September 5, 2014

Kathryn Hernandez, RPM
U. S. EPA, Region 8 8EPR-RA
1595 Wynkoop Street
Denver, CO 80202

RE: Response to Third Round of U.S. EPA Comments on the Sampling and Analysis Plan for Richardson Flat Tailings Site Operable Units 2 and 3, Docket No. CERCLA-08-2014-0003, Park City, Utah

Dear Ms. Hernandez:

This letter provides United Park City Mines Company's (UPCM) responses to the third round of comments provided by the United States Environmental Protection Agency (U.S. EPA) in an email from you dated August 25, 2014 regarding the Sampling and Analysis Plan (SAP, comprised of the Field Sampling Plan [FSP] and Quality Assurance Project Plan [QAPP]) for the Richardson Flat Tailings Site Operable Units 2 and 3 (OU2 and OU3). The SAP was originally submitted to the U.S. EPA on May 5, 2014, and was re-submitted on July 20, 2014, and again on August 28, 2014. Agency clarification was needed for one comment (35) in the July 20, 2014 letter.

The U.S. EPA's comments are provided below in italics, followed by UPCM's responses. A revised SAP is attached to this letter.

This is a response to the Comment Number 35 with clarification as requested:

Comment 35: This comment requests adding an additional water sampling location at the upstream boundary of the P.C. West Reach of OU3. However, there is already a proposed OU2 surface water sampling ***in close proximity to the upstream*** *boundary of the P.C. West Reach (the OU2 sampling location is immediately downstream of North Promontory Ranch Road and shown on FSP Figure 3-1, Sheet 3). No inflows, significant changes in channel characteristics, or other confounding conditions occur between the OU2 sampling location and the P.C. West Reach boundary. Thus, an additional sampling location at the P.C. West Reach boundary would be redundant with the nearby OU2 location. Please ask the comment author if they agree with this rationale.*

Agency Clarification for additional sample:

The OU3 P.C. West Reach is located between the North Promontory Ranch Road and Silver Gate Drive, just north of the wastewater treatment plant. It has been proposed that water samples

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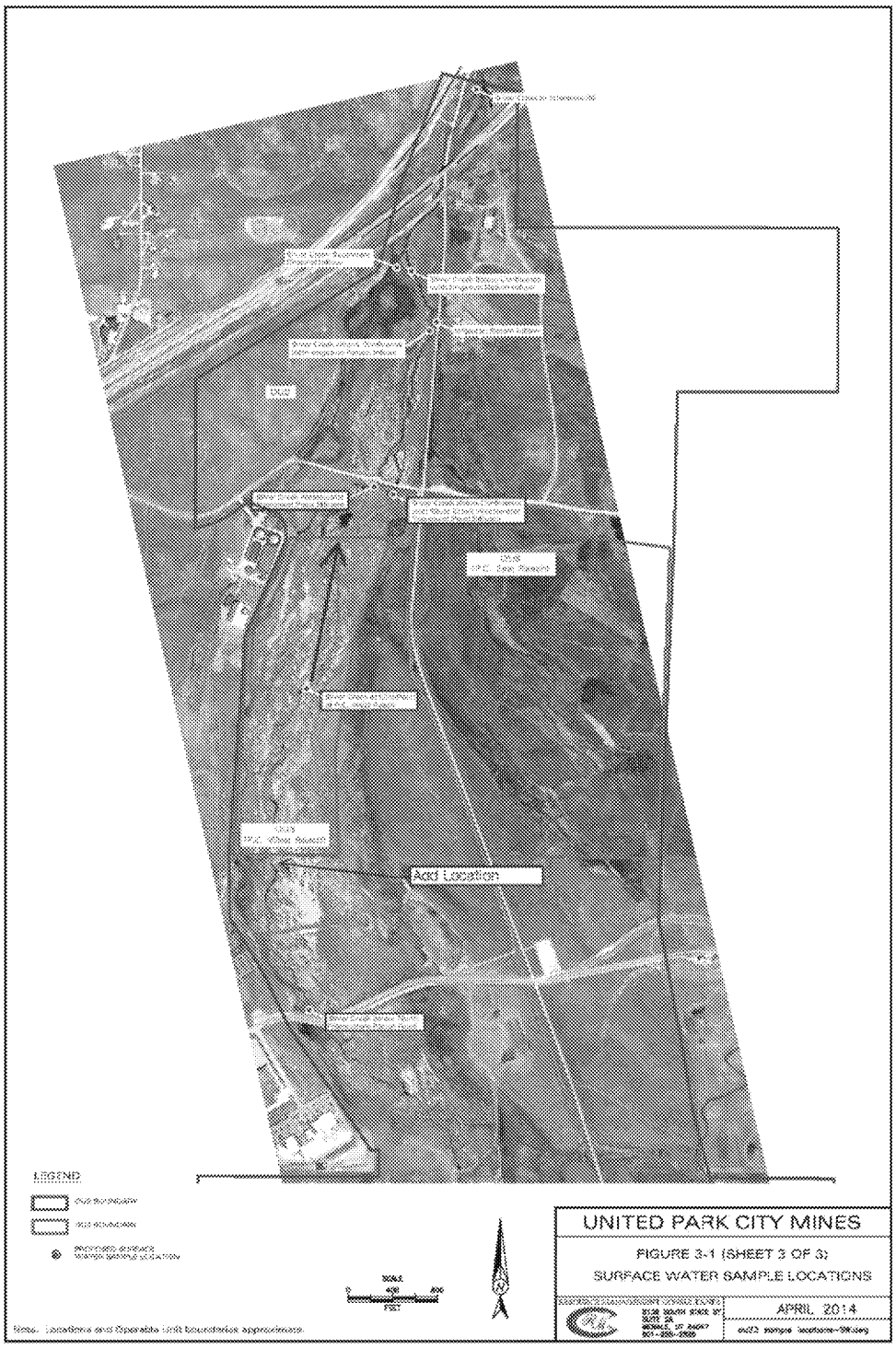
be collected at North Promontory Ranch Road and above the confluence with the wastewater treatment plant effluent near Silver Gate Drive. These samples are within OU2. One sample is proposed in P.C. West Reach at the midpoint of the segment.

Because these three samples are in two separate OU2s, and only one sample will be collected in the middle of the P.C. West Reach, the interpretation of the sample results with respect to OU2 and P.C West Reach will be complicated and it will not be possible to perform an accurate mass loading analysis to differentiate the instream load within the P.C. West Reach and that within the adjacent portions of OU2 both south and north of the P.C. West Reach.

The sample at North Promontory Ranch Road is ~1,100 feet from the southern boundary of the P.C. West Reach and not in close proximity. According to the USGS study, zinc loading increases 25% in the travel from the sample location at North Promontory Ranch Road to the OU3 – P.C. West Reach southern boundary. Cadmium loading increases 13%, illustrating that the loadings for each constituent are not proportional to stream length in this area (the stream length from North Promontory Ranch Road to the P.C. West Reach southern boundary is 20% of the length from North Promontory Ranch Road to the wastewater treatment plant effluent confluence). With only a single sample collected in the P.C. West Reach, proportionality interpretations are the extent of the analysis that can be accomplished to assess loadings with OU2 and P.C. West Reach, . The rationale for the midpoint selection has not been defined in the SAP with respect to how the data will be interpreted, however, not selecting samples at the input and output of the P.C West Reach prevents loading analysis for this reach and the ability to place this reach into perspective with adjacent OU2 segments. The interpretation of the data in the USGS report (Kimball et al., 2007: segments SQ3-005 to SQ3-039, SQ3-039 to SQ3-127, and SQ127-SQ3-140) suggests that zinc loading within OU3 – P.C. West Reach would be underestimated while cadmium loading would be overestimated. Obviously, any loading attributed or not-attributed to P.C. West Reach would end up as an OU2 loading. Without bracketing the P.C West Reach with a new sample (and moving the midpoint sample), a loading analysis to partition the stream load between OU2 and the P.C West Reach cannot be achieved. In addition, since the USGS data was collected (2004), approximately 10 years have passed and loading conditions may be different (pH and zinc showed significant changes in the first 1,100 feet downstream of North Promontory Ranch Road; see attached annotated figures from the Kimball et al., 2007 report).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UNITED PARK CITY MINES
FIGURE 3-1 (SHEET 3 OF 3)
SURFACE WATER SAMPLE LOCATIONS
APRIL 2014

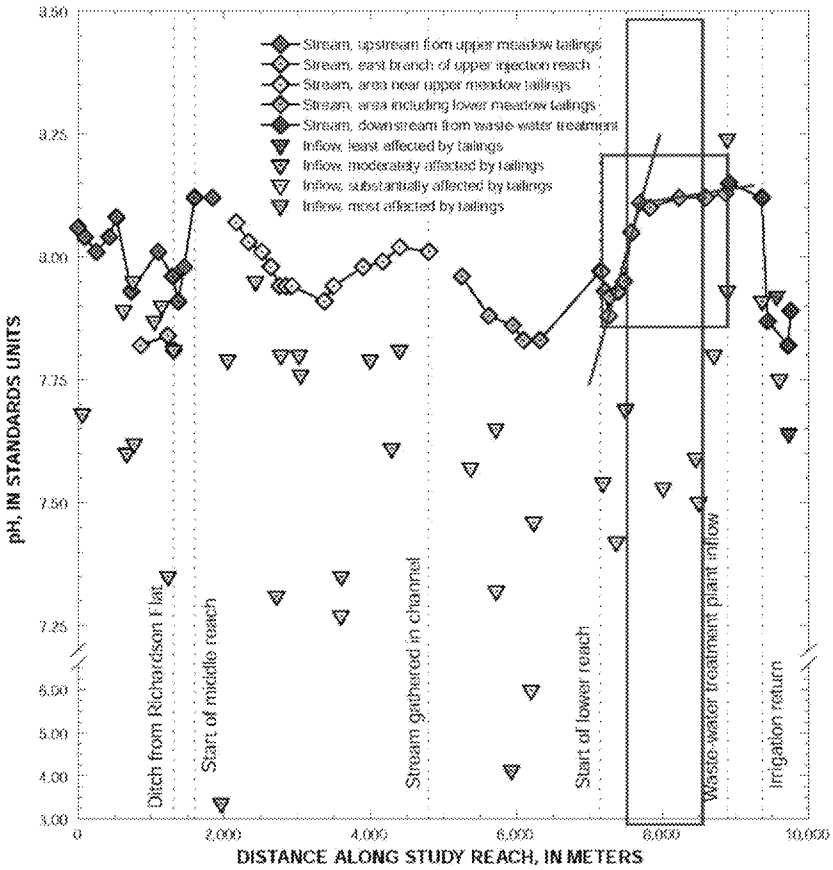

Figure 6. Variation of pH with distance along the study reach for stream-water and inflow samples collected along Silver Creek, Utah, April 2004.

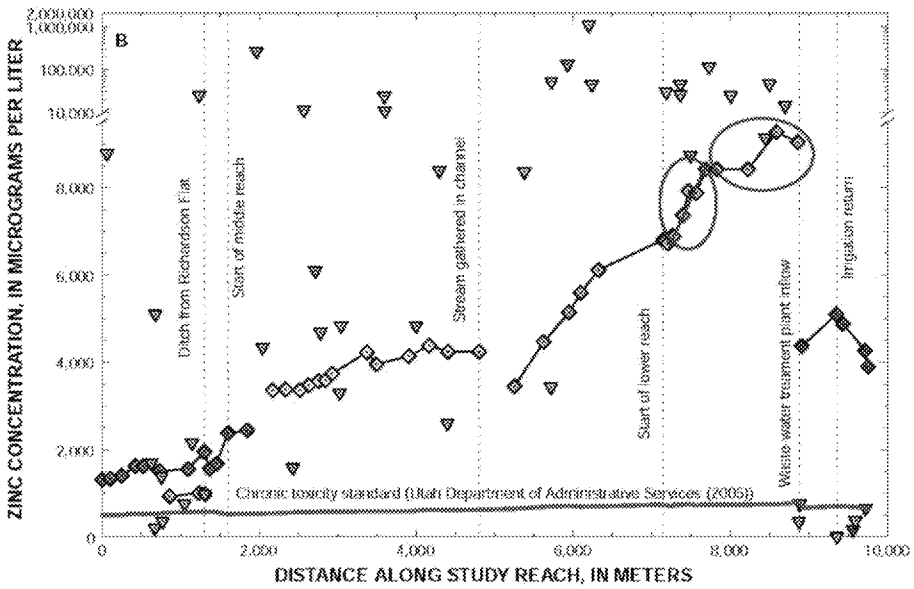

Figure 7. Variation of (A) sulfate and (B) zinc concentrations with distance along the study reach for stream-water and inflow samples collected along Silver Creek Utah, April 2004.

Response to Comment 35: This comment requests adding an additional water sampling location at the upstream boundary of the P. C. West Reach of OU3. The rationale presented for adding the additional sample and relocating one sample point is understood and rational. Therefore one sample has been added at the upstream end of the P. C. West Reach of OU3 and one sample has been relocated to be in close proximity to the downstream end of the P. C. West Reach. In addition, the document has been modified where needed to reflect these changes.

Please contact me with any questions regarding this response.

Sincerely,

Kerry C. Gee
Vice President

Cc: Andrea Madigan, U. S. EPA
Amelia Piggott, U. S. EPA
Mo Slam, UDEQ
Sandra K. Allen, Asst. Attorney General for Utah
Heather Shilton, Asst. Attorney General for Utah
Brad T. Johnson, State of Utah Natural Resource Trustee
Kent Sorenson, Utah State Trustee Technical Advisor
Casey S. Padgett, Department of Interior
Dana Jacobsen, Department of Interior
Trent Duncan, BLM Utah Field Office
John Isanhart, U.S. Fish and Wildlife Service
Chris Cline, U. S. Fish and Wildlife Service
Kevin Murray, Holland and Hart

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U.S. Environmental Protection Agency
Approval of the
SAMPLING AND ANALYSIS PLAN (SAP)
Comprised of the
Field Sampling Plan (FSP) September 2014
Quality Assurance Project Plan (QAPP) September 2014 and
Health and Safety Plan (HASP) September 2014

Richardson Flat Tailings Site
Operable Units 2 and 3

Park City, Utah

In accordance with the Administrative Settlement Agreement and Order on Consent (AOC) for EE/CA Investigation and Removal Action at the Richardson Flats Tailing Site, Operable Units 2 and 3, Park City, Utah, the referenced documents are approved.

