009

Arkema Early Action ARK-SPT-3 9.5-11.5, 13-15

Axial Loading Data

Triaxial Compression R-bar (CU) Tests

Selected for Calculations (**X**)

Max Deviator Stress 3.52

Selected Row for Deviator Stress

Selected Deviator Stress

x Max Obliquity 5.04

Deviator Stress at Max Obliquity 3.24

H_O (in) 5.684 D_O (in) 2.749 A_O (in^2) 5.935

H_C (in) 5.531 D_C (in) 2.690 A_C (in^2) 5.682

Consolidation Pressure(psi/tsf) 3.0 / 0.22

Membrane Thickness: 0.012

Selected Row for Ultimate Deviator Stress (Based on Deviator Stress vs. % Axial Strian Graph)

Ultimate Deviator Stress

Row Number	Elapsed Time	Dial Indicator Reading 0.0001 in	Cumulative Change (ΔH) 0.0001 in	P Axial Load lbs	Axial Strain $\varepsilon = \Delta H_C/H_C$	1-ε	Corrected Area $A_{Corr} = A_C/1-\varepsilon$ in^2	Deviator Stress $\sigma_1-\sigma_3 = P/A_C$ lbs/in^2	Membrane Correction Factor (MF) lbs/in^2	Corrected Deviator Stress $((\sigma_1-\sigma_3)$ - MF-FC)	Pore Pressure (U) lbs/in^2	Δ Pore Pressure (ΔU) lbs/in^2	σ_3 lbs/in^2	σ_3' lbs/in^2	σ_1 lbs/in^2	σ_1' lbs/in^2	p $(\sigma_1+\sigma_3)/2$ lbs/in^2	p' $(\sigma'_1+\sigma'_3)/2$ lbs/in^2	q $(\sigma_1-\sigma_3)/2$ lbs/in^2	Obliquity σ_1'/σ_3' lbs/in^2	Filter Strip Correction Factor (FC) lbs/in^2
1		0.0000	0.0000	0.00	0.0000	1.000	5.682	0.00	0.000	0.00	50.00	0.00	3.00	3.00	3.00	3.00	3.00	3.00	0.00	1.00	0
2		0.0050	0.0050	4.00	0.0010	0.999	5.688	0.70	0.004	0.70	50.50	0.50	3.00	2.50	3.70	3.20	3.35	2.85	0.35	1.28	0
3		0.0100	0.0100	7.00	0.0020	0.998	5.694	1.23	0.007	1.22	50.80	0.80	3.00	2.20	4.22	3.42	3.61	2.81	0.61	1.55	0
4		0.0150	0.0150	9.00	0.0030	0.997	5.699	1.58	0.011	1.57	50.90	0.90	3.00	2.10	4.57	3.67	3.79	2.89	0.79	1.75	0
5		0.0200	0.0200	10.00	0.0040	0.996	5.705	1.75	0.014	1.74	51.10	1.10	3.00	1.90	4.74	3.64	3.87	2.77	0.87	1.91	0
6		0.0250	0.0250	11.00	0.0050	0.995	5.711	1.93	0.018	1.91	51.20	1.20	3.00	1.80	4.91	3.71	3.96	2.76	0.96	2.06	0
7		0.0300	0.0300	12.00	0.0050	0.995	5.711	2.10	0.018	2.08	51.30	1.30	3.00	1.70	5.08	3.78	4.04	2.74	1.04	2.22	0
8		0.0350	0.0350	12.00	0.0060	0.994	5.717	2.10	0.021	2.08	51.40	1.40	3.00	1.60	5.08	3.68	4.04	2.64	1.04	2.30	0
9		0.0400	0.0400	13.00	0.0070	0.993	5.722	2.27	0.025	2.25	51.50	1.50	3.00	1.50	5.25	3.75	4.12	2.62	1.12	2.50	0
10		0.0450	0.0450	13.00	0.0080	0.992	5.728	2.27	0.029	2.24	51.50	1.50	3.00	1.50	5.24	3.74	4.12	2.62	1.12	2.49	0
11		0.0500	0.0500	14.00	0.0090	0.991	5.734	2.44	0.032	2.41	51.60	1.60	3.00	1.40	5.41	3.81	4.20	2.60	1.20	2.72	0
12		0.0550	0.0550	14.00	0.0100	0.990	5.740	2.44	0.036	2.40	51.70	1.70	3.00	1.30	5.40	3.70	4.20	2.50	1.20	2.85	0
13		0.0600	0.0600	14.00	0.0110	0.989	5.746	2.44	0.039	2.40	51.70	1.70	3.00	1.30	5.40	3.70	4.20	2.50	1.20	2.85	0
14		0.0650	0.0650	14.00	0.0120	0.988	5.751	2.43	0.043	2.39	51.70	1.70	3.00	1.30	5.39	3.69	4.19	2.49	1.19	2.84	0
15		0.0700	0.0700	14.00	0.0130	0.987	5.757	2.43	0.046	2.38	51.80	1.80	3.00	1.20	5.38	3.58	4.19	2.39	1.19	2.99	0
16		0.0750	0.0750	15.00	0.0140	0.986	5.763	2.60	0.050	2.55	51.80	1.80	3.00	1.20	5.55	3.75	4.28	2.48	1.28	3.13	0
17		0.0800	0.0800	15.00	0.0140	0.986	5.763	2.60	0.050	2.55	51.80	1.80	3.00	1.20	5.55	3.75	4.28	2.48	1.28	3.13	0
18		0.0850	0.0850	15.00	0.0150	0.985	5.769	2.60	0.054	2.55	51.90	1.90	3.00	1.10	5.55	3.65	4.27	2.37	1.27	3.31	0
19		0.0900	0.0900	15.00	0.0160	0.984	5.775	2.60	0.057	2.54	51.90	1.90	3.00	1.10	5.54	3.64	4.27	2.37	1.27	3.31	0
20		0.0950	0.0950	15.00	0.0170	0.983	5.781	2.59	0.061	2.53	51.90	1.90	3.00	1.10	5.53	3.63	4.26	2.36	1.26	3.30	0
21		0.1500	0.1500	17.00	0.0270	0.973	5.840	2.91	0.096	2.81	52.10	2.10	3.00	0.90	5.81	3.71	4.41	2.31	1.41	4.13	0
22		0.1700	0.1700	18.00	0.0310	0.969	5.864	3.07	0.111	2.96	52.00	2.00	3.00	1.00	5.96	3.96	4.48	2.48	1.48	3.96	0
23		0.1850	0.1850	18.00	0.0330	0.967	5.876	3.06	0.118	2.94	52.10	2.10	3.00	0.90	5.94	3.84	4.47	2.37	1.47	4.27	0
24		0.2000	0.2000	18.00	0.0360	0.964	5.895	3.05	0.128	2.92	52.10	2.10	3.00	0.90	5.92	3.82	4.46	2.36	1.46	4.25	0
25		0.2250	0.2250	19.00	0.0410	0.959	5.925	3.21	0.146	3.06	52.10	2.10	3.00	0.90	6.06	3.96	4.53	2.43	1.53	4.40	0
26		0.2600	0.2600	20.00	0.0470	0.953	5.963	3.35	0.168	3.18	52.10	2.10	3.00	0.90	6.18	4.08	4.59	2.49	1.59	4.54	0
27		0.2850	0.2850	20.00	0.0520	0.948	5.994	3.34	0.186	3.15	52.10	2.10	3.00	0.90	6.15	4.05	4.58	2.48	1.58	4.50	0
28		0.3350	0.3350	20.00	0.0610	0.939	6.051	3.31	0.218	3.09	52.20	2.20	3.00	0.80	6.09	3.89	4.55	2.35	1.55	4.87	0
29		0.3500	0.3500	21.00	0.0630	0.937	6.064	3.46	0.225	3.24	52.20	2.20	3.00	0.80	6.24	4.04	4.62	2.42	1.62	5.04	0
30		0.3750	0.3750	22.00	0.0680	0.932	6.097	3.61	0.243	3.37	52.10	2.10	3.00	0.90	6.37	4.27	4.68	2.58	1.68	4.74	0
31		0.4000	0.4000	22.00	0.0720	0.928	6.123	3.59	0.257	3.33	52.10	2.10	3.00	0.90	6.33	4.23	4.67	2.57	1.67	4.70	0
32		0.4600	0.4600	23.00	0.0830	0.917	6.197	3.71	0.296	3.41	52.10	2.10	3.00	0.90	6.41	4.31	4.71	2.61	1.71	4.79	0
33		0.5000	0.5000	24.00	0.0900	0.910	6.244	3.84	0.321	3.52	52.10	2.10	3.00	0.90	6.52	4.42	4.76	2.66	1.76	4.91	0
34		0.5450	0.5450	23.00	0.0990	0.901	6.307	3.65	0.353	3.30	52.00	2.00	3.00	1.00	6.30	4.30	4.65	2.65	1.65	4.30	0
35		0.5450	0.5450	24.00	0.0990	0.901	6.307	3.81	0.353	3.46	51.90	1.90	3.00	1.10	6.46	4.56	4.73	2.83	1.73	4.14	0
36																					0
37																					0
38																					0
39																					0
40																					0
41																					

Calculations Based on
EM 1110-2-1906 Appendix X
ASTM D 4767-04

Arkema Early Action ARK-SPT-3 9.5-11.5, 13-15

Axial Loading Data
Triaxial Compression R-bar (CU) Tests

Selected for Calculations (**X**)

Max Deviator Stress 6.49

Selected Row for Deviator Stress ____ Selected Deviator Stress ____

x Max Obliquity 3.80 Deviator Stress at Max Obliquity 4.76

Consolidation Pressure(psi/tsf) 5.3 / 0.38

H_O (in) 5.948 D_O (in) 2.833 A_O (in^2) 6.304

H_C (in) 5.748 D_C (in) 2.763 A_C (in^2) 5.997

Membrane Thickness: 0.012

Selected Row for Ultimate Deviator Stress (Based on Deviator Stress vs. % Axial Strian Graph) ____ Ultimate Deviator Stress ____