Approved:_____ Date:
Kathryn Hernandez
USEPA Remedial Project Manager

Concurred:_____ Date:
Trent Duncan
USDOI BLM Project Manager

Concurred:_____ Date:
Mo Slam
UDEQ State Trustee Technical Advisor

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SAMPLING AND ANALYSIS PLAN
Comprised of the
Field Sampling Plan
Quality Assurance Project Plan
and Health and Safety Plan

Richardson Flat Tailings Site
Operable Units 2 and 3

Park City, Utah

Site ID Number: UT980952840

September 5, 2014

Prepared for:

United Park City Mines Company
P.O. Box 1450
Park City, UT 84060

Prepared by:

Resource Environmental Management Consultants, Inc. d.b.a. RMC
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EXECUTIVE SUMMARY

This Sampling and Analysis Plan (SAP) has been developed by United Park City Mines Company for Operable Units 2 and 3 (OU2 and OU3) of the Richardson Flat Tailings Site in accordance with the requirements of the Administrative Settlement Agreement and Order on Consent for EE/CA Investigation and Removal Action for the Richardson Flat Tailings Site, Operable Units 2 and 3, in Park City, Utah, effective as of March 6, 2014 [Settlement Agreement, (EPA et al., 2014)]. The SAP is based on the approved OU2 and OU3 Engineering Evaluation / Cost Analysis Work Plan (EE/CA Work Plan) that is included as Appendix C of the Settlement Agreement.

United Park City Mines Company (United Park) is performing this work under the Settlement Agreement (EPA et al., 2014). The United States Environmental Protection Agency (EPA) is the lead oversight agency. The EPA is joined in oversight by Trustees for Natural Resource Damages and Restoration (NRDR); the United States Bureau of Land Management, the United States Fish and Wildlife Service, the Utah Department of Environmental Quality, the Utah Division of Parks and Recreation, and the State of Utah Natural Resource Trustee. OU2 and OU3 are defined in the Settlement Agreement.

The SAP presents the guidance necessary to complete the OU2 and OU3 EE/CA and includes two major documents: the Field Sampling Plan (FSP) and the Quality Assurance Project Plan (QAPP). These plans are described further below.

- The Field Sampling Plan describes the field sampling and measurement methodologies and summarizes the analytical approach. The plan is intended to provide guidance for all fieldwork.

- The Quality Assurance Project Plan contains the project organization, defines staff responsibilities, and describes procedures for quality assurance (QA) and quality control (QC). Additionally the QAPP contains detailed information on analytical methods, data management, data quality assessments, and data reporting.

Together, these plans represent a comprehensive guide for performing the work required by the Settlement Agreement and will provide United Park, EPA, and all Trustees details of the work to be conducted.

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FIELD SAMPLING PLAN

Richardson Flat Tailings Site
Operable Units 2 and 3

Park City, Utah

Site ID Number: UT980952840

Revision 0

September 5, 2014

Prepared for:

United Park City Mines Company
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LIST OF ACRONYMS AND ABBREVIATIONS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	Contaminant of Potential Concern
CSM	conceptual site model
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
FS	Feasibility Study
FSP	Field Sampling Plan
GPS	Global Positioning System
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
HQ	hazard quotient
IDW	Investigation Derived Waste
O&M	Operations and Maintenance
OU1	Richardson Flat Tailings Site Operational Unit 1
OU2	Richardson Flat Tailings Site Operational Unit 2
OU3	Richardson Flat Tailings Site Operational Unit 3
OU4	Richardson Flat Tailings Site Operational Unit 4
PPE	personal protective equipment
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
RI	Focused Remedial Investigation
RMC	Resource Management Consultants, Inc.
RPD	Relative Percent Difference
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
TAL	Target Analyte List
UDPR	State of Utah Division of Parks and Recreation
United Park	United Park City Mines Company
USFWS	U.S. Fish & Wildlife Service
USGS	United States Geological Survey
XRF	field portable X-Ray fluorescence meter

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1.0 INTRODUCTION

This Field Sampling Plan (FSP) is one of two plans that make up the Sampling and Analysis Plan (SAP) for Operable Units 2 and 3 (OU2 and OU3) of the Site[1]. The companion plan to the FSP is the Quality Assurance Project Plan (QAPP), which is also included in the SAP. The SAP is based on the approved OU2 and OU3 Engineering Evaluation / Cost Analysis Work Plan (EE/CA Work Plan), which details OU2 and OU3 strategy and defines the overall approach for work anticipated to be performed in OU2 and OU3. The OU2 and OU3 EE/CA Work Plan is included as Appendix C of the Administrative Settlement Agreement and Order on Consent for EE/CA Investigation and Removal Action for the Richardson Flat Tailings Site, Operable Units 2 and 3, in Park City, Utah, effective as of March 6, 2014 [Settlement Agreement, (EPA et al., 2014)].

This FSP describes of the procedures and methodologies for data collection at OU2 and OU3, and is intended to guide field personnel in the performance of the specific tasks that are required to accomplish the site characterization that is a part of the OU2 and OU3 Engineering Evaluation/ Cost Analysis (OU2 and OU3 EE/CA). In general, the field activities include collection and analysis of the following sample types: surface water; shallow groundwater; soil; sediment; tailings; and organism tissue (benthic macroinvertebrates, fish, and vegetation).

United Park City Mines Company (United Park) is performing this work under the Settlement Agreement, (EPA et al., 2014) with the United States Environmental Protection Agency (EPA) as the lead oversight agency. The EPA is joined in oversight by Trustees for Natural Resource Damages and Restoration (NRDR); the United States Bureau of Land Management, the United States Fish and Wildlife Service, the Utah Department of Environmental Quality, the Utah Division of Parks and Recreation, and the State of Utah Natural Resource Trustee.

1.1 Site Background

Operable Unit descriptions, site history, environmental setting, and previous site investigations are summarized below. Regional geology, hydrogeology and surface water are described in the Remedial Investigation/Focused Feasibility Study Report for Richardson Flat (RMC, 2004). Operable Unit boundaries are presented in Figure 1-1.

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1 Capitalized terms used, but not defined, herein are defined in the Administrative Settlement Agreement and Order on Consent for EE/CA Investigation and Removal Action for the Richardson Flat Tailings Site, Operable Units 2 and 3, in Park City, Utah, effective as of March 6, 2014 [Settlement Agreement, (EPA et al., 2014)].

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1.1.1 Operable Unit Descriptions

Operable Unit boundaries are defined in the Settlement Agreement and generally described below.

OU1

OU1 consists of approximately 258 acres of land, including a tailings impoundment covering approximately 160 acres of land, located immediately southeast of the junction of U.S. Highway 40 and Utah Highway 248 in Summit County, Utah. The OU1 boundary is further defined in the Record of Decision for OU1 (EPA, 2005).

OU2

OU2 extends approximately 4.5 miles along Silver Creek from U. S. Highway 40 on the southern end to Interstate 80 on its northern end, ranging in width from approximately 2,100 feet at the southern boundary to approximately 3,800 feet near Pivotal Promontory Road. Areas within OU2 that are now categorized as OU3 are excluded from evaluation as OU2.

OU3

OU3 is comprised of five separate areas as presented on Figure 1-1:

- Middle Reach – The first area is commonly known as the Middle Reach of Silver Creek. This area encompasses the Silver Maple Claims from its upstream end at Prospector Park downstream to U.S. Highway 40;
- Floodplain Tailings Reach (FPT Reach) – The second area extends from U.S. Highway 40 northward to State Route 248. A portion of this area is referred to as the "Floodplain Tailings" in the OU1 RI/FS (RMC, 2004); This area was initially included as part of OU2;
- State Route 248 North Reach – The third area extends from State Route 248 northward approximately 9,000 feet through the southerly one-third of the Lower Silver Creek floodplain. This area was initially included as part of OU2;
- P. C. West – The fourth area is located in the northern part of OU3 and is adjacent to the Snyderville Basin Water Reclamation Facility (sewage treatment facility) to the west. This area was initially included as part of OU2; and
- P. C. East – The fifth area is located in the northern part of OU3 to the north of Promontory Road and is adjacent to a residential development, Pivotal Promontory, LLC,

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which has constructed a private club and second-home community on the eastern OU3 boundary. This area was initially included as part of OU2.

1.1.2 Site History

Mining in the Park City area began around 1869 and continued sporadically through 1982. Copper, gold, lead, silver, and zinc were the metals of primary economic interest, but other metals were associated with the ore. Historically, there have been as many as ten mills operating along the banks of Silver Creek. The majority of these milling companies, including the Grasselli, Broadwater and E.J. Beggs mills were located near the Prospector Square area of Park City on the Silver Maple Claims. Within the lower part of the watershed, the primary operating mill was the Big Four Mill, located near the Pace Ranch building that is adjacent to Promontory Road, between the Summit County Sheriff's facility and the Pivotal Promontory, LLC development. The mill straddled the Promontory Roadway in the area of the Pace Ranch building.

1.1.3 Environmental Setting

The Site ranges from approximately 6,475 to 6,800 feet above mean sea level. The Site is located in the Wasatch Mountains, approximately 20 miles northwest of Salt Lake City, Utah.

Silver Creek and the adjacent floodplain receive water from sources that include, but may not be limited to precipitation (primarily snowmelt), groundwater, springs, and urban runoff located within its basin. The 1986 Utah Department of Natural Resources (DNR) report "Water Resources of the Park City Area, Utah with Emphasis on Groundwater," prepared in cooperation with the United States Geological Survey (USGS), indicates that Silver Creek obtains its base flow from springs in consolidated rock. The DNR report also indicates that the primary groundwater contributor to Silver Creek base flow is Dority Spring, located north of Prospector Square (DNR, 1986). Silver Creek is the primary drainage within the watershed.

The Site is characterized by a cool, dry, semi-arid climate. Long-term meteorological observations have not been kept at the Site. The two nearest meteorological data stations are located in Park City, Utah (which is 500 feet higher in elevation and two miles to the southwest in the Wasatch Mountains), and Kamas, Utah (located at a similar elevation to the Site and nine miles to the east). Annual precipitation for the Site likely falls between the values recorded at the two meteorological stations. Annual precipitation at Park City is 21.44 inches of water with an average annual low temperature of 30.8 degrees and an average annual high temperature of 56.3 degrees. Annual precipitation at Kamas is 17.27 inches of water per year with an average annual low temperature of 29.0 degrees and an average annual high temperature of 58.7 degrees (www.wrc.dri.edu, 2001).

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Long-term wind data have not been kept in the vicinity of the Site. The prevailing wind direction is from the northwest to southeast as determined by the EPA contractor Ecology and Environment (E &E) during an air monitoring assessment conducted at OU1 in 1986 (E&E, 1987).

The Site is located within a complex fold and thrust belt later intruded and overlain by volcanic rocks. The area located within the Silver Creek floodplain is composed of colluvium and alluvium derived from sedimentary and volcanic formations located within the Silver Creek watershed. Wetland and upland areas within the Site are generally underlain by the Keetley Formation volcanic rocks which may be more than 1,000 feet thick (Weston, 1999, in RMC, 2004).

The Site is composed of wetland and upland habitats and plant communities. Currently there are no residential properties within the Site boundary. The area is used by recreational visitors and workers also may intermittently enter the Site.

1.1.4 Previous Investigations

Existing site characterization data has been previously collected by:

- Tetra Tech (for EPA);
- United Park City Mines Company;
- USGS;
- BLM;
- Upper Silver Creek Watershed Stakeholders Group; and
- State of Utah.

A list of previous investigations is presented in Table 1-1. Previous investigations are summarized in the Summary of Previous Investigations Report (RMC, 2014). Previous data collection activities in OU2 and the specific reaches of OU3 are discussed below. Data from previous investigations will generally be used qualitatively (i.e., to inform selection of sampling locations presented in this FSP, to inform development of removal action alternatives, etc.). Data that may be used quantitatively (i.e., defining the nature and extent of contamination, conducting risk assessments) may be limited to data collected by Tetra Tech and the USGS.

The majority of OU2 has undergone extensive characterization by Tetra Tech (for EPA Region 8). Data collection included sampling of surface and subsurface soils, surface water, and shallow groundwater. Wetland delineation was also conducted by Tetra Tech. One parcel in the

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southwestern portion of OU2 (parcel SS-65-A-8-(-A)) not investigated by Tetra Tech will be investigated as part of the OU2 and OU3 EE/CA site characterization. Additionally, metals loading to surface water throughout OU2 was investigated by the USGS in 2004 (USGS, 2007).

The Silver Maple Claims area comprises the furthest upstream portion of the Middle Reach of OU3. Metals loading to surface water in the Silver Maple Claims area has been investigated by the USGS (USGS, 2004). Surface and subsurface soils, sediments, tailings and biota have undergone previous characterization by BLM (BLM, 2005). Wetland delineation was also conducted by BLM (BLM, 2003). Data collected by BLM may be used qualitatively in the EE/CA site characterization.

From the downstream end of Silver Maple Claims to U.S. Highway 40, no characterization of groundwater, surface or subsurface soils, sediments, or the volume and areal extent of tailings has been conducted in the Middle Reach of OU3. Surface water data has been collected by United Park. Middle Reach surface water data collected by United Park may be used qualitatively in the EE/CA site characterization.

In the Floodplain Tailings Reach of OU3, metals loading to surface water has been investigated by the USGS (USGS, 2007). Surface water and shallow groundwater data was collected by United Park during the OU1 RI (RMC, 2004). Shallow groundwater data was collected from the Silver Creek alluvial aquifer and from within saturated tailings. Surface water and shallow groundwater data collected by United Park during the OU1 RI may be used qualitatively as part of the OU2 and OU3 EE/CA site characterization. The monitoring wells and piezometers installed for the OU1 RI will be utilized to collect new shallow groundwater data. No characterization of surface or subsurface soils, sediments, or the volume and areal extent of tailings has been conducted in the Floodplain Tailings Reach of OU3.