Row Number	Elapsed Time	Dial Indicator Reading 0.0001 in	Cumulative Change (ΔH) 0.0001 in	P Axial Load lbs	Axial Strain $\varepsilon = \Delta H_C/H_C$	1-ε	Corrected Area $A_{Corr} = A_C/1-\varepsilon$ in^2	Deviator Stress $\sigma_1-\sigma_3 = P/A_C$ lbs/in^2	Membrane Correction Factor (MF) lbs/in^2	Corrected Deviator Stress $((\sigma_1-\sigma_3)$ - MF-FC)	Pore Pressure (U) lbs/in^2	Δ Pore Pressure (ΔU) lbs/in^2	σ_3 lbs/in^2	σ_3' lbs/in^2	σ_1 lbs/in^2	σ_1' lbs/in^2	p $(\sigma_1+\sigma_3)/2$ lbs/in^2	p' $(\sigma'_1+\sigma'_3)/2$ lbs/in^2	q $(\sigma_1.\sigma_3)/2$ lbs/in^2	Obliquity σ_1'/σ_3' lbs/in^2	Filter Strip Correction Factor (FC) lbs/in^2
1		0.0000	0.0000	0.00	0.0000	1.000	5.997	0.00	0.000	0.00	50.00	0.00	5.30	5.30	5.30	5.30	5.30	5.30	0.00	1.00	0
2		0.0050	0.0050	2.00	0.0010	0.999	6.003	0.33	0.003	0.33	49.90	-0.10	5.30	5.40	5.63	5.73	5.47	5.57	0.17	1.06	0
3		0.0100	0.0100	5.00	0.0020	0.998	6.009	0.83	0.007	0.82	49.90	-0.10	5.30	5.40	6.12	6.22	5.71	5.81	0.41	1.15	0
4		0.0150	0.0150	9.00	0.0030	0.997	6.015	1.50	0.010	1.49	50.30	0.30	5.30	5.00	6.79	6.49	6.05	5.75	0.75	1.30	0
5		0.0200	0.0200	12.00	0.0030	0.997	6.015	2.00	0.010	1.99	50.70	0.70	5.30	4.60	7.29	6.59	6.30	5.60	1.00	1.43	0
6		0.0255	0.0255	15.00	0.0040	0.996	6.021	2.49	0.014	2.48	51.10	1.10	5.30	4.20	7.78	6.68	6.54	5.44	1.24	1.59	0
7		0.0300	0.0300	16.00	0.0050	0.995	6.027	2.65	0.017	2.63	51.50	1.50	5.30	3.80	7.93	6.43	6.62	5.12	1.32	1.69	0
8		0.0350	0.0350	18.00	0.0060	0.994	6.033	2.98	0.021	2.96	51.80	1.80	5.30	3.50	8.26	6.46	6.78	4.98	1.48	1.85	0
9		0.0400	0.0400	19.00	0.0070	0.993	6.039	3.15	0.024	3.13	52.00	2.00	5.30	3.30	8.43	6.43	6.86	4.86	1.56	1.95	0
10		0.0450	0.0450	20.00	0.0080	0.992	6.045	3.31	0.028	3.28	52.20	2.20	5.30	3.10	8.58	6.38	6.94	4.74	1.64	2.06	0
11		0.0500	0.0500	22.00	0.0090	0.991	6.051	3.64	0.031	3.61	52.60	2.60	5.30	2.70	8.91	6.31	7.10	4.50	1.80	2.34	0
12		0.0550	0.0550	22.00	0.0100	0.990	6.058	3.63	0.035	3.60	52.70	2.70	5.30	2.60	8.90	6.20	7.10	4.40	1.80	2.38	0
13		0.0600	0.0600	23.00	0.0100	0.990	6.058	3.80	0.035	3.77	52.80	2.80	5.30	2.50	9.07	6.27	7.18	4.38	1.88	2.51	0
14		0.0650	0.0650	23.00	0.0110	0.989	6.064	3.79	0.038	3.75	52.90	2.90	5.30	2.40	9.05	6.15	7.18	4.28	1.88	2.56	0
15		0.0700	0.0700	24.00	0.0120	0.988	6.070	3.95	0.042	3.91	53.00	3.00	5.30	2.30	9.21	6.21	7.25	4.25	1.95	2.70	0
16		0.0750	0.0750	24.00	0.0130	0.987	6.076	3.95	0.045	3.91	53.00	3.00	5.30	2.30	9.21	6.21	7.25	4.25	1.95	2.70	0
17		0.0800	0.0800	25.00	0.0140	0.986	6.082	4.11	0.049	4.06	53.00	3.00	5.30	2.30	9.36	6.36	7.33	4.33	2.03	2.77	0
18		0.0850	0.0850	25.00	0.0150	0.985	6.088	4.11	0.052	4.06	53.10	3.10	5.30	2.20	9.36	6.26	7.33	4.23	2.03	2.84	0
19		0.0900	0.0900	26.00	0.0160	0.984	6.094	4.27	0.056	4.21	53.20	3.20	5.30	2.10	9.51	6.31	7.41	4.21	2.11	3.01	0
20		0.1050	0.1050	26.00	0.0180	0.982	6.107	4.26	0.063	4.20	53.30	3.30	5.30	2.00	9.50	6.20	7.40	4.10	2.10	3.10	0
21		0.1150	0.1150	27.00	0.0200	0.980	6.119	4.41	0.069	4.34	53.50	3.50	5.30	1.80	9.64	6.14	7.47	3.97	2.17	3.41	0
22		0.1450	0.1450	28.00	0.0250	0.975	6.151	4.55	0.087	4.46	53.60	3.60	5.30	1.70	9.76	6.16	7.53	3.93	2.23	3.63	0
23		0.1550	0.1550	28.00	0.0270	0.973	6.163	4.54	0.094	4.45	53.60	3.60	5.30	1.70	9.75	6.15	7.52	3.92	2.22	3.62	0
24		0.1650	0.1650	30.00	0.0290	0.971	6.176	4.86	0.101	4.76	53.60	3.60	5.30	1.70	10.06	6.46	7.68	4.08	2.38	3.80	0
25		0.1850	0.1850	31.00	0.0320	0.968	6.195	5.00	0.111	4.89	53.50	3.50	5.30	1.80	10.19	6.69	7.74	4.24	2.44	3.72	0
26		0.2100	0.2100	31.00	0.0370	0.963	6.227	4.98	0.129	4.85	53.40	3.40	5.30	1.90	10.15	6.75	7.73	4.33	2.43	3.55	0
27		0.2350	0.2350	33.00	0.0410	0.959	6.253	5.28	0.142	5.14	53.20	3.20	5.30	2.10	10.44	7.24	7.87	4.67	2.57	3.45	0
28		0.2500	0.2500	33.00	0.0430	0.957	6.266	5.27	0.149	5.12	53.10	3.10	5.30	2.20	10.42	7.32	7.86	4.76	2.56	3.33	0
29		0.2950	0.2950	35.00	0.0510	0.949	6.319	5.54	0.177	5.36	53.10	3.10	5.30	2.20	10.66	7.56	7.98	4.88	2.68	3.44	0
30		0.3150	0.3150	36.00	0.0550	0.945	6.346	5.67	0.191	5.48	53.00	3.00	5.30	2.30	10.78	7.78	8.04	5.04	2.74	3.38	0
31		0.3350	0.3350	37.00	0.0580	0.942	6.366	5.81	0.202	5.61	53.00	3.00	5.30	2.30	10.91	7.91	8.10	5.10	2.80	3.44	0
32		0.3500	0.3500	37.00	0.0610	0.939	6.387	5.79	0.212	5.58	53.10	3.10	5.30	2.20	10.88	7.78	8.09	4.99	2.79	3.54	0
33		0.3850	0.3850	38.00	0.0670	0.933	6.428	5.91	0.233	5.68	53.10	3.10	5.30	2.20	10.98	7.88	8.14	5.04	2.84	3.58	0
34		0.4300	0.4300	39.00	0.0750	0.925	6.483	6.02	0.261	5.76	53.10	3.10	5.30	2.20	11.06	7.96	8.18	5.08	2.88	3.62	0
35		0.4930	0.4930	43.00	0.0860	0.914	6.561	6.55	0.299	6.25	53.00	3.00	5.30	2.30	11.55	8.55	8.43	5.43	3.13	3.72	0
36		0.5150	0.5150	43.00	0.0900	0.910	6.590	6.53	0.313	6.22	53.00	3.00	5.30	2.30	11.52	8.52	8.41	5.41	3.11	3.70	0
37		0.5350	0.5350	44.00	0.0930	0.907	6.612	6.65	0.323	6.33	53.00	3.00	5.30	2.30	11.63	8.63	8.46	5.46	3.16	3.75	0
38		0.5700	0.5700	45.00	0.0990	0.901	6.656	6.76	0.344	6.42	52.90	2.90	5.30	2.40	11.72	8.82	8.51	5.61	3.21	3.67	0
39		0.5950	0.5950	45.00	0.1040	0.896	6.693	6.72	0.361	6.36	52.90	2.90	5.30	2.40	11.66	8.76	8.48	5.58	3.18	3.65	0
40		0.6100	0.6100	46.00	0.1060	0.894	6.708	6.86	0.368	6.49	52.90	2.90	5.30	2.40	11.79	8.89	8.55	5.65	3.25	3.71	0
41		0.7700	0.7700	48.00	0.1340	0.866	6.925	6.93	0.466	6.46	52.50	2.50	5.30	2.80	11.76	9.26	8.53	6.03	3.23	3.31	0
42																					0
43																					

Calculations Based on
EM 1110-2-1906 Appendix X
ASTM D 4767-04

Arkema Early Action ARK-SPT-3 9.5-11.5, 13-15

Axial Loading Data

Triaxial Compression R-bar (CU) Tests

Selected for Calculations (**X**)

	Max Deviator Stress	30.16																Consolidation Pressure(psi/tsf)	45.1	/	3.25
x	Selected Row for Deviator Stress	26		Selected Deviator Stress	29.11			H_O (in)	5.850	D_O (in)	2.850	A_O (in^2)	6.380							
	Max Obliquity	5.35		Deviator Stress at Max Obliquity	29.57			H_C (in)	5.205	D_C (in)	2.703	A_C (in^2)	5.738			Membrane Thickness:	0.024				

Selected Row for Ultimate Deviator Stress (Based on Deviator Stress vs. % Axial Strian Graph) Ultimate Deviator Stress

Row Number	Elapsed Time	Dial Indicator Reading 0.0001 in	Cumulative Change (ΔH) 0.0001 in	P Axial Load lbs	Axial Strain $\varepsilon = \Delta H_C/H_C$	1-ε	Corrected Area $A_{Corr} = A_C/1-\varepsilon$ in^2	Deviator Stress $\sigma_1-\sigma_3 = P/A_C$ lbs/in^2	Membrane Correction Factor (MF) lbs/in^2	Corrected Deviator Stress $((\sigma_1-\sigma_3)$ - MF-FC)	Pore Pressure (U) lbs/in^2	Δ Pore Pressure (ΔU) lbs/in^2	σ_3 lbs/in^2	σ_3' lbs/in^2	σ_1 lbs/in^2	σ_1' lbs/in^2	p $(\sigma_1+\sigma_3)/2$ lbs/in^2	p' $(\sigma'_1+\sigma'_3)/2$ lbs/in^2	q $(\sigma_1-\sigma_3)/2$ lbs/in^2	Obliquity σ_1'/σ_3' lbs/in^2	Filter Strip Correction Factor (FC) lbs/in^2
1		0.0000	0.0000	0.00	0.0000	1.000	5.738	0.00	0.000	0.00	40.00	0.00	45.10	45.10	45.10	45.10	45.10	45.10	0.00	1.00	0
2		0.0050	0.0050	22.00	0.0010	0.999	5.744	3.83	0.007	3.82	42.20	2.20	45.10	42.90	48.92	46.72	47.01	44.81	1.91	1.09	0
3		0.0100	0.0100	51.00	0.0020	0.998	5.750	8.87	0.014	8.86	45.80	5.80	45.10	39.30	53.96	48.16	49.53	43.73	4.43	1.23	0
4		0.0150	0.0150	70.00	0.0030	0.997	5.755	12.16	0.021	12.14	49.10	9.10	45.10	36.00	57.24	48.14	51.17	42.07	6.07	1.34	0
5		0.0200	0.0200	85.00	0.0040	0.996	5.761	14.75	0.028	14.72	51.70	11.70	45.10	33.40	59.82	48.12	52.46	40.76	7.36	1.44	0
6		0.0255	0.0255	96.00	0.0050	0.995	5.767	16.65	0.036	16.61	53.80	13.80	45.10	31.30	61.71	47.91	53.41	39.61	8.31	1.53	0
7		0.0300	0.0300	104.00	0.0060	0.994	5.773	18.01	0.043	17.97	55.60	15.60	45.10	29.50	63.07	47.47	54.09	38.49	8.99	1.61	0
8		0.0350	0.0350	112.00	0.0070	0.993	5.779	19.38	0.050	19.33	57.40	17.40	45.10	27.70	64.43	47.03	54.77	37.37	9.67	1.70	0
9		0.0400	0.0400	117.00	0.0080	0.992	5.784	20.23	0.057	20.17	58.70	18.70	45.10	26.40	65.27	46.57	55.19	36.49	10.09	1.76	0
10		0.0450	0.0450	120.00	0.0090	0.991	5.790	20.73	0.064	20.67	59.80	19.80	45.10	25.30	65.77	45.97	55.44	35.64	10.34	1.82	0
11		0.0500	0.0500	124.00	0.0100	0.990	5.796	21.39	0.071	21.32	60.90	20.90	45.10	24.20	66.42	45.52	55.76	34.86	10.66	1.88	0
12		0.0550	0.0550	130.00	0.0110	0.989	5.802	22.41	0.078	22.33	62.40	22.40	45.10	22.70	67.43	45.03	56.27	33.87	11.17	1.98	0
13		0.0600	0.0600	133.00	0.0120	0.988	5.808	22.90	0.085	22.82	63.40	23.40	45.10	21.70	67.92	44.52	56.51	33.11	11.41	2.05	0
14		0.0650	0.0650	136.00	0.0120	0.988	5.808	23.42	0.085	23.34	64.10	24.10	45.10	21.00	68.44	44.34	56.77	32.67	11.67	2.11	0
15		0.0750	0.0750	142.00	0.0140	0.986	5.820	24.40	0.099	24.30	65.90	25.90	45.10	19.20	69.40	43.50	57.25	31.35	12.15	2.27	0
16		0.1000	0.1000	149.00	0.0190	0.981	5.849	25.47	0.135	25.34	68.40	28.40	45.10	16.70	70.44	42.04	57.77	29.37	12.67	2.52	0
17		0.1100	0.1100	153.00	0.0210	0.979	5.861	26.10	0.149	25.95	69.00	29.00	45.10	16.10	71.05	42.05	58.08	29.08	12.98	2.61	0
18		0.1200	0.1200	156.00	0.0230	0.977	5.873	26.56	0.163	26.40	69.70	29.70	45.10	15.40	71.50	41.80	58.30	28.60	13.20	2.71	0
19		0.1500	0.1500	161.00	0.0290	0.971	5.909	27.25	0.206	27.04	71.20	31.20	45.10	13.90	72.14	40.94	58.62	27.42	13.52	2.95	0
20		0.1700	0.1700	164.00	0.0330	0.967	5.934	27.64	0.234	27.41	71.90	31.90	45.10	13.20	72.51	40.61	58.81	26.91	13.71	3.08	0
21		0.1800	0.1800	165.00	0.0350	0.965	5.946	27.75	0.249	27.50	72.20	32.20	45.10	12.90	72.60	40.40	58.85	26.65	13.75	3.13	0
22		0.2000	0.2000	167.00	0.0380	0.962	5.965	28.00	0.270	27.73	72.70	32.70	45.10	12.40	72.83	40.13	58.97	26.27	13.87	3.24	0
23		0.2300	0.2300	170.00	0.0440	0.956	6.002	28.32	0.313	28.01	73.20	33.20	45.10	11.90	73.11	39.91	59.11	25.91	14.01	3.35	0
24		0.2600	0.2600	173.00	0.0500	0.950	6.040	28.64	0.355	28.29	74.20	34.20	45.10	10.90	73.39	39.19	59.25	25.05	14.15	3.60	0
25		0.3250	0.3250	180.00	0.0620	0.938	6.117	29.43	0.440	28.99	76.20	36.20	45.10	8.90	74.09	37.89	59.60	23.40	14.50	4.26	0
26		0.3500	0.3500	182.00	0.0670	0.933	6.150	29.59	0.476	29.11	76.80	36.80	45.10	8.30	74.21	37.41	59.66	22.86	14.56	4.51	0
27		0.3850	0.3850	185.00	0.0740	0.926	6.197	29.85	0.526	29.32	77.70	37.70	45.10	7.40	74.42	36.72	59.76	22.06	14.66	4.96	0
28		0.4150	0.4150	188.00	0.0800	0.920	6.237	30.14	0.568	29.57	78.30	38.30	45.10	6.80	74.67	36.37	59.89	21.59	14.79	5.35	0
29		0.4550	0.4550	190.00	0.0870	0.913	6.285	30.23	0.618	29.61	76.00	36.00	45.10	9.10	74.71	38.71	59.91	23.91	14.81	4.25	0
30		0.4950	0.4950	193.00	0.0950	0.905	6.340	30.44	0.675	29.77	75.90	35.90	45.10	9.20	74.87	38.97	59.99	24.09	14.89	4.24	0
31		0.5150	0.5150	195.00	0.0990	0.901	6.369	30.62	0.703	29.92	75.90	35.90	45.10	9.20	75.02	39.12	60.06	24.16	14.96	4.25	0
32		0.5500	0.5500	197.00	0.1060	0.894	6.418	30.69	0.753	29.94	75.50	35.50	45.10	9.60	75.04	39.54	60.07	24.57	14.97	4.12	0
33		0.5950	0.5950	200.00	0.1140	0.886	6.476	30.88	0.810	30.07	75.50	35.50	45.10	9.60	75.17	39.67	60.14	24.64	15.04	4.13	0
34		0.6400	0.6400	203.00	0.1230	0.877	6.543	31.03	0.874	30.16	75.70	35.70	45.10	9.40	75.26	39.56	60.18	24.48	15.08	4.21	0
35		0.6650	0.6650	204.00	0.1280	0.872	6.580	31.00	0.909	30.09	75.90	35.90	45.10	9.20	75.19	39.29	60.15	24.25	15.05	4.27	0
36		0.7000	0.7000	206.00	0.1340	0.866	6.626	31.09	0.952	30.14	75.70	35.70	45.10	9.40	75.24	39.54	60.17	24.47	15.07	4.21	0
37		0.7600	0.7600	206.00	0.1460	0.854	6.719	30.66	1.037	29.62	75.80	35.80	45.10	9.30	74.72	38.92	59.91	24.11	14.81	4.18	0
38		0.7950	0.7950	207.00	0.1530	0.847	6.775	30.55	1.087	29.46	76.20	36.20	45.10	8.90	74.56	38.36	59.83	23.63	14.73	4.31	0
39		0.8200	0.8200	208.00	0.1580	0.842	6.815	30.52	1.122	29.40	76.10	36.10	45.10	9.00	74.50	38.40	59.80	23.70	14.70	4.27	0
40		0.8300	0.8300	208.00	0.1590	0.841	6.823	30.49	1.129	29.36	76.00	36.00	45.10	9.10	74.46	38.46	59.78	23.78	14.68	4.23	0
41																					0
42																					0
43																					0
44																					0

Calculations Based on
EM 1110-2-1906 Appendix X
ASTM D 4767-04

KLEINFELDER
Bright People. Right Solutions.