The majority of the State Route 248 North Reach of OU3 has undergone extensive characterization by Tetra Tech (for EPA Region 8). Data collection included sampling of surface and subsurface soils, surface water, and shallow groundwater, and wetland delineation. Additionally, metals loading to surface water has been investigated by the USGS (USGS, 2007) and the State of Utah (UDERR, 2002). Three parcels in the southeastern portion of this reach (parcels SS-65-A-5, SS-65-A-6 and SS-65-1) were not investigated by Tetra Tech. Surface and subsurface soils data collection was conducted by the property owner in 2009 and the results may be utilized for the EE/CA site characterization. This is further discussed in Section 3.2.

The P.C. West Reach of OU3 has undergone characterization by Tetra Tech (for EPA Region 8). Data collection included surface and subsurface soils, surface water and shallow groundwater along a single transect. Tetra Tech also performed a wetland delineation throughout the P. C.

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West Reach. Additionally, metals loading to surface water has been investigated by the USGS (USGS, 2007) and the State of Utah (UDERR, 2002).

The P.C. East Reach has undergone extensive characterization by Tetra Tech (for EPA Region 8). Data collection included sampling of surface and subsurface soils and shallow groundwater, and wetland delineation.

1.2 Report Organization

The FSP is organized into five sections, including this introduction. Section 2.0 of this report provides the sampling scope and objectives. Section 3.0 provides the details of the sampling procedures and methodologies that apply to data collection activities conducted pursuant to the Settlement Agreement. Section 4.0 summarizes sample handling and sample analysis, which is detailed in the QAPP. Section 5.0 presents references.

2.0 SAMPLING GOALS, OBJECTIVES, AND SCOPE

The goal of sampling efforts to be conducted under this FSP is to define the nature and extent of contamination and to collect data needed to evaluate potential risks posed to human and ecological receptors by metals in surface water, shallow groundwater, soils, sediments, tailings and biota in the vicinity of OU2 and OU3. Results from these sampling efforts, coupled with results from previous studies, will be used to conduct the EE/CA for OU2 and OU3.

The objectives of sampling activities described in this FSP are:

- Determine the nature and extent of contamination;
- Collect data of sufficient quantity and quality to complete the EE/CA. Data will be collected to fill in data gaps in previous studies. Data collected will build upon and supplement the existing dataset;
- Collect data to perform ecological and human health risk assessments;
- Collect data to determine potential removal action alternatives;

This FSP describes the collection and analysis of the following sample types:

- Surface water;
- Shallow Groundwater;
- Soil;
- Sediment;
- Tailings; and
- Organism tissue (fish, benthic macroinvertebrates, vegetation).

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Site characterization activities, where applicable, will be conducted based on appropriate elements of the "Triad" approach described by EPA in the following documents:

- Improving Sampling, Analysis, and Data Management for Site Investigation and Cleanup (EPA, 2001);
- Best Management Practices for Site Assessment, Remediation, and Greener Cleanups (EPA, 2012a); and
- Triad Training for Practitioners (EPA, 2012b)

The triad approach allows for a dynamic and flexible decision making process. The Triad approach allows for the streamlined use of a three-pronged approach incorporating the following elements:

- Systematic Planning;
- Dynamic Work Plan; and
- Use of on-site analytic tools (e.g., field portable XRF for soil screening).

2.1 Draft Human Health Conceptual Site Model

A draft human health conceptual site model (CSM) is presented below in Figure 2-1. The draft human health CSM may be revised during development of the EE/CA. A final human health CSM will be included with the final EE/CA.

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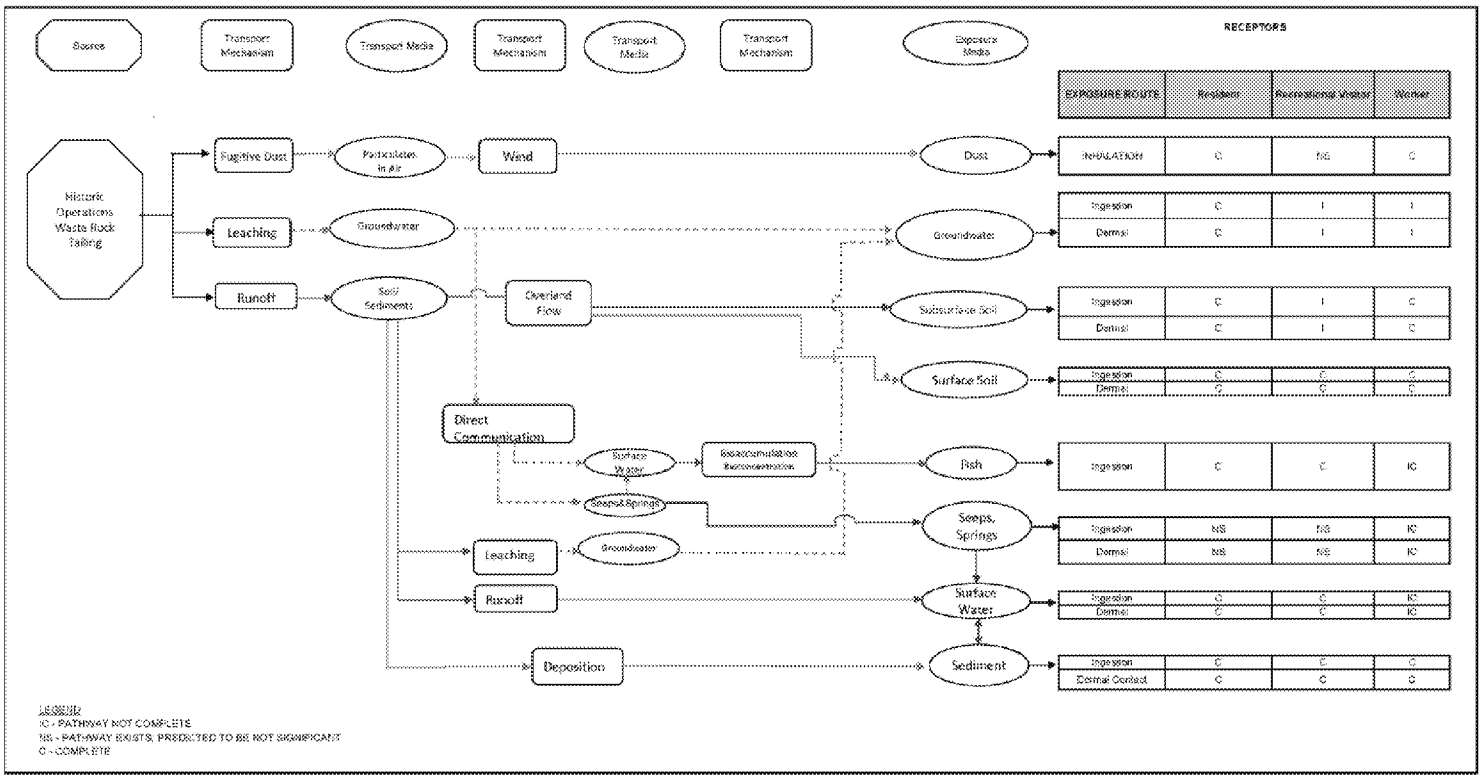
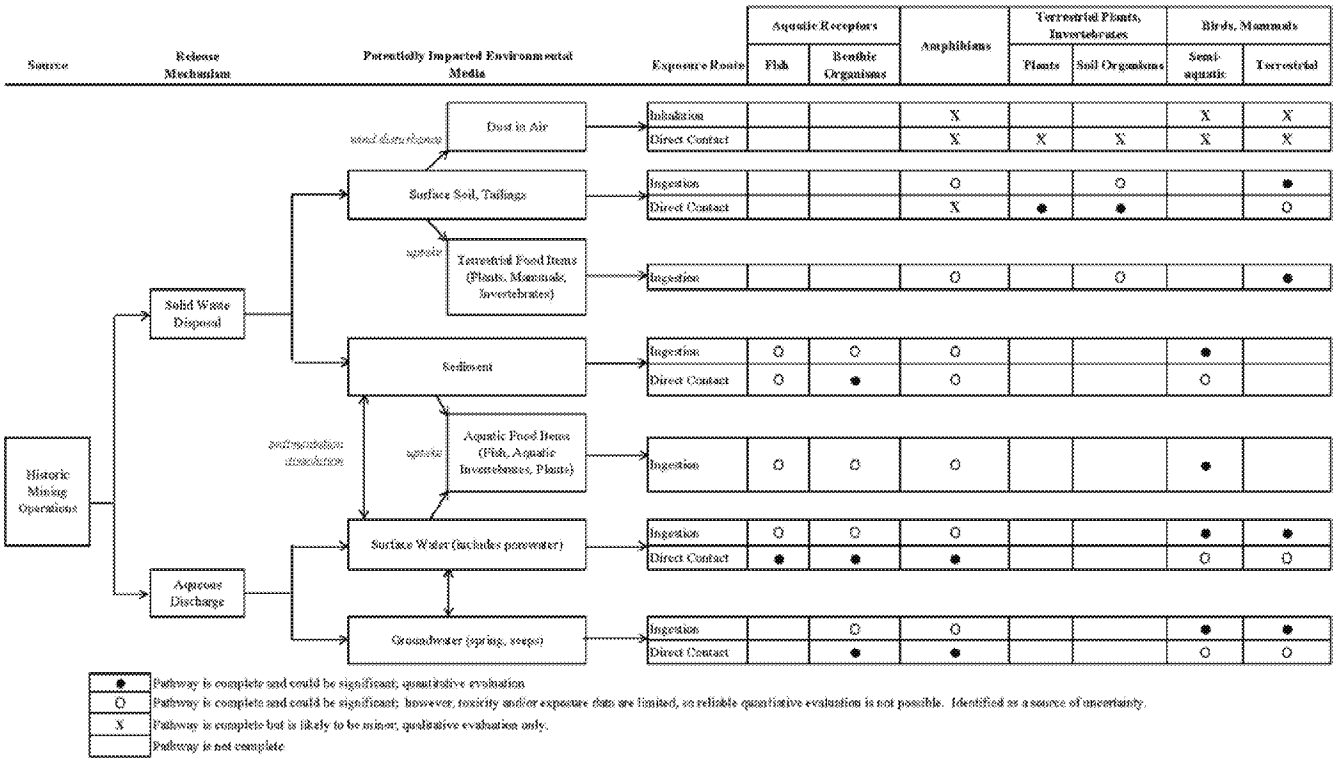
Figure 2-1: Draft Human Health Conceptual Site Model for Richardson Flat OU2/OU3



2.2 Draft Ecological Conceptual Site Model

A draft ecological CSM is presented below in Figure 2-2. The draft ecological CSM may be revised during development of the EE/CA. A final ecological CSM will be included with the final EE/CA

Figure 2-2: Draft Ecological Conceptual Site Model for Richardson Flat OU2/OU3



2.3 Preliminary Identification of Potential Receptor Groups, Candidate Species, Assessment Endpoints and Measurement Endpoints

A preliminary identification of potential receptor groups, candidate species, assessment endpoints and measurement endpoints is presented in Table 2-1 below.

Table 2-1: Preliminary Identification of Potential Receptor Groups, Candidate Species, Assessment Endpoints and Measurement Endpoints

Receptor Group	Candidate Key Species	Assessment Endpoint	Measurement Endpoint	Habitat
Aquatic Community	Salmonid species; potentially cutthroat.	Enable a self-sustaining fishery	Water – State and Federal WQC[1]	Creek Channel and Wetland
Benthic Invertebrates	Community-Level	Enable a benthic community	Sediment – TEC or PEC[2]	Wetland and Riparian
Amphibians	Frogs and toads; potentially Columbia Spotted Frog	Enable self-sustaining amphibian populations	Surface water and State and Federal WQC; HQ[3] – Pending literature review to determine feasibility	Wetland
Aquatic Dependent Avian Community (Probing/dabbling/passerine)	American Dipper, Mallard/Coot Belted Kingfisher	Ensure protection of avian populations and their habitats from the deleterious effects of site related contamination	Sediment, Surface Water, Invertebrates, and Fish. HQs for abiotic media ingestion and dietary ingestion (measured concentrations in aquatic prey and forage)	Wetland and Riparian
Upland Avian Community (ground dwelling /raptor/passerine)	Dark-eyed Junco, American Robin, Sage Grouse, Kestrel	Ensure protection of avian populations and their habitats from the deleterious effects of site related contamination	Soil, Surface Water. HQs for abiotic media ingestion and dietary ingestion (measured concentrations in forage, modeled uptake into terrestrial prey)	Upland
Mammals	Deer Mouse, Meadow Vole, Raccoon, Mink	Ensure protection of mammalian populations and their habitats from the deleterious effects of site related contamination	Sediment, Surface Water, Soil, Invertebrates, and Fish. HQs for abiotic media ingestion and dietary ingestion (measured concentrations in aquatic prey and forage, modeled uptake in terrestrial prey)	Upland, Wetland, Riparian

1 – WQC = Water Quality Criteria
2 – TEC = Threshold Effect Concentration, PEC = Probable Effect Concentration
3 – HQ = Hazard Quotient

2.4 Focused Data Quality Objectives

General data quality objectives are presented in Table 2 of the QAPP. Focused data quality objectives for human health and ecological risk assessment are presented in Tables 2-2 and 2-3 below, respectively.