Laboratory Test Report

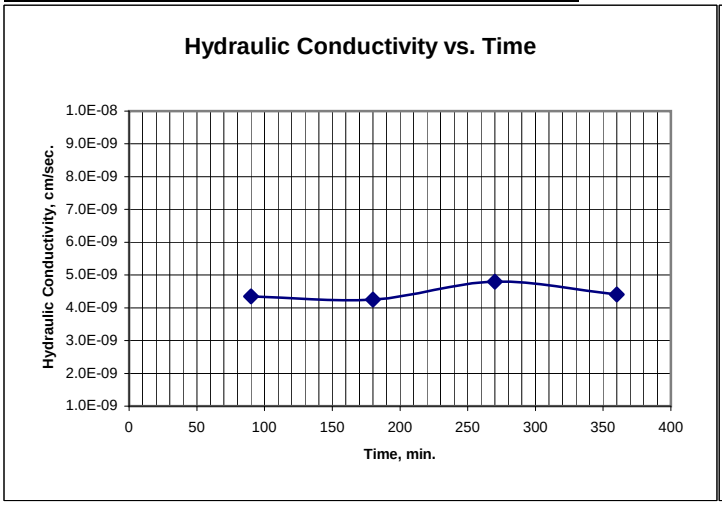
Hydraulic Conductivity - Falling Head Rising Tail (ASTM D 5084, Method C)

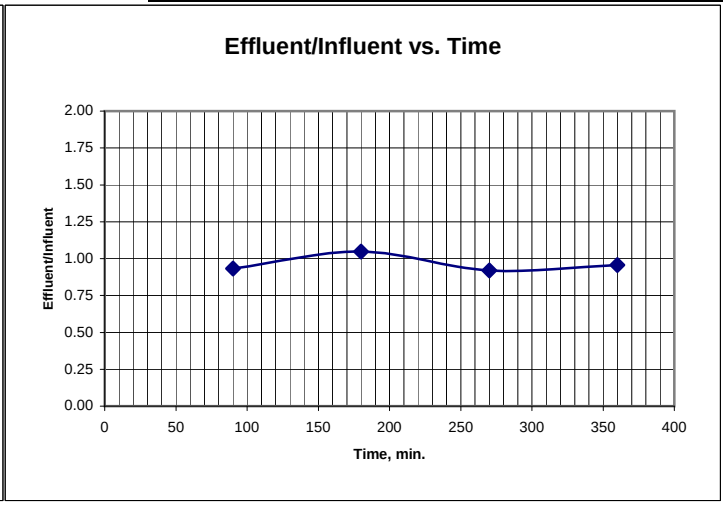
Project Name:	ARCADIS - Arkema Early Action
Project No.:	107510
Boring No.:	SPT-1
Sample No.:	SPT-1
Sample Depth, ft.:	13-15'
Sample Description:	Dark Gray SILT (MH)
Report Date:	February 8, 2010

Water Content, %:		Density, pcf, Initial:		Density, pcf, Final:		Saturation, %:		Specific Gravity:
Initial:	73.7	Wet:	94.5	Wet:	99.0	Initial:	94.9	2.70
Final:	0.0	Dry:	54.4	Dry:	60.0	Final:	97.2	assumed

Sample Length, in.		Sample Diameter, in.		Pressures, psi:				Permeant:
Initial:	2.611	Initial:	2.872	Cell:	44.90	Influent:	41.50	
Final:	2.508	Final:	2.790	Confining:	3.40	Effluent:	1.00	Deaired Water

Trial:	1		2		3		4	
	Start	Finish	Start	Finish	Start	Finish	Start	Finish
Time, min.:	0	90	90	180	180	270	270	360
Influent, mL:	12.00	12.44	12.44	12.85	12.85	13.35	13.35	13.80
Effluent, mL:	12.00	11.59	11.59	11.16	11.16	10.70	10.70	10.27
Temp, °C:	21	21	21	22	22	22	22	22
k @ 20°C, cm/sec.:	4.4E-09		4.2E-09		4.8E-09		4.4E-09	
Dev. From Avg.:	0.98		0.95		1.08		0.99	
DEffluent/DInfluent:	0.93		1.05		0.92		0.96	
Pipette Area, cm^2:	0.8814				B-Parameter:		0.98	





Hydraulic Conductivity @ 20°C, cm/sec:	**4.5E-09**

KLEINFELDER
Bright People. Right Solutions.

Laboratory Test Report

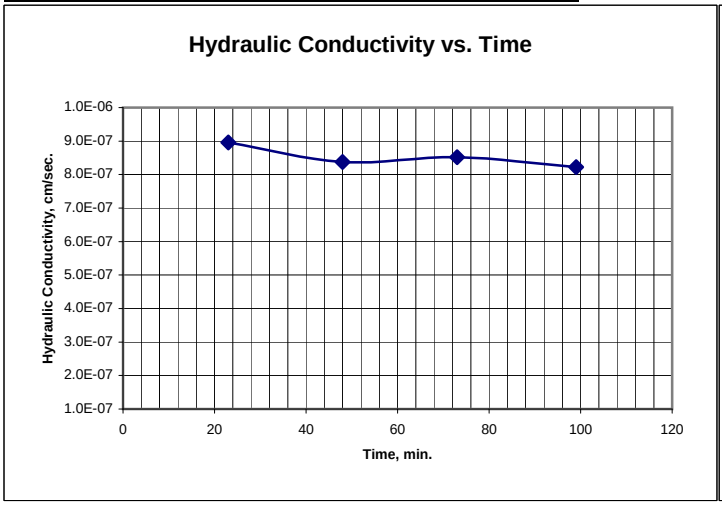
Hydraulic Conductivity - Falling Head Rising Tail (ASTM D 5084, Method C)

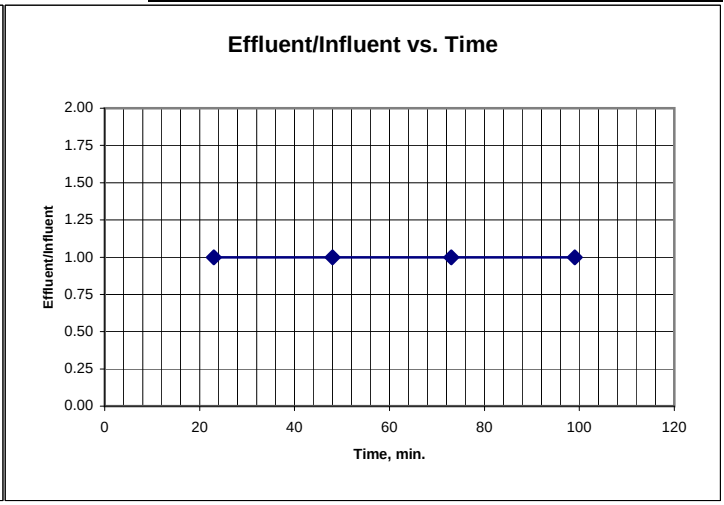
Project Name:	ARCADIS - Arkema Early Action
Project No.:	107510
Boring No.:	SPT-2
Sample No.:	SPT-2
Sample Depth, ft.:	20.5-22.5'
Sample Description:	Dark Gray Sandy SILT (MH)
Report Date:	February 8, 2010

Water Content, %:		Density, pcf, Initial:		Density, pcf, Final:		Saturation, %:		Specific Gravity:
Initial:	45.0	Wet:	104.4	Wet:	105.3	Initial:	90.7	2.70
Final:	0.0	Dry:	72.0	Dry:	69.5	Final:	97.8	assumed

Sample Length, in.		Sample Diameter, in.		Pressures, psi:				Permeant:
Initial:	2.658	Initial:	2.801	Cell:	47.00	Influent:	41.00	
Final:	2.583	Final:	2.772	Confining:	6.00	Effluent:	40.00	Deaired Water

Trial:	1		2		3		4	
	Start	Finish	Start	Finish	Start	Finish	Start	Finish
Time, min.:	0	23	23	48	48	73	73	99
Influent, mL:	12.00	12.50	12.50	13.00	13.00	13.50	13.50	14.00
Effluent, mL:	12.00	11.50	11.50	11.00	11.00	10.50	10.50	10.00
Temp, °C:	19	19	19	19	19	19	19	20
k @ 20°C, cm/sec.:	9.0E-07		8.4E-07		8.5E-07		8.2E-07	
Dev. From Avg.:	1.05		0.98		1.00		0.97	
DEffluent/DInfluent:	1.00		1.00		1.00		1.00	
Pipette Area, cm^2:	0.8814				B-Parameter:		0.98	





Hydraulic Conductivity @ 20°C, cm/sec:	**8.5E-07**

9200 SW Nimbus Ave., Suite A, Portland, OR 97008 p | 503.644.9447 f | 503.643.1905

KLEINFELDER
Bright People. Right Solutions.

Laboratory Test Report

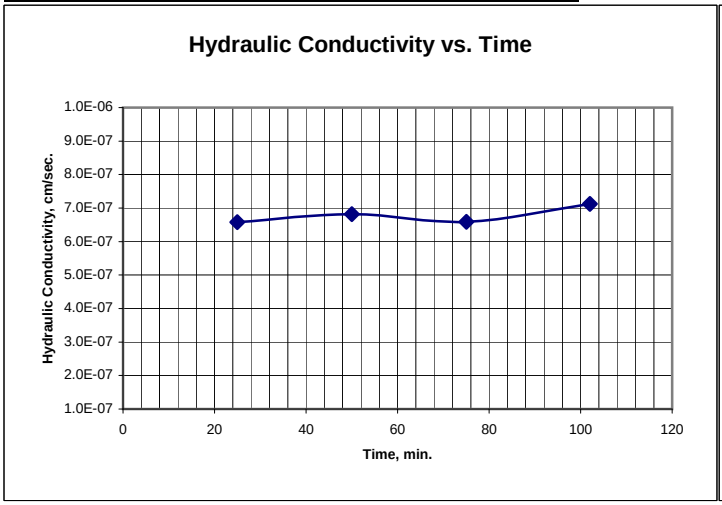
Hydraulic Conductivity - Falling Head Rising Tail (ASTM D 5084, Method C)

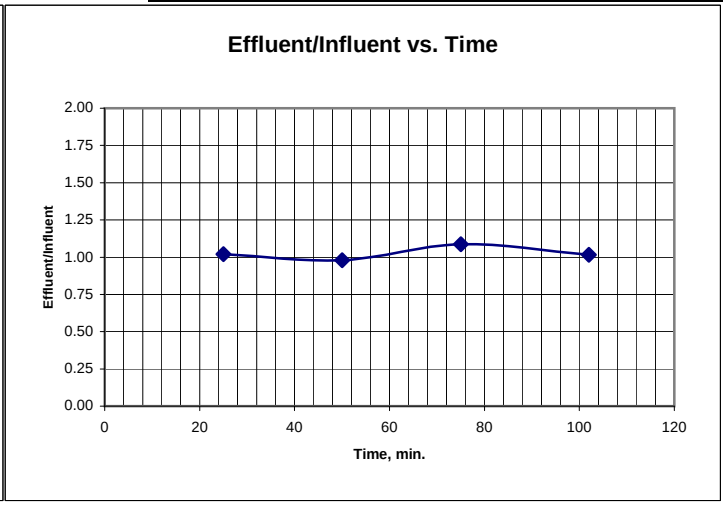
Project Name:	ARCADIS - Arkema Early Action
Project No.:	107510
Boring No.:	SPT-3
Sample No.:	SPT-3
Sample Depth, ft.:	13-15'
Sample Description:	Dark Gray SILT (MH)
Report Date:	February 8, 2010

Water Content, %:		Density, pcf, Initial:		Density, pcf, Final:		Saturation, %:		Specific Gravity:
Initial:	72.4	Wet:	93.5	Wet:	100.6	Initial:	92.9	2.70
Final:	0.0	Dry:	54.2	Dry:	61.7	Final:	98.2	assumed

Sample Length, in.		Sample Diameter, in.		Pressures, psi:				Permeant:
Initial:	2.341	Initial:	2.858	Cell:	52.90	Influent:	50.00	
Final:	2.248	Final:	2.745	Confining:	2.90	Effluent:	49.00	Deaired Water

Trial:	1		2		3		4	
	Start	Finish	Start	Finish	Start	Finish	Start	Finish
Time, min.:	0	25	25	50	50	75	75	102
Influent, mL:	12.00	12.49	12.49	13.00	13.00	13.46	13.46	15.89
Effluent, mL:	12.00	11.50	11.50	11.00	11.00	10.50	10.50	8.03
Temp, °C:	23	23	23	23	23	23	23	23
k @ 20°C, cm/sec.:	6.6E-07		6.8E-07		6.6E-07		7.1E-07	
Dev. From Avg.:	0.97		1.01		0.97		1.05	
DEffluent/DInfluent:	1.02		0.98		1.09		1.02	
Pipette Area, cm^2:	0.8814				B-Parameter:		0.98	





Hydraulic Conductivity @ 20°C, cm/sec:	6.8E-07

9200 SW Nimbus Ave., Suite A, Portland, OR 97008 p | 503.644.9447 f | 503.643.1905

KLEINFELDER
Bright People. Right Solutions.

POINT LOAD TEST
ASTM D 5731-02/DIAMETRIAL

Project Name:	Arkema Early Action	Date Sampled:	N/A
Project Number:	107510	Sampled By:	Arcadis
Conducted By:	R. Goff	Reviewed By:	
Date:	12/18/2009	Date Reviewed:	
Machine:	ROCTEST		

C= 23 for 2 inch diameter
C= 24.5 for 2.4 inch diameter

Core	Depth (ft.)	Gage (psi)	D_e (inches)	L (inches)	P (lbf)	D_e^2 (in^2)	I_s (psi)	F	$I_{s(50)}$ (psi)	σ_{uc} (psi)
SPT-1	30-31.5'	725	2.41		1215.8	5.81	209.3	1.09	229.21	5616
SPT-1	34-36'	1500	2.41		2515.5	5.81	433.1	1.09	474.23	11619
SPT-1	37-39'	2700	2.41		4527.9	5.81	779.6	1.09	853.61	20913

Sample Description: Basalt, hard to very hard, vesicular to dense, reddish-gray to gray.

$I_{s(50)} = F * I_s$ (psi)

$F = (D / 1.97)^{0.45}$

$\sigma_{uc} = C * I_{s(50)}$ (psi)

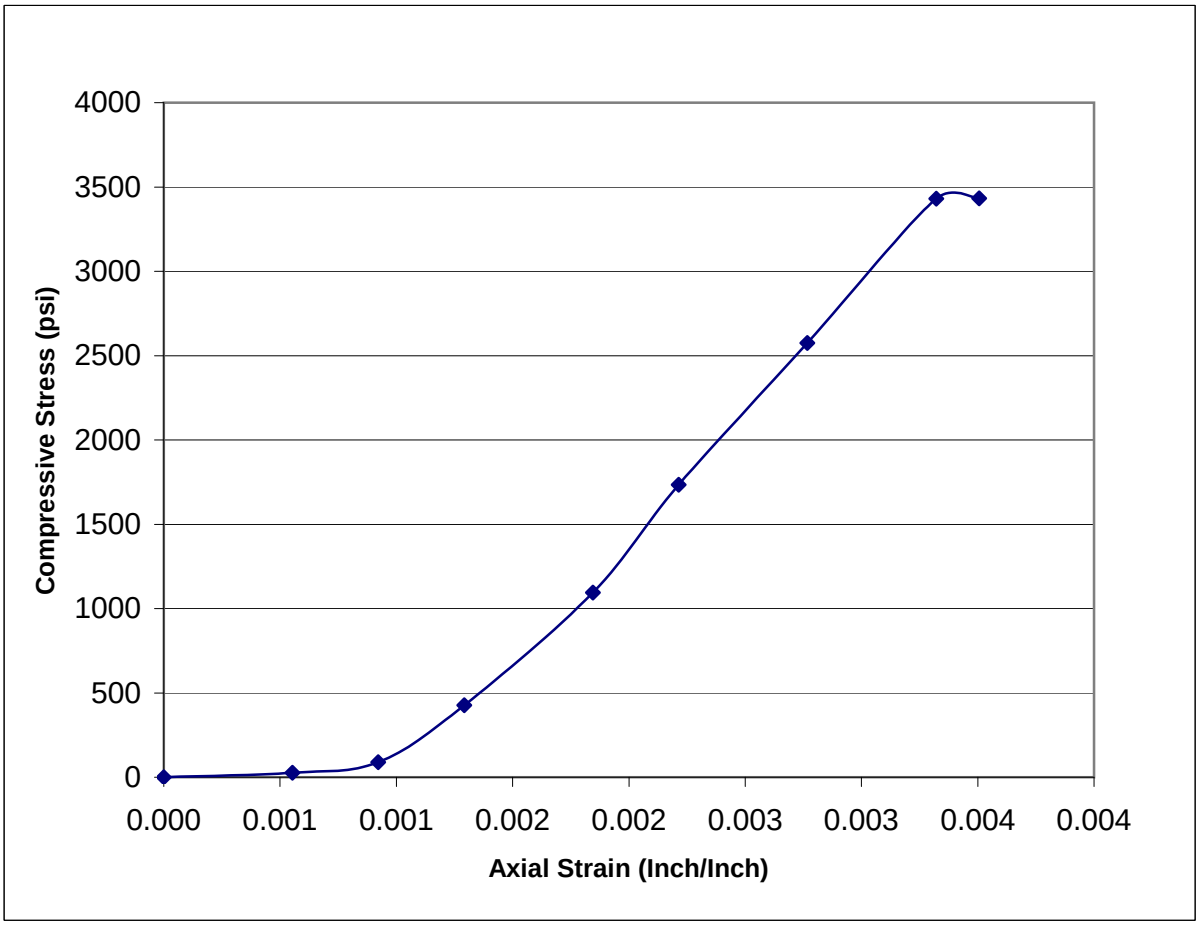
σ_{uc} = uniaxial compressive strength

C = factor that depends on site-specific correlation between σ_{uc} and $I_s(50)$ (23.00 if site-specific correlation is not available)

$I_{s(50)}$ = corrected point load strength index.

Unconfined Compressive Strength Test Results
ASTM D7012-04

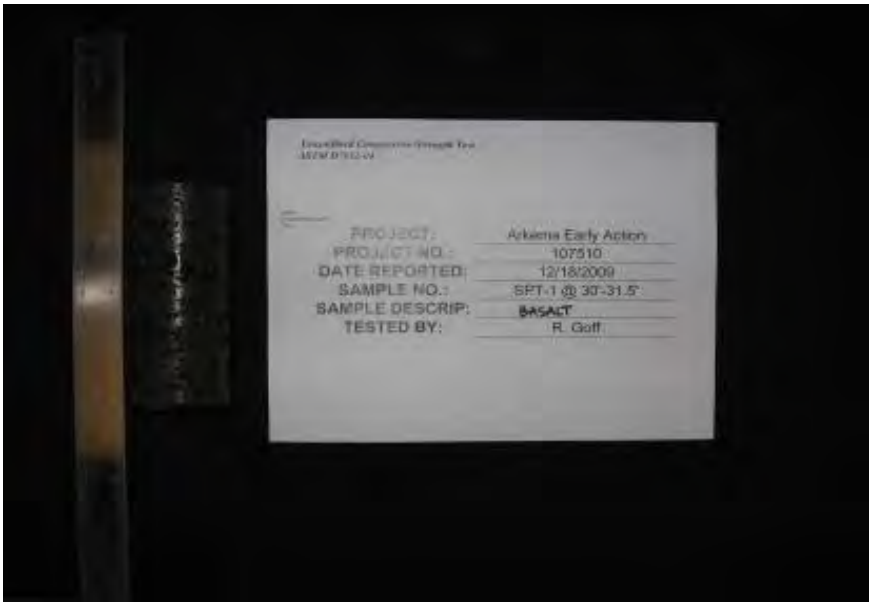
PROJECT:	**Arkema Early Action**	**LAB #:**	**2592**
PROJECT NO.:	**107510**	**SAMPLE #:**	**SPT-1 @ 30'-31.5'**
LOCATION:	**Portland, Oregon**	**DESCRIPTION:**	**Basalt**
SAMPLED BY:	**ARCADIS**	**DATE REPORTED:**	**12/18/2009**
DATE SAMPLED:	**N/A**	**TESTED BY:**	**R. Goff**

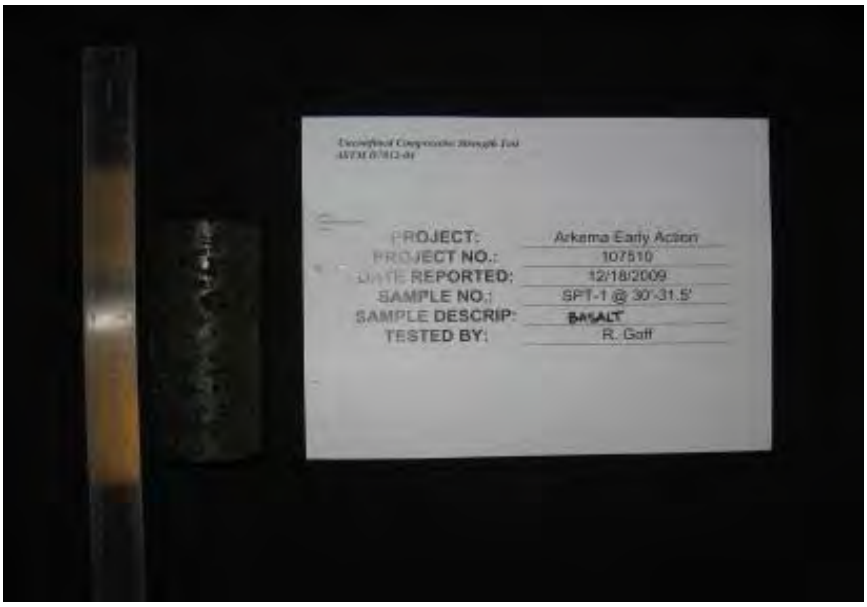


9200 SW Nimbus Avenue v Beaverton, OR 97008 v 503.644.9447 phone v 503.643.1905 fax

KLEINFELDER
Bright People. Right Solutions.