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Table 2-2: Data Quality Objectives for the Human Health Risk Assessment

Step 1: State the Problem
A human health risk assessment (HHRA) will be conducted with data collected under this FSP and QAPP, in addition to utilizing historic data to the extent possible. The HHRA will address the presence of hazardous substances within the Richardson Flat Tailings Site Operable Units 2 and 3 (OU2 and OU3). The pollutants of interest in OU2 and OU3 are heavy metals present in the Silver Creek watershed. Tailings are primarily present in the floodplain of Silver Creek in OU2 and OU3. Limited areas of contaminated soils are also known to exist in upland areas of OU2 and OU3 as a result of historic water diversions and irrigation activity. Known and potentially contaminated media include soil, sediment, groundwater and surface water. In regards to surface water, the Silver Creek watershed from the confluence with the Weber River to its headwaters has been included on Utah's 303(d) lists as impaired since 1998, and a total maximum daily load for dissolved zinc and cadmium was completed in in 2004. Silver Creek is classified as a 3A—Cold Water Fishery, 1C—Domestic Water Supply, and 4—Agriculture. Thus, Silver Creek may be used for domestic purposes, contacted by recreational visitors for purposes including fishing, and may also be used for watering livestock or irrigation.
Step 2: Identify the Goals of the Study
The goal of the HHRA is to determine the level of risk posed to human receptors by contaminated media present at the Site in order to determine if a response action is appropriate. For the OU2 and OU3 HHRA, the following DQO has been proposed: • Collect the data necessary to conduct a HHRA in accordance with applicable EPA regulations and guidance. These goals will be accomplished through: • Soil sampling as described in the FSP; • Sediment sampling as described in the FSP; • Surface water sampling as described in the FSP; • Groundwater sampling as described in the FSP; • Biota (game fish) sampling as described in the FSP; • Modeled exposure to fugitive dust based on surface soil sampling data; and • Reference site sampling as described in the FSP to establish natural background metals concentrations in the various sample media.
Step 3: Identify Information Inputs

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The specific environmental media to be sampled in OU2 and OU3 for the HHRA are surface water in Silver Creek and selected tributaries, groundwater in the shallow Silver Creek alluvial aquifer, surface and subsurface soils in upland and wetland areas, sediments in wetland areas, and biota. Proposed surface water, groundwater and soil sampling locations are presented in Figure 3-1, Figure 3-2 and Figure 3-3 of the FSP, respectively. Sediment and biota sampling locations will be co-located with Silver Creek surface water sampling locations. The Silver Creek surface water sampling locations that will be utilized for sediment and biota sampling will be determined in a later field reconnaissance event and the factors that will be considered in sampling location selection are described in Section 3.2 of the FSP.

Secondary data sources – Secondary data sources of sufficient quality that may be used quantitatively in the HHRA may be limited to data collected by Tetra Tech (for EPA) and the USGS. Secondary data sources will be evaluated for usability per the data quality assessment procedures specified in the QAPP. A complete listing of the secondary data sources available for the Site is presented in the Summary of Previous Investigations Report prepared by RMC (RMC, 2014).

Primary data – The data collection described in the FSP will be the primary data used in the HHRA. The historic data were used for scoping the current sampling effort.

- Screening levels provided by USEPA
  - QAPP Table 3
- Surface water samples
  - 23 locations (FSP Figure 3-1)
- Groundwater samples
  - 29 locations (FSP Figure 3-2)
- Soil samples
  - Hundreds of locations (FSP Figure 3-3)
- Sediment samples
  - 14 locations co-located with surface water samples as described in Section 3.2 of the FSP
- Game fish tissue samples
  - 13 locations co-located with surface water samples as described in Section 3.2 of the FSP

Step 4: Define the Boundaries of the Study

Spatial Boundaries

The study area encompasses the boundaries of OU2 and OU3. Operable Unit boundaries are defined in the Settlement Agreement and generally described below.

OU2 extends approximately 4.5 miles along Silver Creek from U. S. Highway 40 on the southern end to Interstate 80 on its northern end, ranging in width from approximately 2,100 feet at the southern boundary to approximately 3,800 feet near Pivotal Promontory Road. Areas within OU2 that are now categorized as OU3 are excluded from evaluation as OU2.

OU3 is comprised of five separate areas as shown on Figure 1-1 of the FSP:

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- Middle Reach – The first area is commonly known as the Middle Reach of Silver Creek. This area encompasses the Silver Maple Claims from its upstream end at Prospector Park downstream to U.S. Highway 40;
- Floodplain Tailings Reach (FPT Reach) – The second area extends from U.S. Highway 40 northward to State Route 248. A portion of this area is referred to as the "Floodplain Tailings" in the OU1 RI/FS (RMC, 2004); This area was initially included as part of OU2;
- State Route 248 North Reach – The third area extends from State Route 248 northward approximately 9,000 feet through the southerly one-third of the Lower Silver Creek floodplain. This area was initially included as part of OU2;
- P. C. West – The fourth area is located in the northern part of OU3 and is adjacent to the Snyderville Basin Water Reclamation Facility (sewage treatment facility) to the west. This area was initially included as part of OU2; and
- P. C. East – The fifth area is located in the northern part of OU3 to the north of Promontory Road and is adjacent to a residential development, Pivotal Promontory, LLC, which has constructed a private club and second-home community on the eastern OU3 boundary. This area was initially included as part of OU2.

Temporal Boundaries

Surface water and groundwater will be sampled quarterly for one year starting in approximately fall 2014. Soil sampling is expected to begin in fall 2014 and be completed in late summer or early fall 2015 (with a hiatus during the 2014/2015 winter season and possibly spring 2015 season). Game fish tissue sampling is expected to occur in July or August 2015.

Step 5: Develop the Strategy for Information Synthesis – Develop an Analytic Approach

The following decision rules will be applied to the data collected under this FSP and QAPP used in the HHRA:

- If the data are validated, they can be used in the HHRA.
- If the data are "R" qualified, they will be rejected from the HHRA. If the data are "J" qualified, they will be retained for use in the HHRA.
- If the reporting limits (RLs) are at or below human health screening levels (SLs) (based on a hazard quotient of 0.1 and a cancer risk of 10E-6), then data are usable for risk assessment.
- If the best achievable laboratory RL is above the lowest SL, the laboratory RL will serve as the SL.
- If the laboratory RLs are above the SLs due to elevated contaminant concentrations, then the data are useable qualitatively for identification of contaminant sources, but risk cannot be quantified and these analytes will be addressed in the uncertainty analysis.
- For surface water, groundwater, sediment and fish tissue samples, if there are at least 10 samples in each medium of concern for each analyte on the target analyte list (TAL), then the dataset will be considered robust enough to perform the risk assessment. For surface soil samples, if there is at least one sample for every 20 acres for each analyte on the target analyte list (TAL), then the dataset will be considered robust enough to perform the risk assessment.

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• If the maximum concentrations for each analyte exceed their respective SLs, then the analyte will be further evaluated in the baseline HHRA. • If the historic data were collected from areas that have not undergone remediation, and can be predicted to be reflective of current site conditions, then they can be used in the HHRA. • If game fish tissue data cannot be obtained, then literature bioaccumulation factors such as those in the USEPA EcoSSL guidance will be utilized to estimate tissue concentrations. • If tissue concentrations are measured or estimated, then the dietary exposure pathway for anglers can be quantified. • If surface water data are collected, then the surface water exposure pathways can be quantified for all receptors on the draft human health conceptual site model (CSM). • If sediment data are collected, then the sediment exposure pathways can be quantified for all receptors on the draft human health CSM. • If soil data are collected, then the soil exposure pathways can be quantified for all receptors on the draft human health CSM.
Step 6: Specify Performance or Acceptance Criteria
This has been documented in the field sampling SOPs attached to the FSP and sections B through D of the QAPP for laboratory methods.
Step 7: Develop the Plan for Obtaining Data
The data requirements of the SAP encompass aspects of historical record searches and data evaluation, primary data collection, field data and laboratory results and database management to reduce sources of errors and uncertainty in the use of the data. Directed sampling will be employed at the locations shown in the FSP. These locations are distributed throughout OU2 and OU3. Sampling locations and total number of samples for each OU may be modified from that presented in the FSP based on observed site conditions and to maximize the potential for adequate characterization. Optimization of the sampling design may result in an iterative process based on site-specific field observations, intermediate data interpretation, and apparent conditions. Specific sampling protocols are presented in the FSP. Analytical data will be downloaded and manipulated electronically to reduce manual data entry whenever possible. Concerns regarding data uncertainty and potential decision errors are addressed in the general DQOs presented in Table 2 of the QAPP.

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Table 2-3: Data Quality Objectives for the Ecological Risk Assessment

Step 1: State the Problem
An ecological risk assessment (ERA) will be conducted with data collected under this FSP and QAPP, in addition to utilizing historic data to the extent possible. The ERA will address the presence of hazardous substances within the Richardson Flat Tailings Site Operable Units 2 and 3 (OU2 and OU3). The pollutants of interest in OU2 and OU3 are heavy metals present in the Silver Creek watershed. Tailings are primarily present in the floodplain of Silver Creek in OU2 and OU3. Limited areas of contaminated soils are also known to exist in upland areas of OU2 and OU3 as a result of historic water diversions and irrigation activity. Known and potentially contaminated media include soil, sediment, groundwater and surface water. In regards to surface water, the Silver Creek watershed from the confluence with the Weber River to its headwaters has been included on Utah's 303(d) lists as impaired since 1998, and a total maximum daily load for dissolved zinc and cadmium was completed in in 2004. Silver Creek is classified as a 3A—Cold Water Fishery, 1C—Domestic Water Supply, and 4—Agriculture. Thus, Silver Creek may be used for domestic purposes, contacted by recreational visitors for purposes including fishing, and may also be used for watering livestock or irrigation.
Step 2: Identify the Goals of the Study
The goal of the ERA is to determine the level of risk posed to ecological receptors by the contaminated media present at the Site in order to determine if a response action is appropriate. For the OU2 and OU3 ERA, the following DQO has been proposed: • Collect the data necessary to conduct an ERA in accordance with applicable EPA regulations and guidance. These goals will be accomplished through: • Soil sampling as described in the FSP; • Sediment sampling as described in the FSP; • Surface water sampling as described in the FSP; • Groundwater sampling as described in the FSP; • Biota sampling as described in the FSP; and • Reference site sampling as described in the FSP to establish natural background metals concentrations in the various sample media.
Step 3: Identify Information Inputs
The specific environmental media to be sampled in OU2 and OU3 for the ERA are surface water in Silver Creek and selected tributaries, , groundwater in the shallow Silver Creek alluvial aquifer, surface and subsurface soils in upland and wetland areas, sediments in wetland areas, and biota. Proposed surface water, groundwater and soil sampling locations are presented in Figure 3-1, Figure 3-2 and Figure 3-3 of the FSP, respectively. Sediment and biota sampling locations will be co-located with Silver Creek surface water sampling locations. The Silver Creek surface water sampling locations that will be utilized for

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sediment and biota sampling will be determined in a later field reconnaissance event and the factors that will be considered in sampling location selection are described in Section 3.2 of the FSP.

Secondary data sources – Secondary data sources of sufficient quality that may be used quantitatively in the ERA may be limited to data collected by Tetra Tech (for EPA) and the USGS. Secondary data sources will be evaluated for usability per the data quality assessment procedures specified in the QAPP. A complete listing of the secondary data sources available for the Site is presented in the Summary of Previous Investigations Report prepared by RMC (RMC, 2014).

Primary data – The data collection described in the FSP will be the primary data used in the ERA. The historic data were used for scoping the current sampling effort.

- Screening levels provided by USEPA
  - QAPP Table 3
- Surface water samples
  - 23 locations (FSP Figure 3-1)
- Groundwater samples
  - 29 locations (FSP Figure 3-2)
- Soil samples
  - Hundreds of locations (FSP Figure 3-3)
- Sediment samples
  - 14 locations co-located with surface water samples as described in Section 3.2 of the FSP
- Fish tissue samples
  - 13 locations co-located with surface water samples as described in Section 3.2 of the FSP
- Vegetation tissue samples
  - 14 locations co-located with surface water samples as described in Section 3.2 of the FSP
- Benthic macroinvertebrate tissue samples
  - 13 locations co-located with surface water samples as described in Section 3.2 of the FSP

Step 4: Define the Boundaries of the Study

Spatial Boundaries

The study area encompasses the boundaries of OU2 and OU3. Operable Unit boundaries are defined in the Settlement Agreement and generally described below.

OU2 extends approximately 4.5 miles along Silver Creek from U. S. Highway 40 on the southern end to Interstate 80 on its northern end, ranging in width from approximately 2,100 feet at the southern boundary to approximately 3,800 feet near Pivotal Promontory Road. Areas within OU2 that are now categorized as OU3 are excluded from evaluation as OU2.

OU3 is comprised of five separate areas as shown on Figure 1-1 of the FSP:

- Middle Reach – The first area is commonly known as the Middle Reach of Silver Creek. This area

encompasses the Silver Maple Claims from its upstream end at Prospector Park downstream to U.S. Highway 40;

- Floodplain Tailings Reach (FPT Reach) – The second area extends from U.S. Highway 40 northward to State Route 248. A portion of this area is referred to as the "Floodplain Tailings" in the OU1 RI/FS (RMC, 2004); This area was initially included as part of OU2;
- State Route 248 North Reach – The third area extends from State Route 248 northward approximately 9,000 feet through the southerly one-third of the Lower Silver Creek floodplain. This area was initially included as part of OU2;
- P. C. West – The fourth area is located in the northern part of OU3 and is adjacent to the Snyderville Basin Water Reclamation Facility (sewage treatment facility) to the west. This area was initially included as part of OU2; and
- P. C. East – The fifth area is located in the northern part of OU3 to the north of Promontory Road and is adjacent to a residential development, Pivotal Promontory, LLC, which has constructed a private club and second-home community on the eastern OU3 boundary. This area was initially included as part of OU2.

Temporal Boundaries

Biological data must be collected at the optimum time for sampling, which is after spring runoff but late enough in the summer to optimize species identification and sample mass. It is predicted that sampling for organism tissue and sediment will occur in July or August 2015. Surface water and groundwater will be sampled quarterly for one year starting in approximately fall 2014. Soil sampling is expected to begin in fall 2014 and be completed in late summer or early fall 2015 (with a hiatus during the 2014/2015 winter season and possibly spring 2015 season).