Unconfined Compressive Strength Test Photos
ASTM D 7012-04

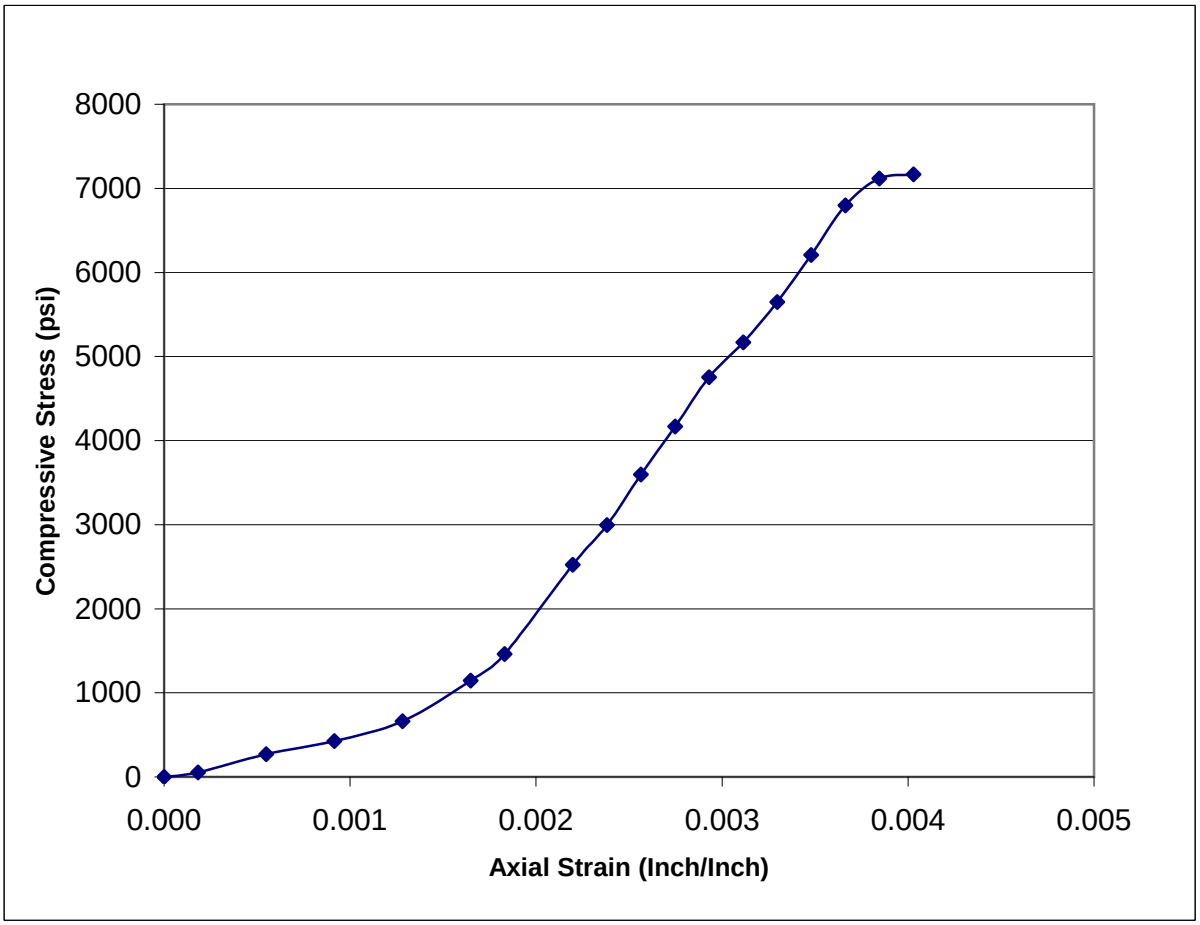




9200 SW Nimbus Avenue v Beaverton, OR 97008 v 503.644.9447 phone v 503.643.1905 fax

Unconfined Compressive Strength Test Results
ASTM D7012-04

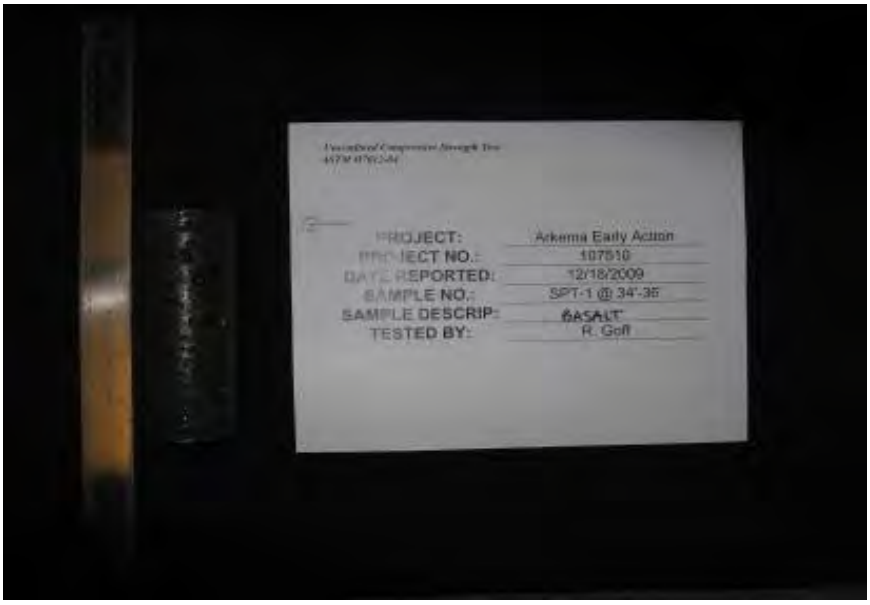
PROJECT:	**Arkema Early Action**	**LAB #:**	**2592**
PROJECT NO.:	**107510**	**SAMPLE #:**	**SPT-1 @ 34'-36'**
LOCATION:	**Portland, Oregon**	**DESCRIPTION:**	**Basalt**
SAMPLED BY:	**ARCADIS**	**DATE REPORTED:**	**12/18/2009**
DATE SAMPLED:	**N/A**	**TESTED BY:**	**R. Goff**

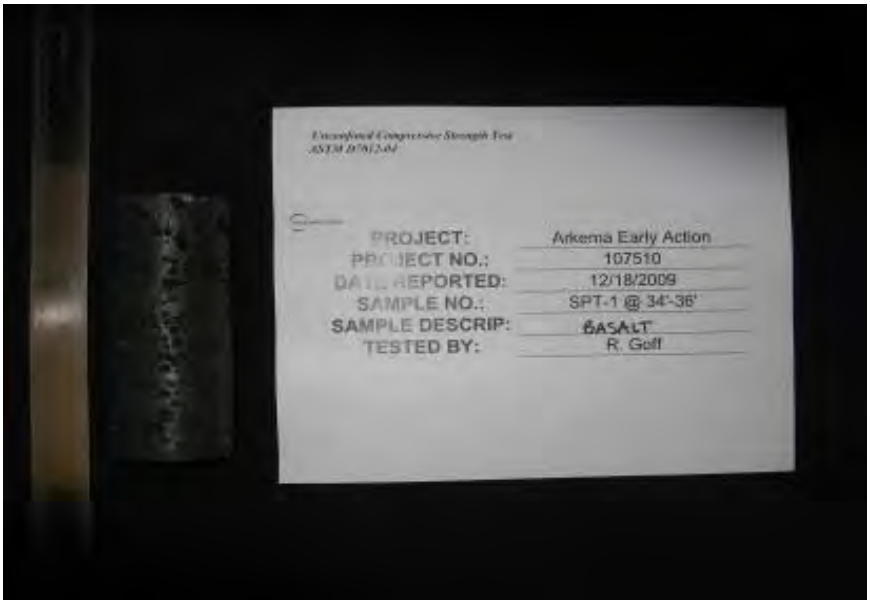


9200 SW Nimbus Avenue v Beaverton, OR 97008 v 503.644.9447 phone v 503.643.1905 fax

KLEINFELDER
Bright People. Right Solutions.

Unconfined Compressive Strength Test Photos
ASTM D 7012-04



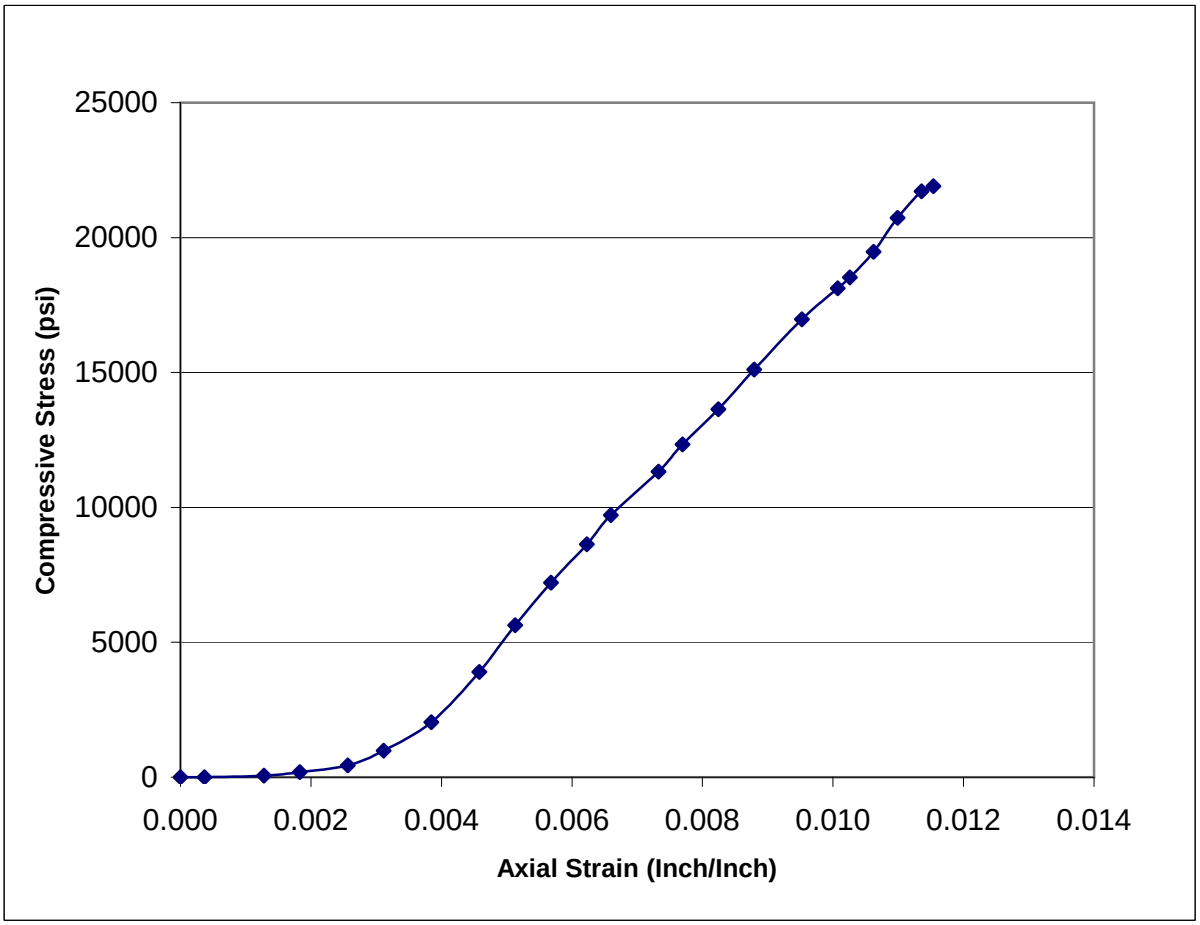


9200 SW Nimbus Avenue v Beaverton, OR 97008 v 503.644.9447 phone v 503.643.1905 fax

KLEINFELDER
Bright People. Right Solutions.

Unconfined Compressive Strength Test Results
ASTM D7012-04

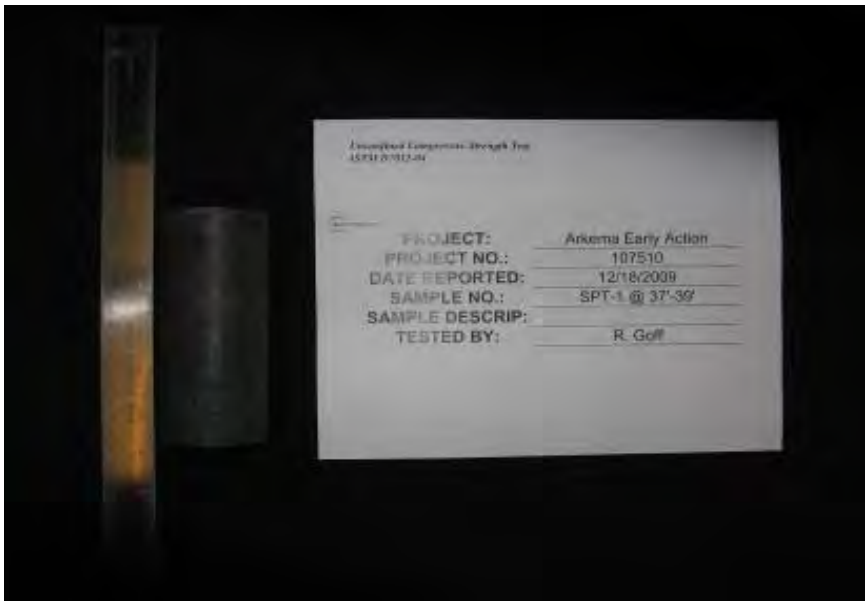
PROJECT:	**Arkema Early Action**	**LAB #:**	**2592**
PROJECT NO.:	**107510**	**SAMPLE #:**	**SPT-1 @ 37'-39'**
LOCATION:	**Portland, Oregon**	**DESCRIPTION:**	**Basalt**
SAMPLED BY:	**ARCADIS**	**DATE REPORTED:**	**12/18/2009**
DATE SAMPLED:	**N/A**	**TESTED BY:**	**R. Goff**

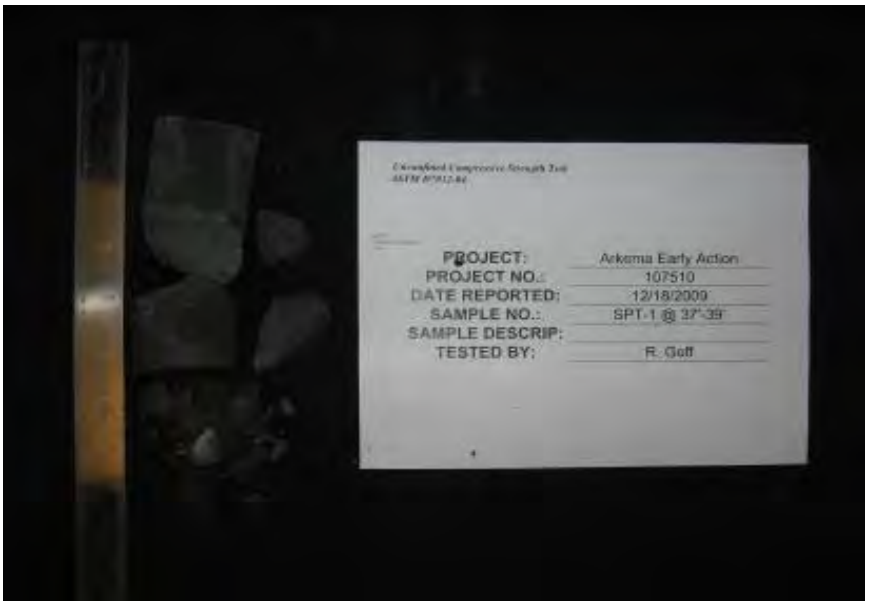


9200 SW Nimbus Avenue v Beaverton, OR 97008 v 503.644.9447 phone v 503.643.1905 fax

KLEINFELDER
Bright People. Right Solutions.

Unconfined Compressive Strength Test Photos
ASTM D 7012-04





9200 SW Nimbus Avenue v Beaverton, OR 97008 v 503.644.9447 phone v 503.643.1905 fax

Appendix G

Evaluation of PTW Threshold for HxCDF

EVALUATION OF PTW THRESHOLD FOR HxCDF

Principal threat waste (PTW) sediment concentrations were specified for five focused contaminants of concern (COCs), and two additional polychlorinated dibenzo-*p*-dioxin/furan (PCDD/F) congeners in the U.S. Environmental Protection Agency's (EPA) Record of Decision (ROD) for the Portland Harbor Superfund Site (Tables 6 and 21, USEPA 2017). Polychlorinated biphenyls, DDx, carcinogenic polycyclic aromatic hydrocarbons, and PCDD/F congeners 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD), 1,2,3,7,8-pentachlorodibenzo-*p*-dioxin (PeCDD), and 2,3,4,7,8-pentachlorodibenzofuran (PeCDF) have specified PTW thresholds and remedial action levels (RALs). Two additional PCDD/F congeners, 1,2,3,4,7,8-hexachlorodibenzofuran (HxCDF) and 2,3,7,8-tetrachlorodibenzofuran (TCDF), have specified PTW sediment concentrations only. The ROD PTW sediment concentrations were based on the EPA's feasibility study (USEPA 2016a) risk analysis for each of these chemicals; however, EPA reported two different risk levels for HxCDF at river mile (RM) 7 in two different parts of the EPA's feasibility study document.

To resolve this conflict, the discrepancy in the feasibility study was evaluated, and a proposed resolution to screening sediment to achieve the HxCDF PTW sediment threshold, in addition to all of the focused COCs, is provided below.

HxCDF Risk Contribution at RM 7W

In Appendix B of the feasibility study, where EPA presents the *Derivation of Risk-Based Preliminary Remediation Goals*, EPA reports HxCDF contributes 8% of the total PCDD/F risk for RM 6.5–7.5W (Table B2-1, USEPA 2016a). At this river mile, EPA calculated the majority (83%) of the PCDD/F risk is from PeCDF (62%) and TCDF (21%). Based on EPA's calculations, TCDD and PeCDD contribute approximately another 2% of the total PCDD/F risk.

However, in Appendix J of the feasibility study where EPA presents the *Calculation of Residual and Post Construction Risk Estimates* for all of the alternatives, HxCDF risk is estimated to be 2E-02 for the no action Alternative A (Table J2.3-8a, USEPA 2016a), which essentially means 100% of the risk at RM 7W would be from HxCDF (Alternative A, Table J2.3-8b, USEPA 2016a). According to Appendix J of the feasibility study, under a no action alternative, the total risk for the remaining four PCDD/F congeners at RM 7W would be less than 4% of the total risk from PCDD/Fs in this river mile, which is inconsistent with EPA's other analyses in Appendix B of the feasibility study and in the baseline human health risk assessment (BHRRA; USEPA 2016b).

The conflicting risk estimates for PCDD/Fs at RM 7W as presented in EPA's feasibility study Appendices B and J cannot both be correct. After review of both appendices, we believe the Appendix B calculations are better aligned with the findings of the distribution and toxicity of HxCDF and the results of the BHHRA. Presented below is a summary of the risk contributed by HxCDF utilizing EPA's Appendix B calculations, and a proposed solution to identifying an HxCDF PTW threshold that will be consistent with EPA's risk analysis and that can be used for evaluating PTW for the remedial design.

Defining HxCDF PTW Footprint at RM 7W

Based on EPA's feasibility study Appendix B, PeCDF and TCDF congeners contribute approximately 83% of the total risk (Table G-1). At RM 7W, the highest concentrations of PeCDF and TCDF are also co-located and highly correlated with some of the highest concentrations of HxCDF[1] (Figures G-1 and G-2). Thus, targeting PeCDF and TCDF locations exceeding PTW sediment concentrations will also capture HxCDF PTW. This approach **will have no impact on Arkema Project Area PTW identification as it relates to EPA's risk management framework** because HxCDF concentrations are significantly correlated with PeCDF and TCDF.