Step 5: Develop the Strategy for Information Synthesis – Develop an Analytic Approach

The following decision rules will be applied to the data collected under this FSP and QAPP used in the ERA:

- If the data are validated, they can be used in the ERA.
- If the data are "R" qualified, they will be rejected from the ERA. If the data are "J" qualified, they will be retained for use in the ERA.
- If the reporting limits (RLs) are at or below ecological screening levels (SLs) (based on a hazard quotient of 0.1), then data are usable for risk assessment.
- If the best achievable laboratory RL is above the lowest SL, the laboratory RL will serve as the SL.
- If the laboratory RLs are above the SLs due to elevated contaminant concentrations, then the data are useable qualitatively for identification of contaminant sources, but risk cannot be quantified and these analytes will be addressed in the uncertainty analysis.
- If there are at least 10 samples in each medium of concern for each analyte on the target analyte list (TAL), then the dataset will be considered robust enough to perform the risk assessment.
- If the maximum concentrations for each analyte exceed their respective SLs, then the analyte will be further evaluated in the baseline ERA.
- If the historic data were collected from areas that have not undergone remediation, and can

be predicted to be reflective of current site conditions, then they can be used in the ERA. • If fish or macroinvertebrate tissue data cannot be obtained, then literature bioaccumulation factors such as those in the USEPA EcoSSL guidance will be utilized to estimate tissue concentrations. • If tissue concentrations are measured or estimated, then the dietary exposure pathway for birds and mammals feeding on plants, invertebrates, or fish can be quantified; dietary exposure pathways for species feeding on other birds and mammals will be modeled. • If surface water data are collected, then the surface water exposure pathways can be quantified for all receptors on the draft ecological conceptual site model (CSM). • If sediment data are collected, then the sediment exposure pathways can be quantified for all receptors on the draft ecological CSM. • If soil data are collected, then the soil exposure pathways can be quantified for all receptors on the draft ecological CSM.
Step 6: Specify Performance or Acceptance Criteria
This has been documented in the field sampling SOPs attached to the FSP and sections B through D of the QAPP for laboratory methods.
Step 7: Develop the Plan for Obtaining Data
The data requirements of the SAP encompass aspects of historical record searches and data evaluation, primary data collection, field data and laboratory results and database management to reduce sources of errors and uncertainty in the use of the data. Directed sampling will be employed at the locations shown in the FSP. These locations are distributed throughout OU2 and OU3. Sampling locations and total number of samples for each OU may be modified from that presented in the FSP based on observed site conditions and to maximize the potential for adequate characterization. Optimization of the sampling design may result in an iterative process based on site-specific field observations, intermediate data interpretation, and apparent conditions. Specific sampling protocols are presented in the FSP. Analytical data will be downloaded and manipulated electronically to reduce manual data entry whenever possible. Concerns regarding data uncertainty and potential decision errors are addressed in the general DQOs presented in Table 2 of the QAPP

3.0 SAMPLING PROGRAM, PROCEDURES, AND METHODOLOGY

This section describes the sampling program and presents the procedures for collecting and locating samples. All Standard Operating Procedures (SOPs) referenced in this FSP are provided

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in Appendix A. Field activities will be recorded on the field forms included in Appendix C. Sections 3.1 and 3.2 describe the proposed sampling program and sample locations.

3.1 Sampling Program

Table 3-1 summarizes the parameters to be measured during implementation of this SAP. The EPA Target Analyte List for metals, plus additional parameters, is proposed for analysis in Table 3-1. Prior to initiation of sample collection, some metals may be removed from the analyte list for OU2 and the Floodplain Tailings Reach, State Route 248 North Reach, P.C. East Reach and P.C. West Reach of OU3 if warranted based on comparison of existing historical data to established screening values provided by EPA and presented in Table 3 of the QAPP. This comparison will be documented in a Technical Memorandum to EPA and will involve a sample-by-sample evaluation to determine if the concentration of each analyte exceeded human health and ecological screening values, estimation of summary statistics, and calculation of the maximum screening hazard quotient (HQ) which is the maximum detected value divided by the minimum human health or ecological screening level. In the Middle Reach of OU3, all samples will be analyzed for the EPA Target Analyte List for metals due to a lack of available data. Any reduction in the analytical suite will be conducted in consultation with EPA and in accordance with *Region 8 Superfund Technical Guidance: Evaluating and Identifying Contaminants of Concern for Human Health* (EPA, 1994).

The sampling program consists of evaluation of the environmental media listed in Table 3-2 below. Table 3-2 also summarizes the sampling objectives. Sampling objectives listed in Table 3-2 are overall objectives and may not apply to all areas depending on the specific data gaps present. Focused sampling objectives for OU2 and OU3 are further discussed in Section 3.2.1 through 3.2.5, respectively. Soil and surface water data will be used for both determining the nature and extent of contamination and for risk assessment purposes. Groundwater data will be used for determining the nature and extent of contamination. Sediment and organism tissue data will be used for risk assessment purposes.

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Table 3-2: Sample Media and Sampling Objectives

Media	Sampling and Analysis Objectives
Soil Samples	• Determine nature and extent of contaminated surface and subsurface soils. • Determine exposure of humans and ecological receptors to metals. • Prepare estimates of contaminated soil volumes • Complete sampling objectives described in Section 2.0.
Sediment Samples	• Determine nature and extent of contaminated sediments. • Determine exposure of benthic macroinvertebrates, fish, wildlife and wetland plants to metals. • Complete sampling objectives described in Section 2.0.
Surface Water	• Evaluate source areas to the extent practicable. • Evaluate surface water/groundwater interaction to the extent practicable. • Determine exposure of human and ecological receptors, including benthic macroinvertebrates, fish, and wildlife, to metals. • Estimate metals dose and risk to wildlife ingesting water, and applicable subsequent human health considerations (i.e., game fish consumption). • Complete sampling objectives described in Section 2.0.
Shallow Alluvial Groundwater	• Evaluate source areas to the extent practicable. • Evaluate surface water/groundwater interaction to the extent practicable.

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	• Determine seasonal groundwater flux to the extent practicable. • Complete sampling objectives described in Section 2.0.
Organism Tissue Samples – Vegetation, Benthic Macroinvertebrates and Fish	• Comparison to OU1 Baseline Ecological Risk Assessment values. • Quantify the dietary exposure pathway for humans consuming game fish. • Quantify the dietary exposure pathway for semi-aquatic birds and mammals. • Examine trends relative to contaminant trends in abiotic media. • Evaluate uptake of metals from sediment and surface water. • Determine bioaccumulation of metals.

3.2 Sample Locations

Sampling locations for the OU2 and OU3 EE/CA site characterization are described in Sections 3.2.1 through 3.2.5. Proposed sampling locations are shown on the following figures:

- Figure 3-1 (Surface Water);
- Figure 3-2 (Groundwater); and
- Figure 3-3 (Soil).

Additional sample locations may be added or proposed sample locations may be modified if indicated by field conditions observed during sampling events and/or piezometer installation. For instance, additional surface water samples will be collected if flow is observed in irrigation ditches present in the P.C. East Reach of OU3, or soil sample locations may be modified to avoid standing water or potential safety hazards. Additionally, surface water samples will be collected from springs or seeps observed in OU2 and OU3 if the observed flow is sufficient for sample collection. Addition or modification of sampling locations will be avoided if possible due to the potential to skew overall sampling results.

The rationale used to select the sampling locations for OU2 and OU3 (Sections 3.2.2 and 3.2.3, respectively) is discussed below:

- Surface Water: Silver Creek sampling locations were selected to bracket major geographic boundaries and potential source areas within the Site. Additional sample

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locations outside of Silver Creek were added to characterize surface water inflows to Silver Creek (i.e., OU1 inflow, effluent from the Silver Creek wastewater treatment plant, return flow from irrigation ditches).

- Groundwater: An extensive network of piezometers was installed by Tetra Tech in OU2 and the State Route 248 North, P.C. West, and P.C. East Reaches of OU3. Monitoring wells and piezometers were also installed in the Floodplain Tailings Reach of OU3 by United Park during the OU1 Remedial Investigation (RMC, 2004). Groundwater sampling in these portions of the Site will utilize a select portion of these existing piezometers and monitoring wells. The selected existing piezometers and monitoring wells provide adequate spatial coverage across the Site, are located both in the Silver Creek floodplain and nearby upland areas, and are located in proximity to many of the proposed Silver Creek surface water sampling locations. Additionally, the Tetra Tech piezometers include two sets of nested pairs where one piezometer is screened in tailings and the other piezometer is screened in underlying soils.

  No piezometers or monitoring wells exist in the Middle Reach of OU3 and installation of new piezometers is required to address this data gap. Proposed piezometer locations are located in close proximity to Middle Reach surface water sampling locations and at a higher spatial density than the existing piezometers that will utilized in the rest of the Site.

- Soil: In OU2 and the State Route 248 North, P.C. West, and P.C. East Reaches of OU3, surface and subsurface soils have been extensively characterized by Tetra Tech. Thus, soil sampling locations in these areas have been selected to fill gaps in the Tetra Tech data. These data gaps include areal gaps where no data exists, and vertical gaps where subsurface soil sampling did not extend into uncontaminated soils. In areal gaps, surface and subsurface samples will be collected. For vertical gaps, Tetra Tech sample locations that did not define the vertical extents of contamination will be resampled. Subsurface soil sampling will extend from the surface to a minimum of one foot into uncontaminated soils.

  As noted in Section 1.1.4, three parcels in the southeastern portion of the S.R. 248 reach of OU3 (parcels SS-65-A-5, SS-65-A-6 and SS-65-1) were not investigated by Tetra Tech. Surface and subsurface soils data collection was conducted by the landowner in 2009. Data collection was conducted by a qualified environmental contractor under an EPA-approved Sampling and Analysis Plan. All reasonable efforts will be made to obtain the data available for these parcels from the landowner; therefore no sample locations are planned for this area if this data is obtained and is usable (see Figure 3-3, Sheet 2).

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Landowners have granted access to their property and if the existing data cannot be obtained or is not of sufficient quality, surface and subsurface soil sampling will be conducted. Sample density will meet or exceed the soil sample density in the remainder of the S.R. 248 reach.

In the Middle Reach and Floodplain Tailings Reach of OU3, existing data does not exist or is not of sufficient quality. Surface and subsurface soil sampling will be conducted along transects spaced at 400-foot intervals. Sample spacing along the transects will be approximately 200 feet with narrower spacing in places as required by OU boundary constraints. Subsurface sampling will extend from the surface to a minimum of one foot into uncontaminated soils.

- Sediment and Organism Tissue: Sampling locations for sediment and organism tissue (vegetation, benthic macroinvertebrates and fish) samples will be co-located with Silver Creek surface water sampling locations. Co-located data will help to provide a better understanding of fate and transport in the aquatic ecosystem. The Silver Creek surface water sampling locations that will be utilized will be selected in coordination with EPA. Sampling locations will also be randomized to the degree possible. It is anticipated that during the fall of 2014, a field reconnaissance event will be conducted where initial proposed sampling locations and potential alternative locations are selected. The initial proposed sampling locations and potential alternative locations will be documented (photographs and narrative descriptions) in a Technical Memorandum to EPA. UPCM will then work with EPA in the selection of final sampling locations. Factors that will be considered in identifying sampling locations will include but may not be limited to: 1) channel characteristics and the depositional environment; 2) surface water sampling results; 3) vegetative communities present (e.g., there is sufficient vegetation to sample); 4) presence or absence of visually evident tailings; 5) known or suspected groundwater discharge characteristics (e.g., gaining or losing); and 6) existence of potential safety hazards.

Where required, landowners will be contacted for permission prior to sampling. The State of Utah Division of Parks and Recreation (UDPR) will be notified at least thirty-days in advance of any data collection activities on property owned or managed by UDPR such as the Rail Trail.

3.2.1 OU1

Surface water discharge from OU1 will be sampled quarterly for one year as part of the OU2 and OU3 EE/CA site characterization. This will be conducted to quantify metals loading from OU1 and demonstrate the effectiveness of source control efforts undertaken at OU1 from 2007 to 2011. No other sampling is proposed for OU1 during the OU2 and OU3 EE/CA site

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characterization. The OU1 surface water sampling location is shown in Figure 3-1 (Sheets 1 and 2).

3.2.2 OU2

In OU2, the EE/CA site characterization will involve the following data collection activities:

- Soils: Subsurface soils data will be collected from locations where Tetra Tech sampling did not define the vertical extents of contamination. Surface and subsurface soils data will be collected in Tetra Tech sampling gaps where no data currently exists. As shown on Figure 3-3 (Sheets 2 through 4), 103 soil sampling locations are proposed in OU2 (surface and subsurface soils at 49 new locations, and subsurface soils at 54 locations previously sampled by Tetra Tech where the vertical extent of contamination was not defined). Figure 3-3 (Sheets 2 through 4) includes the location of all Tetra Tech soil samples in order to fully portray the extent of the existing dataset. As shown on the figure legend, new soil sampling locations are indicated by green circles and Tetra Tech locations that will be resampled to define the vertical extent of contamination are indicated by magenta circles.

- Surface Water: Surface water samples will be collected quarterly for one year from selected locations. As shown on Figure 3-1 (Sheets 3 and 4), 8 surface water sampling locations are proposed in OU2. Additional surface water sampling locations may be added in the field based on field conditions observed during sampling events and the status of irrigation diversions and flows (e.g., if flow is present in an irrigation ditch a sample will be collected at an appropriate location).

- Groundwater: Shallow groundwater analytical samples will be collected quarterly for one year. In order to determine seasonal fluctuations in groundwater levels, water level measurements will be collected monthly for one year. Samples and water level measurements will be collected from 12 existing piezometers previously installed and sampled by Tetra Tech. The piezometer locations are shown on Figure 3-2 (Sheets 3 and 4). The piezometers will be inspected in a preliminary field reconnaissance event prior to sampling and will be re-developed and replaced if necessary.

- Sediment and Organism Tissue: Sediment and organism tissue (vegetation, benthic macroinvertebrates and fish) samples will be collected from five locations that will be selected in the field. Sampling locations for sediment and organism tissue (vegetation, benthic macroinvertebrates and fish) samples will be co-located with Silver Creek surface water sampling locations. Standard literature values (EPA, 2007) will be substituted if

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sufficient quantities of fish and benthic macroinvertebrate tissue are unable to be collected.

3.2.3 OU3

The five separate areas that comprise OU3 (Section 1.1.1) are discussed below.

Middle Reach

In the Middle Reach of OU3, the EE/CA site characterization will involve the following data collection activities:

- Soils: Surface and subsurface soils data will be collected throughout the Middle Reach from the locations shown on Figure 3-3. As shown on Figure 3-3, sampling will be conducted along transects spaced at 400-foot intervals. Sample spacing along the transects will be approximately 200 feet with narrower spacing in places as required by OU boundary constraints. As shown on Figure 3-3 (Sheet 1), 81 soil sampling locations are proposed in the Middle Reach of OU3.

  Additionally, portions of a historic irrigation ditch may exist in the western end of the Middle Reach of OU3 south of the Rail Trail. Additional soil samples will be collected where proposed soil sampling transects cross existing identifiable portions of the historic irrigation ditch. Because the historic irrigation ditch is generally not readily apparent on aerial photographs, these sample locations have not been added to Figure 3-3, Sheet 1. The historic irrigation ditch soil sampling may add up to ten additional soil sample locations to the Middle Reach of OU3 (from the western-most transects). The identifiable portions of the historic irrigation ditch will be inspected in a field reconnaissance event prior to initiating soil sampling in the Middle Reach of OU3 so that field sampling personnel are familiar with its location.

- Surface Water: Surface water samples will be collected quarterly from selected locations. As shown on Figure 3-1, six surface water sampling locations are proposed in or in close proximity to the Middle Reach of OU3.

- Groundwater: Shallow groundwater analytical samples will be collected quarterly for one year. In order to determine seasonal fluctuations in groundwater levels, water level measurements will be collected monthly for one year. Samples and water level measurements will be collected from six new piezometers that will be installed and sampled by United Park. The locations of the proposed Middle Reach piezometers are shown on Figure 3-2 (Sheet 1). Piezometer locations are co-located with surface water

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sampling locations to the extent practicable to evaluate surface water and groundwater interactions.

- Sediment and Organism Tissue: Sediment and organism tissue (vegetation, benthic macroinvertebrates and fish) samples will be collected from three locations that will be selected in the field. Sampling locations for sediment and organism tissue (vegetation, benthic macroinvertebrates and fish) samples will be co-located with Silver Creek surface water sampling locations. Standard literature values (EPA, 2007) will be substituted if sufficient quantities of fish and benthic macroinvertebrate tissue are unable to be collected.

Floodplain Tailings Reach

In the Floodplain Tailings Reach of OU3, the EE/CA site characterization will involve the following data collection activities:

- Soils: Surface and subsurface soils data will be collected from the locations shown on Figure 3-3. As shown on Figure 3-3, sampling will be conducted along transects spaced at 400-foot intervals. Sample spacing along the transects will be approximately 200 feet, with narrower spacing in places as required by OU boundary constraints. As shown on Figure 3-3 (Sheet 1), 20 soil sampling locations are proposed in the Floodplain Tailings Reach of OU3.

- Surface Water: Surface water samples will be collected quarterly for one year from selected locations. As shown on Figure 3-1 (Sheets 1 and 2), 2 surface water sampling locations are proposed in the Floodplain Tailings Reach of OU3.

- Groundwater: Shallow groundwater analytical samples will be collected quarterly for one year. In order to determine seasonal fluctuations in groundwater levels, water level measurements will be collected monthly for one year. Samples and water level measurements will be collected from four existing piezometers previously installed and sampled by United Park. The piezometer locations are shown on Figure 3-2 (Sheet 2). The piezometers will be inspected in a preliminary field reconnaissance event prior to sampling and will be re-developed and replaced if necessary.

- Sediment and Organism Tissue: Sediment and organism tissue (vegetation, benthic macroinvertebrates and fish) samples will be collected from one location that will be selected in the field. The sampling location for sediment and organism tissue (vegetation, benthic macroinvertebrates and fish) samples will be co-located with a Silver Creek

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surface water sampling location. Standard literature values (EPA, 2007) will be substituted if sufficient quantities of fish and benthic macroinvertebrate tissue are unable to be collected.

State Route 248 North Reach

The majority of the State Route 248 North Reach has undergone extensive characterization by Tetra Tech (for EPA). Data collection included sampling of surface and subsurface soils, surface water, and shallow groundwater. Wetland delineation was also conducted by Tetra Tech. Additionally, metals loading to surface water has been investigated by the USGS (USGS, 2007) and the State of Utah (UDERR, 2002).

In the State Route 248 North Reach of OU3, the EE/CA site characterization will involve the following data collection activities:

- Soils: Subsurface soils data will be collected from locations where Tetra Tech sampling did not define the vertical extents of contamination. Surface and subsurface soils data will be collected in Tetra Tech sampling gaps where no data currently exists. As shown on Figure 3-3 (Sheets 2 and 3), 24 soil sampling locations are proposed in the State Route 248 North Reach of OU3 (surface and subsurface soils at 13 new locations, and subsurface soils at 11 locations previously sampled by Tetra Tech where the vertical extent of contamination was not defined). Figure 3-3 (Sheets 2 and 3) includes the location of all Tetra Tech soil samples in order to fully portray the extent of the existing dataset. As shown on the figure legend, new soil sampling locations are indicated by green circles and Tetra Tech locations that will be resampled to define the vertical extent of contamination are indicated by magenta circles.

- Surface Water: Surface water samples will be collected quarterly for one year from selected locations. As shown on Figure 3-1 (Sheets 2 and 3), 7 surface water sampling locations are proposed in the State Route 248 North Reach of OU3. Additional surface water sampling locations may be added in the field based on field conditions observed during sampling events and the status of irrigation diversions and flows (e.g., if flow is present in an irrigation ditch a sample will be collected at an appropriate location).

- Groundwater: Shallow groundwater analytical samples will be collected quarterly for one year. In order to determine seasonal fluctuations in groundwater levels, water level measurements will be collected monthly for one year. Samples and water level measurements will be collected from three existing piezometers previously installed and sampled by Tetra Tech. The piezometer locations are shown on Figure 3-2 (Sheet 2). The

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piezometers will be inspected in a preliminary field reconnaissance event prior to sampling and will be re-developed and replaced if necessary.

- Sediment and Organism Tissue: Sediment and organism tissue (vegetation, benthic macroinvertebrates and fish) samples will be collected from three locations that will be selected in the field. Sampling locations for sediment and organism tissue (vegetation, benthic macroinvertebrates and fish) samples will be co-located with Silver Creek surface water sampling locations. Standard literature values (EPA, 2007) will be substituted if sufficient quantities of fish and benthic macroinvertebrate tissue are unable to be collected.

P.C. West Reach

In the P.C. West Reach of OU3, the EE/CA site characterization will involve the following data collection activities:

- Soils: Subsurface soils data will be collected from locations where Tetra Tech sampling did not define the vertical extents of contamination. Surface and subsurface soils data will be collected in Tetra Tech sampling gaps where no data currently exists. As shown on Figure 3-3 (Sheet 4), 9 soil sampling locations are proposed in the P.C. West Reach of OU3 (surface and subsurface soils at 6 new locations, and subsurface soils at 3 locations previously sampled by Tetra Tech where the vertical extent of contamination was not defined). Figure 3-3 (Sheet 4) includes the location of all Tetra Tech soil samples in order to fully portray the extent of the existing dataset. As shown on the figure legend, new soil sampling locations are indicated by green circles and Tetra Tech locations that will be resampled to define the vertical extent of contamination are indicated by magenta circles.

- Surface Water: Surface water samples will be collected quarterly for one year from selected locations. As shown on Figure 3-1 (Sheet 4), two surface water sampling locations are proposed in the P.C. West Reach of OU3.

- Groundwater: Shallow groundwater analytical samples will be collected quarterly for one year. In order to determine seasonal fluctuations in groundwater levels, water level measurements will be collected monthly for one year. Samples and water level measurements will be collected from three existing piezometers previously installed and sampled by Tetra Tech. The piezometer locations are shown on Figure 3-2 (Sheet 4). The piezometers will be inspected in a preliminary field reconnaissance event prior to sampling and will be re-developed and replaced if necessary.

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- Sediment and Organism Tissue: Sediment and organism tissue samples will be collected from two locations that will be selected in the field. The sampling locations for sediment and organism tissue (vegetation, benthic macroinvertebrates and fish) samples will be co-located with the Silver Creek surface water sampling locations. Standard literature values (EPA, 2007) will be substituted if sufficient quantities of fish and benthic macroinvertebrate tissue are unable to be collected.

P.C. East Reach

In the P.C. East Reach of OU3, the EE/CA site characterization will involve the following data collection activities:

- Soils: Subsurface soils data will be collected from locations where Tetra Tech sampling did not define the vertical extents of contamination. Surface and subsurface soils data will be collected in Tetra Tech sampling gaps where no data currently exists. As shown on Figure 3-3 (Sheet 4), 34 soil sampling locations are proposed in the P.C. East Reach of OU3 (surface and subsurface soils at 14 new locations, and subsurface soils at 20 locations previously sampled by Tetra Tech where the vertical extent of contamination was not defined). Figure 3-3 (Sheet 4) includes the location of all Tetra Tech soil samples in order to fully portray the extent of the existing dataset. As shown on the figure legend, new soil sampling locations are indicated by green circles and Tetra Tech locations that will be resampled to define the vertical extent of contamination are indicated by magenta circles.

- Surface Water: No surface water sampling is proposed since Silver Creek does not flow through the P.C. East Reach and no other perennial water sources are known to exist. Surface water sampling locations will be added in the field if flow is observed in irrigation ditches (multiple irrigation ditches pass through the reach) or from springs or seeps discharging shallow groundwater.

- Groundwater: Shallow groundwater analytical samples will be collected quarterly for one year. In order to determine seasonal fluctuations in groundwater levels, water level measurements will be collected monthly for one year. Samples and water level measurements will be collected from one existing piezometer previously installed and sampled by Tetra Tech. The piezometer location is shown on Figure 3-2 (Sheet 4). The piezometer will be inspected in a preliminary field reconnaissance event prior to sampling and will be re-developed and replaced if necessary.

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- Sediment and Organism Tissue: Sediment and organism tissue (vegetation) samples will be collected, if possible, from one location that will be selected in the field. The selected sampling location for sediment and vegetation tissue samples will be co-located with a surface water sampling location if possible. It is possible that sediment samples may not be able to be collected due to a lack of perennial water sources in the P.C. East Reach. Benthic macroinvertebrate and fish tissue samples will not be collected due to the lack of perennial water sources in the P.C. East Reach. Standard literature values (EPA, 2007) will be substituted for sample media that cannot be collected to due to lack of perennial water sources.

3.2.4 OU4

Data collected from Richardson Flat Tailings Site Operable Unit 4 (Prospector Drain) by Park City Municipal Corporation (PCMC) may be applicable to the OU2 and OU3 EE/CA site characterization. United Park plans to make all reasonable efforts to obtain OU4 data from PCMC when and if necessary.

3.2.5 Reference Site

Several potential reference sites are currently being evaluated for use. The reference site(s) will be selected in collaboration with EPA, et al. at a later date. Sample collection at the reference site(s) will involve collecting five samples of each of the following media:

- Surface Water;
- Sediment;
- Vegetation Tissue;
- Fish Tissue; and
- Benthic Macroinvertebrate Tissue.

Standard literature values (EPA, 2007) will be substituted if the required quantities of fish and benthic macroinvertebrate tissue are unable to be collected.

3.3 Survey

Handheld global positioning system (GPS) receivers will be used to locate all sampling locations in the field. The GPS unit that will be used for the project has a resolution of ± 1 foot, an accuracy of ± 10 feet, and uses the NAD83 datum. Monitoring well elevations will be surveyed by a Utah licensed land surveyor for vertical elevation (z) to ± 0.01 foot. Survey points will be permanently marked in the field for use in static water level measurement.

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3.4 Static Water Level Measurement

Static water level at all groundwater monitoring locations will be measured with an electronic water-level probe per RMC SOP 3C. If sampling will occur, water levels will be measured before piezometers are purged and sampled. All measurements will be made to ± 0.01 ft from the surveyed measuring point at the top of casing, and will be recorded on the appropriate field form. Field measurements will be used in conjunction with the surveyed measuring points to determine the static water level elevation in feet above mean sea level (amsl).

3.5 Field Water Quality Measurement

Field water quality measurements will be measured in-stream or with a flow-through cell as appropriate using a YSI 556 multiparameter meter (or equivalent). Field water quality measurements will consist of the following data: pH, conductivity, temperature, dissolved oxygen (DO), and oxidation reduction potential (ORP). Data will be recorded on the appropriate sample forms. The water quality meter will be properly maintained and calibrated in accordance with manufacturers' instructions.

3.6 Shallow Groundwater Sampling

Shallow groundwater samples will be collected to characterize water in the Silver Creek alluvial aquifer. Samples may be collected from the following potential locations:

- Existing monitoring wells and piezometers; and/or
- New monitoring wells or piezometers installed as part of the OU2 and OU3 EE/CA site characterization.

Groundwater samples will be conducted in accordance with the following SOPs as applicable:

- RMC SOP 3A, Hollowstem Auger Drilling, Soil sampling and Monitoring Well Installation;
- RMC SOP 3B, Standard Procedures for Monitoring Well Development; and
- RMC SOP 3C, Standard Procedures for Groundwater Sampling.

Table 3-1 presents the parameters, analytical methods, laboratory methods, container types, preservation requirements and holding times for specified analytes. Groundwater samples for dissolved metals analysis may be field or laboratory filtered as required. Field data will be collected per Section 3.5. Monitoring well locations will be logged with a GPS device. Monitoring wells will be installed by a driller licensed in the State of Utah. Monitoring well

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elevations will surveyed by a surveyor licensed in the State of Utah. Existing monitoring wells and piezometers will be utilized to the greatest extent possible.

3.7 Surface Water Sampling

Surface water samples will be collected per RMC SOP 1 (Appendix A). Water samples for dissolved metals analysis will be filtered in the field at the time of collection or as soon thereafter as practically possible. Table 3-1 presents the parameters, analytical methods, laboratory methods, container types, preservation requirements and holding times for specified analytes. Field data will be collected per Section 3.5. Surface water sampling events will not be conducted during precipitation events or within 48 hours of precipitation events greater than 0.5 inches to ensure that surface water data is representative and not significantly influenced by recent or ongoing precipitation.

3.8 Surface Water Flow Measurement

Surface water flow shall be measured whenever possible when surface water samples are collected so that metals loading can be determined. To minimize sediment disturbance during sampling, the stream flow measurements will be conducted after the completion of sample collection or downstream from the sampling point. Surface water flow measurement procedures are described in RMC SOP 1.