Table G-1. Summary of PTW Thresholds and Contribution to PCDD/F Risk at RM 7W

PCDD/F Congener	PTW Concentration (10^{-3} risk; µg/kg)[a]	Based on Tissue PRG (µg/kg)[b]	% Contribution to Total PCDD/F Risk at RM 6.5–7.5W[c]
2,3,7,8-TCDD	0.01	0.008	1%
2,3,7,8-TCDF	0.6	0.08	21%
1,2,3,7,8-PeCDD	0.01	0.008	1%
2,3,4,7,8-PeCDF	0.2	0.03	62%
1,2,3,4,7,8-HxCDF	0.04	0.08	8%
Total risk contribution from the 5 COC congeners			93%
Total risk contribution from the 2 COC congeners (excluding TCDD, PeCDD, and HxCDF)			83%

Notes:

PRG = preliminary remediation goal

[a] From Table 6 of the ROD (USEPA 2017); estimated using the food web model and the 10^{-3} fish tissue PRGs (see note b).

[b] For PCDD/Fs, EPA approximated the 10^{-3} cancer risk by multiplying the 10^{-6} cancer risk-based goals by 1,000 for each chemical under the human health fish consumption pathway (i.e., RAO2 tissue PRGs; Table 17 of the ROD, USEPA 2017).

[c] From Table B2-1 of the feasibility study; based on smallmouth bass tissue (USEPA 2016a).

[1]PeCDF concentrations are positively and significantly correlated with HxCDF (0.97 and 0.99, surface and subsurface sediment, respectively); TCDF concentrations are positively and significantly correlated with HxCDF (0.93 and 0.98, surface and subsurface sediment, respectively); based on the Spearman Rank Sum Test.

Targeting the locations at RM 7W exceeding the PTW sediment concentration for PeCDF would capture all PCDD/F PTW within the Arkema Project Area because:

- PeCDF is the highest contributor to PCDD/F risk in this river mile (Table G-1)
- PeCDF is significantly correlated with elevated concentrations of TCDF (the next highest contributor to PCDD/F risk)
- PeCDF is significantly correlated with elevated concentrations of HxCDF (Figures G-1 and G-2).

The area of PTW defined by the focused COCs and additional contaminant TCDF will be used to appropriately define sediment management options in accordance with the ROD decision tree.

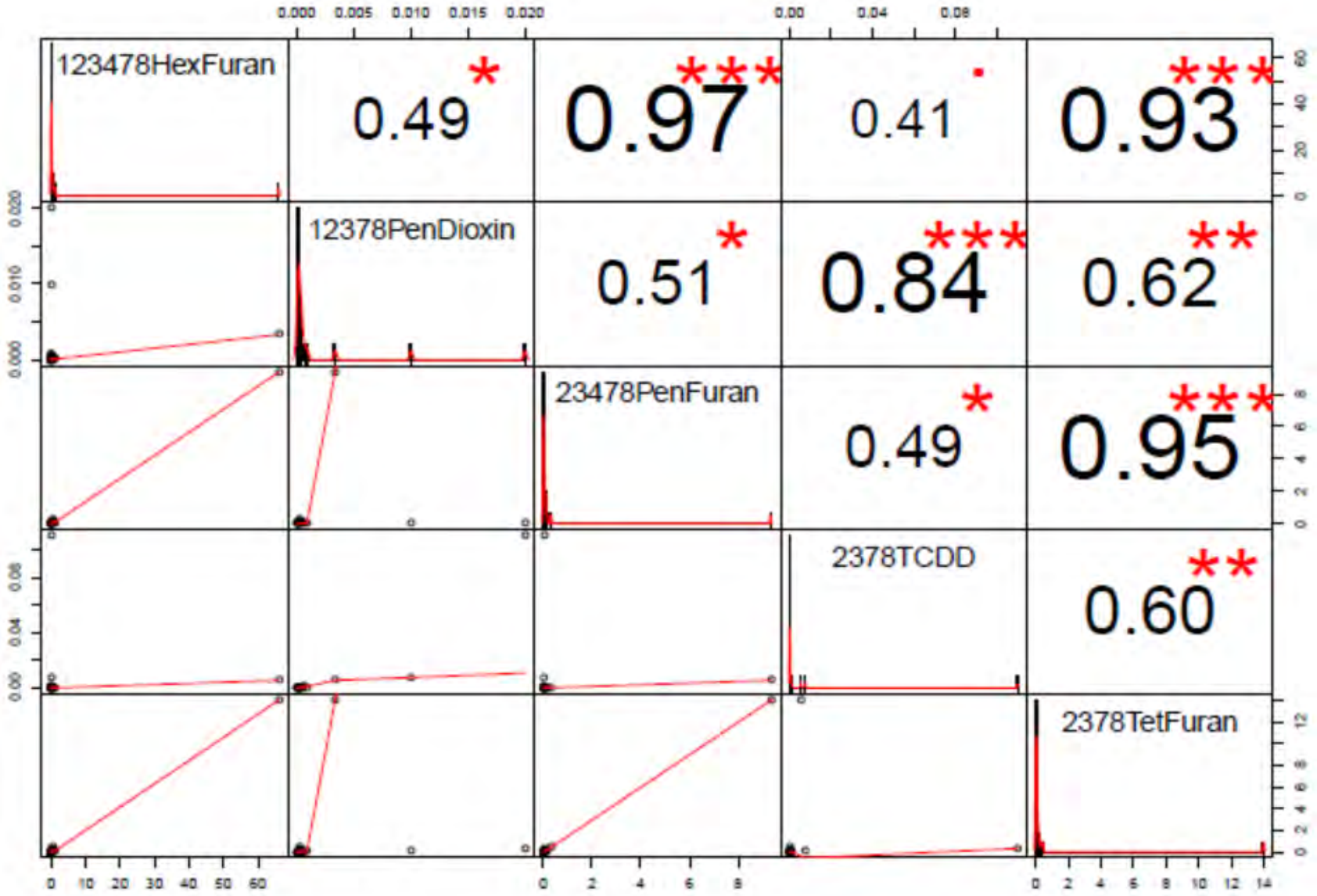
References

USEPA. 2016a. Portland Harbor RI/FS Feasibility Study Report. Final. U.S. Environmental Protection Agency, Seattle, Washington. June.

USEPA. 2016b. Portland Harbor RI/FS, Final Remedial Investigation; Appendix F: Baseline Human Health Risk Assessment.

USEPA. 2017. Record of decision, Portland Harbor Superfund Site, Portland, Oregon. U.S. Environmental Protection Agency, Region 10, Seattle, WA. January.

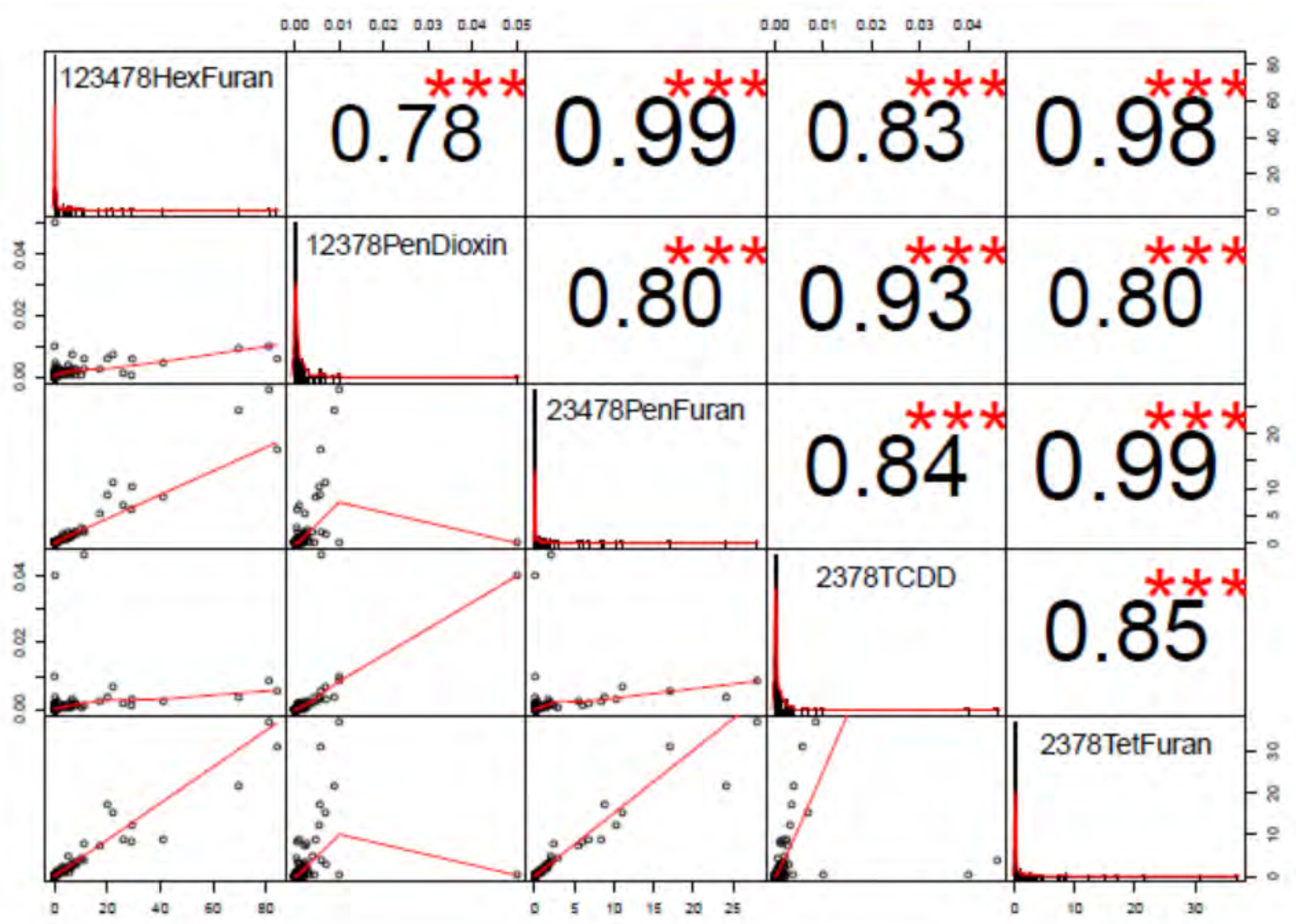
Figures



integral consulting inc.

DRAFT

Figure G-1.
Correlation Matrix for PCDD/F COCs in Surface Sediment
Arkema Project Area Pre-design Investigation Work Plan



integral consulting inc.

DRAFT

Figure G-2.
Correlation Matrix for PCDD/F COCs in Subsurface Sediment
Arkema Project Area Pre-design Investigation Work Plan