3.9 XRF Soil Screening

The XRF will be used as a screening tool during the OU2 and OU3 EE/CA site characterization (i.e., determining when at-depth soil sampling has reached the lower extent of contamination, random spot sampling, etc.). XRF results will not be used to determine the nature and extent of contamination or for risk assessment purposes.

XRF soil screening will be conducted according to RMC SOP 8 which is based on EPA Method 6200.

3.10 Surface Soil Sampling

Surface soil samples (0-2 inches) will be collected following RMC SOP 2. The surface of the soil will be scraped free of vegetation from the sample location with a gloved hand, shovel, stainless steel spoon, and/or disposable sampling instrument. The underlying soil sample will be collected with a disposable sample collection device or gloved hand. All 0-2 inch surface soil samples will be sieved using a No. 10 (2 mm) sieve. The sieved soil samples will be placed into a labeled pre-cleaned four ounce glass jar and sealed. Sieves will be decontaminated between

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sample locations per RMC SOP 6. Composite samples will be homogenized in one-gallon resealable plastic bags (Ziploc® or equivalent) or a decontaminated stainless steel bowl. Large gravel and rock fragments will be discarded. A labeled pre-cleaned four ounce glass jar will then be filled with the homogenized sample and sealed. Use of composite soil sampling is not anticipated for the EE/CA Site Characterization. Composite soil sampling procedures were included for completeness. Sample locations will be logged with a GPS unit. All samples will be analyzed as bulk samples by the analytical laboratory by methods presented in Table 3-1.

3.11 Subsurface Soil Sampling

Subsurface soil samples (>6 inches) will be collected following RMC SOP 2B and/or RMC SOP 2C. Surface vegetation will be scraped away from the sample location with a shovel, stainless steel spoon or disposable sampling instrument. A backhoe or similar equipment may be used to excavate test pits for sample collection. A geoprobe will be employed as required if groundwater prevents test pit excavation to below the base of contaminated soils. This equipment will be operated by a professional operator and arranged for by the United Park or RMC Project Manager. All appropriate safety precautions will be taken when working around this equipment. The target depth increment sample will be collected by one of the following methods:

- Hand-powered auger;
- Soil probe;
- Shovel;
- Gloved hand; or
- Disposable sample trowel.

If non-disposable equipment is used to collect the sample, the sampling equipment will be decontaminated prior to sample collection. Decontamination procedures are discussed in Section 3.17 and detailed in RMC SOP 6 (Appendix A). Sample depth increments will be determined in the field based on site conditions (i.e., soil color or texture changes, XRF screening results), with the exception that a standard 6-12 inch subsurface soil sample will be collected at all sampling locations to facilitate exposure estimates for burrowing animals and plants. Total subsurface soil sampling depth will extend a minimum of one foot into uncontaminated soils. Grab samples will be placed into a labeled pre-cleaned four ounce glass jar. Composite samples will be homogenized in one-gallon resealable plastic bags (Ziploc® or equivalent) or a decontaminated stainless steel bowl. Large gravel and rock fragments will be discarded. A labeled pre-cleaned four ounce glass jar will then be filled with the homogenized sample and sealed. Use of composite soil sampling is not anticipated for the EE/CA Site Characterization. Composite soil sampling procedures were included for completeness. The sampling equipment will be

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decontaminated between each depth increment. All samples will be analyzed as bulk samples by the analytical laboratory by methods presented in Table 3-1.

3.12 Tailings Sampling

Tailings metals concentrations will be compared to data collected during the OU1 RI (RMC, 2004). If the metals concentrations in tailings in OU2 and OU3 are similar to tailings in OU1, the long-term fate analysis conducted in OU1 will be used. If the metals concentrations in tailings in OU2 and OU3 are found to differ significantly from the tailings in OU1, a new long-term fate analysis may be conducted. OU2/OU3 tailings will be considered similar to OU1 tailings if mean metals concentrations are within ±25% of mean metals concentrations measured in OU1 tailings.

Surface and subsurface tailings sample collection will be conducted according to procedures specified in Section 3.10 and Section 3.11, respectively. One tailings sample will be collected from each soil sampling location where visually evident tailings are present. Sample locations will be logged with a GPS unit. All tailings samples will be analyzed as bulk soil samples by the analytical laboratory by methods presented in Table 3-1. XRF screening will be conducted above and below any color or texture changes. A backhoe will be used to dig test pits in selected locations to maximize visual observations of tailings, soils and the tailings/soils interface. The test pit will enable sampling personnel to view the tailing/soils interface in a three-dimensional view. This will provide an understanding of the physical characteristics of the interface as well as provide information about the spatial configuration of the interface. Test pits will be excavated with minimal possible disturbance and will not be excavated below the water table. Excavated soils will be sorted and stockpiled adjacent to the test pit. Upon completion of sampling activities the test pit will be backfilled. To prevent soil mixing, each soil horizon will be backfilled with materials removed from that horizon. Materials will be compacted with the bucket of the backhoe during backfilling. A geoprobe will be employed as required if groundwater prevents test pit excavation to below the base of the tailings.

3.13 Sediment Sampling

Sediment samples will be collected from surficial materials (upper one inch) in accordance with RMC SOP 4. Sediment samples will be co-located with surface water sampling locations. Samples will be collected with a disposable sample collection device or gloved hand and placed into a labeled pre-cleaned four ounce glass jar and sealed. Composite samples will be homogenized in one-gallon resealable plastic bags (Ziploc® or equivalent) or a decontaminated stainless steel bowl. Large gravel and rock fragments will be discarded. A labeled pre-cleaned four ounce glass jar will then be filled with the homogenized sample and sealed. All samples will be analyzed as bulk samples by the analytical laboratory by methods presented in Table 3-1.

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3.14 Plant Sampling

Plant tissue samples will be collected for ecological risk assessment purposes. Sampling methods described below are modeled on vegetation sampling procedures presented in *SERAS Standard Operating Procedures for Terrestrial Plant Community Sampling* (Appendix A). A single dominant plant species that serves as a food source for terrestrial receptors will be targeted for tissue sampling. The dominant forage plant species will be determined by conducting a qualitative survey of the plant species on-site. A qualified botanist will record visual cover estimates at each sampling location. The forage species with the highest average cover within each plant community will be selected for plant tissue collection.

A 0.75 or 1 m^2 PVC tube quadrant frame will be used to delimit each of the individual sampling points. Tissue from several individual plants of the dominant herbaceous plant species may have to be collected at each location to obtain enough sample volume. Vegetation sampling locations will be co-located with the surface water and sediment sampling locations. Herbaceous plant tissue sampling will involve the collection of the aboveground biomass only, utilizing a pair of stainless steel scissors.

If plots are dominated (in terms of percent cover) by woody shrubs (such as willow species), then branches will be cut from the dominant shrub species using pruning shears. The branch including its leaves, buds and fruiting structures (if present) will comprise the tissue sample. Several plants within the large plots will be sampled in order to provide a representative mass of plant tissue from the dominant species.

One-gallon, resealable plastic bags (Ziploc® or equivalent) will be used to contain vegetation samples. The samples will be placed on ice in coolers, transported to the laboratory and transferred to a refrigerator at $4^{o} \pm 2^{o}$ C until analysis within required holding times. All samples will be analyzed by the analytical laboratory by methods presented in Table 3-1

3.15 Fish Sampling

Fish tissue samples will be collected. For ecological risk assessment purposes, whole fish composite samples of the two most abundant species of forage fishes will be collected from locations associated with Silver Creek and the reference site. At each sampling location, sufficient individuals of each of the two dominant fish species captured will be collected for analysis. Only fish from 2-6 inches in total length will be retained for analysis in order to target the size classes available to a wide range of predators and to limit variability of the data due to any age/size-related factors. Species will be maintained separately for analysis. Three composite samples of four individual fish of each species, or sufficient individuals to make up a minimum of 50 grams will be formed at each station by placing individuals into three separate

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clean plastic trays for length measurement and identification. The individuals comprising each composite sample will be selected so that the average total length of fish does not differ significantly between replicate composite samples (by species).

For human health risk assessment purposes, filets of game fish (trout, if present) will be collected from locations associated with Silver Creek and the reference site. Because game fish may be scarce or not present at many locations, samples will not be composited. Filets will be prepared and submitted skin-on as described in EPA-600-R-92-111, *Fish Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters* (Appendix A) Filets from up to three individual fish from each station will be submitted for analysis.

Depending on the physical characteristics of the sampling locations, fish will be collected using beach seines, minnow traps, electrofishing units, or a combination of techniques. Procedures for operation of each type of equipment are summarized below. Detailed procedures are described in EPA-600-R-92-111, *Fish Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters* (Appendix A).

Beach seines are manually dragged along the shore to collect fish in shallow waters. Minnow traps are passive collection devices (i.e., fish enter the traps but cannot escape) that must be anchored in place and set for at least several hours and optimally overnight.

Electrofishing units will only be employed if a sufficient number of fish are unable to be captured using beach seines and minnow traps. Electrofishing units send an electric current through the water, temporarily stunning the fish. The stunned fish are then collected with a net. Because the electrofishing unit generates electric current, several precautions must be taken to avoid electrocution during sampling. Electrofishing will only be conducted by technicians who are familiar with the appropriate safety procedures, and all equipment will be maintained and operated according to the manufacturer's instructions. All persons in the sampling crew must wear hip boots or chest waders as a safety precaution.

The following information will be recorded as soon as possible after sample collection for all fish collected:

- Weight and total length measurements;
- Reproductive state (if possible to determine in the field);
- Presence of visible abnormalities.

Procedures for determining length and weight of fish are described in EPA-600-R-92-111, *Fish Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters*.

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After length and weight measurements have been made, fish will be double-wrapped in plastic wrap and double-bagged in resealable plastic bags (Ziploc® or equivalent) containing a sample identification label. Fish for composite samples will be bagged together to represent one sample for analytical purposes. Samples will be immediately placed on ice for transport to the field office or interim sample storage location. If samples are not shipped to an analytical lab immediately, they will be stored in a freezer (-4° C or colder) prior to shipment.

Samples will be packaged on ice in coolers and shipped by local courier or overnight delivery service to the analytical laboratory for chemical analysis. The analytical laboratory performing chemical analyses on whole-body samples will be responsible for sample homogenization and (if appropriate) transferring sample aliquots required for chemical analysis to the appropriate laboratories.

3.16 Benthic Macroinvertebrate Sampling

Sampling and analysis of metals concentrations in benthic macroinvertebrates will be completed to evaluate metals bioaccumulation and potential for transfer to higher trophic levels. Sampling stations will be co-located with surface water sampling locations as described in Section 3.2.

Sampling for benthic macroinvertebrates will be conducted in approximately mid-summer. This will ensure that sampling occurs late enough in the year to optimize species abundance and sample mass, but before water supplies start drying out in late summer/early autumn. This is particularly a concern in years with low snowpack or other drought conditions.

Sampling to collect macroinvertebrate tissues for metals analysis will be completed using dip nets. The number of samples required to collect tissues for constituent analyses will vary at each location according to the abundance of macroinvertebrates present. Sample collection at each location will continue until the minimum mass requirement for tissue analysis is obtained at each location (30-50 grams of organisms), or until a reasonable effort has been expended to obtain the sample. The contents of each dip net will be combined into a large collection container, covered with water, and sorted in the field to isolate macroinvertebrate specimens. Organisms will be transferred to four ounce glass jars and preserved on ice for subsequent transfer to the analytical laboratory. Organisms collected from each sampling location for tissue analysis will not be separated into individual taxa. Detailed sampling procedures for collecting and processing macroinvertebrate tissues are included in State of Utah – Macroinvertebrates Wetlands SOP (Appendix A).

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3.17 Decontamination

All sampling equipment will be decontaminated prior to use at each station and between media types. Equipment decontamination procedures are detailed in RMC SOP 6. Equipment decontamination will be performed by placing the sampling equipment in a bucket filled with deionized (DI) water and non-phosphate soap, and removing any visible residual material from the sampling equipment with a brush. Sampling equipment will then be triple rinsed with deionized water. Upon completion of this procedure, all equipment will be air dried and stored in a "clean" vessel until ready for use. Disposable, one use, sampling equipment will be used to the extent possible.

3.18 Investigation Derived Waste Management

Investigation-derived waste (IDW) generated during sample collection will be managed according to EPA publication 9345.3-03FS, *Guide to Management of Investigation–Derived Wastes* (EPA, 1992). Collecting only the volume of material needed to satisfy laboratory analytical requirements will minimize the generation of IDW. Any excess material will be discarded at the sample collection point whenever possible. If non-de minimis quantities of soil IDW are generated (i.e., from installation of monitoring wells), the soil will be collected in 5-gallon buckets and disposed of at an appropriate location within the OU1 tailings impoundment. Monitoring well development water and purge water will be discharged onto the ground surface close to the well. PPE and sampling equipment, such as gloves, sample tubing, and filters, will be disposed of as municipal solid waste. PPE and sampling equipment will be cleaned of greater than de minimis quantities of contaminated materials (i.e., tailings) prior to disposal. Per EPA publication 9345.3-03FS, waste characterization is not required.

3.19 Sample Labeling and Identification

All sample containers will be labeled at the time of sample collection. Labels will be completed with permanent ink. Sample containers will be immediately labeled with the following information:

- Sample ID;
- Date and time collected;
- Preservative (including unpreserved); and
- Sampler's initials.

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3.19.1 Sample ID Components

All Sample IDs shall contain the following information separated by dashes:

Operable Unit ID: OU1 – Richardson Flat Tailings Site Operable Unit 1; OU2 – Richardson Flat Tailings Site Operable Unit 2; OU3 – Richardson Flat Tailings Site Operable Unit 3; OU4 – Richardson Flat Tailings Site Operable Unit 4; REF – Reference site

Sample Type: One digit sample type code (0 = normal sample, 9 = field duplicate sample, 7 = equipment rinsate blank)

Sample Media: Two character sample media code:

- SW = Surface water
- GW = Groundwater
- SO = Soil
- TL = Tailings
- SD = Sediment
- VG = Vegetation
- BM = Benthic macroinvertebrates
- FI = Fish

Sample Location: Unique narrative identifier describing the sample location. This may be based on:

- An existing sample location name;
- The sample's geographic location (i.e., SCI80 for a sample collected from Silver Creek at the Interstate 80 overpass; SC WWTP EFF for effluent from the Silver Creek wastewater treatment plant);
- Monitoring well/Piezometer ID number;
- Sample grid number;
- Test pit number; or
- Other unique characteristics as required to definitively describe the sample location.

All capital letters shall be used in the sample location identifier.

ED_006076_00000126-00056

Water samples collected for analysis of metals shall be labeled to indicate whether the sample container will be analyzed for total or dissolved metals:

- Total metals = T
- Dissolved metals = D

Soil samples shall be labeled to indicate the sample depth interval:

- Surface = 0
- Subsurface = Four digit number, with the first two digits being the starting depth and the last two being the ending depth, in feet (i.e., 0204 for a sample collected from 2 to 4 feet below ground surface)

3.19.2 Sample ID Examples

Surface Water with Field Duplicates and Co-Located Sediment and Biota Samples

A surface water sample collected from Silver Creek at the Interstate 80 overpass in OU2 for analysis of metals would consist of two sample containers labeled as follows:

- OU2-0-SW-SCI80-T
- OU2-0-SW-SCI80-D

The field duplicate of this sample would consist of two bottles labeled as follows:

- OU2-9-SW-SCI80-T
- OU2-9-SW-SCI80-D

The co-located sediment sample would be labeled as follows:

- OU2-0-SD-SCI80

A co-located fish sample would be labeled as follows:

- OU2-0-FI-SCI80

A co-located benthic macroinvertebrate sample would be labeled as follows:

- OU2-0-BM-SCI80

ED_006076_00000126-00057

Groundwater

A groundwater sample collected from hypothetical piezometer "X" in OU3 for analysis of metals would consist of two sample containers labeled as follows:

- OU3-0-GW-PZX-T
- OU3-0-GW-PZX-D

Soil

Soil samples collected from hypothetical sample grid point "1A" in OU3 at the surface and depths of 1-3 feet and 3-5 feet would consist of three sample containers labeled as follows:

- OU3-0-SO-1A-0
- OU3-0-SO-1A-0103
- OU3-0-SO-1A-0305

Reference Site Vegetation

A vegetation sample collected from hypothetical reference site "Z" would be labeled as follows:

- REF-0-VG-Z

3.19.3 Sample Labeling QA/QC Procedures

Prior to leaving a sample location, the RMC FM or the most senior member of the sampling crew (if the RMC FM is not present) will check all samples and labels in order to insure that all samples have been collected and properly processed (if applicable), that sufficient quantity or mass of samples have been collected, that labels have been filled out properly, and that sample containers are properly sealed to prevent loss of sample during transport and storage. Performance of this check will be noted in the field logbook (Section 3.21.1).

3.20 Quality Control / Quality Assurance Samples

QA/QC sampling procedures will be followed to reduce cross contamination and sampling errors, as outlined in the QAPP.

ED_006076_00000126-00058

Field duplicates will be collected at a frequency of 5% (one per 20 primary samples) or one for each day of sampling, whichever is greater. Equipment rinsate blank samples will be collected at a frequency of 5% (one per 20) of the primary samples collected with non-disposable equipment. In cases where a field duplicate sample is collected, the higher of either the primary or field duplicate sample results for each analyte will be used for site characterization and risk assessment.

3.21 Field Documentation

Documentation of field activities consists of the information recorded in the field log book and on the field data forms. The following subsections provide details regarding each type of documentation. Field equipment and supplies are listed in Table 3-3.

3.21.1 Field Log Book

Documentation of field activities will be conducted in accordance with RMC SOP 5 (Sample Handling and Documentation). The field sampling team will maintain a daily comprehensive field logbook that includes:

- Date;
- Sampler names;
- Other personnel present;
- Activities performed;
- General site conditions;
- Weather conditions;
- Vegetative community observations;
- Sample times;
- Any significant field event or observations;
- Field calculations not recorded elsewhere; and
- References to information recorded elsewhere.

The field activities will be recorded in bound, waterproof notebooks. All entries will be will be made in permanent ink and will be clear, objective, and legible. Representative photographs will also be taken of field activities and sample locations, and a description will be recorded in the logbook. Photographs will be taken at each plant sampling location. The RMC Field Manager is responsible for maintenance and document control of the field logbook(s). The RMC Field Manager is identified in the QAPP.

ED_006076_00000126-00059

3.21.2 Field Forms

Specific field activities related to sample collection and equipment calibration will be recorded on the field forms included in Appendix C. Field forms should be filled out completely and should include notes indicating any pertinent information regarding each specific sample. All field calculations associated with a measurement or sample that is being recorded on a field form should also be recorded on the appropriate field form (i.e., purge volume calculations).

4.0 SAMPLE HANDLING AND ANALYSIS

4.1 Chain-of-Custody Procedures

The possession and handling of all environmental samples will be traceable from the time of collection, through analysis, until final disposition using a Chain-of-Custody record. The Chain-of-Custody record will be completed by sampling and laboratory personnel and will accompany every sample drop off. A sample container is considered to be in a person's custody if it is:

- In a person's physical possession;
- In view of the person after he or she has taken possession of it;
- Secured by the person so that no one can tamper with it; or
- In a secured area.

4.2 Custody Seals

Custody seals will be used for any samples shipped to a laboratory and will be attached to all shipping containers before the samples leave the custody of sampling personnel. Custody seals will bear the signature of the collector and the date signed, and will be attached so that they must be broken in order to open shipping containers. Custody seals will not be required for containers taken directly to the laboratory by sampling personnel.

4.3 Sample Analysis

Whenever possible, samples will be submitted to a local laboratory for analysis. Table 3-1 presents the parameters, analytical methods, laboratory methods, container types, preservation requirements and holding times for specified sample types and analytes.

5.0 REFERENCES

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ED_006076_00000126-00060

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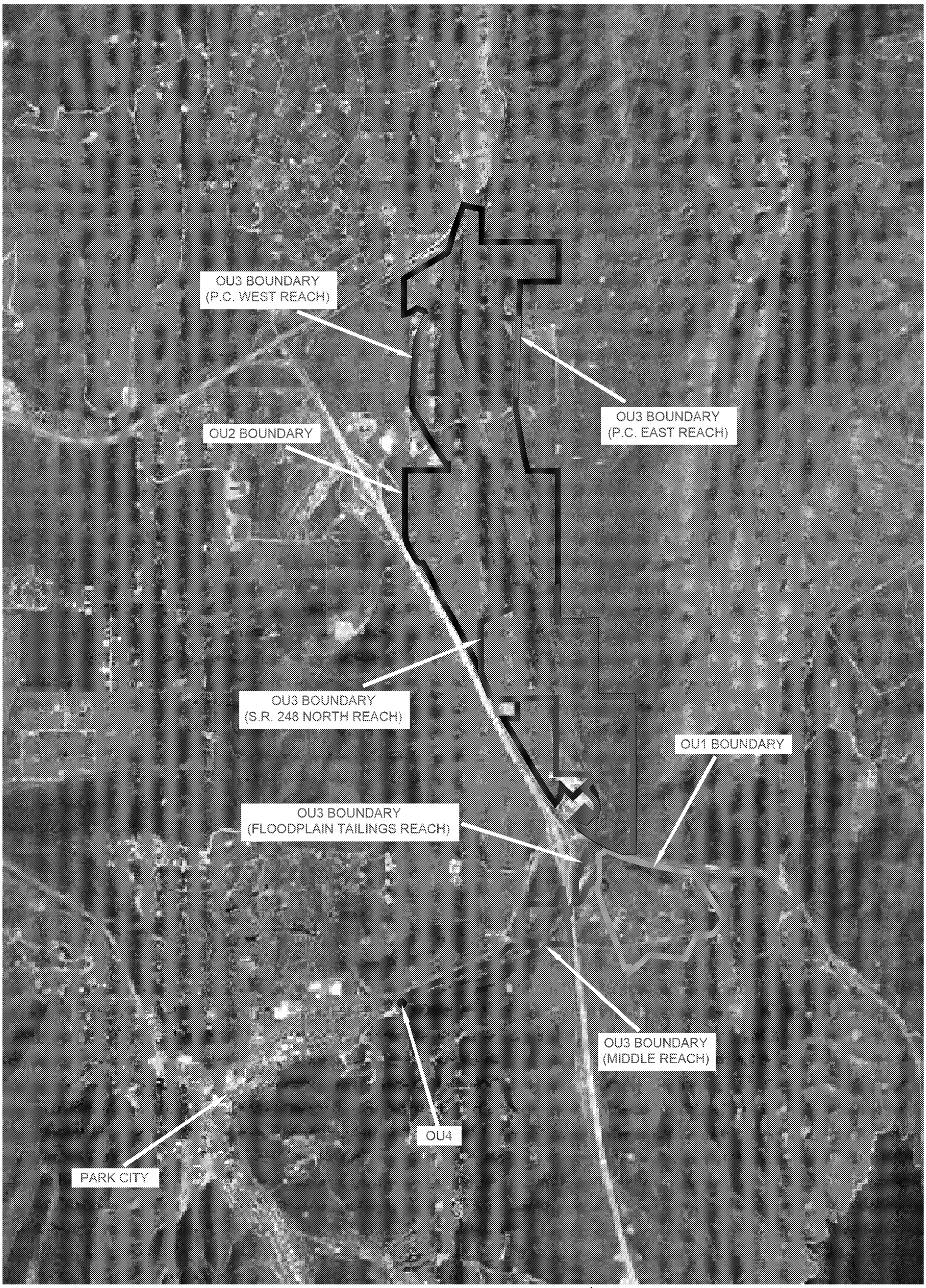
ED_006076_00000126-00061



SCALE
0 0.5 1.0
MILES

N

NOTES:
BOUNDARIES APPROXIMATE, NOT SURVEYED.
IMAGE SOURCE – ESRI MAP SERVER.

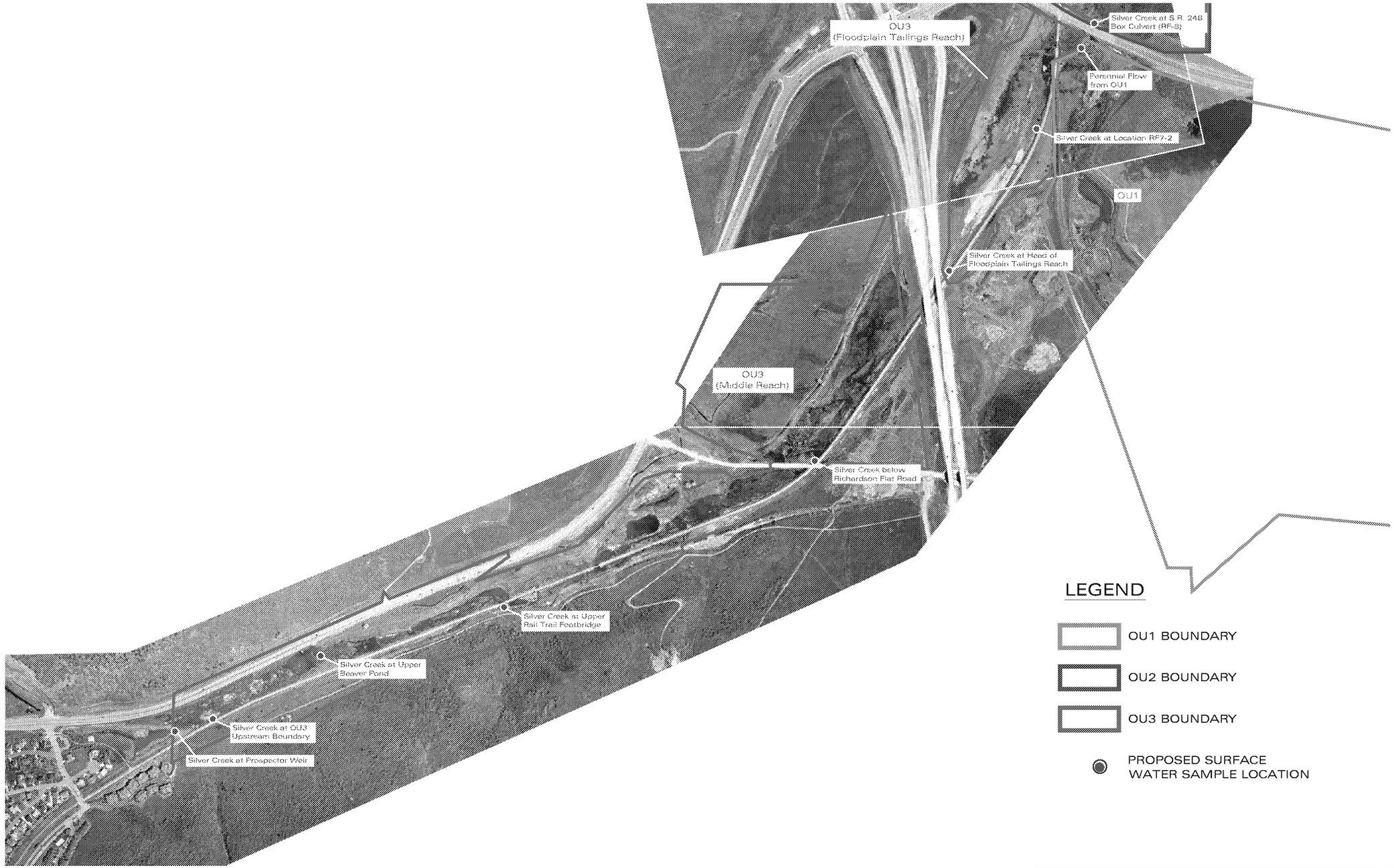
UNITED PARK CITY MINES

FIGURE 1-1
SITE MAP

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2825

MARCH 2014

site map.dwg



LEGEND

- OU1 BOUNDARY
- OU2 BOUNDARY
- OU3 BOUNDARY
- PROPOSED SURFACE WATER SAMPLE LOCATION

SCALE
0 400 800
FEET

N

UNITED PARK CITY MINES

FIGURE 3-1 (SHEET 1 OF 4)

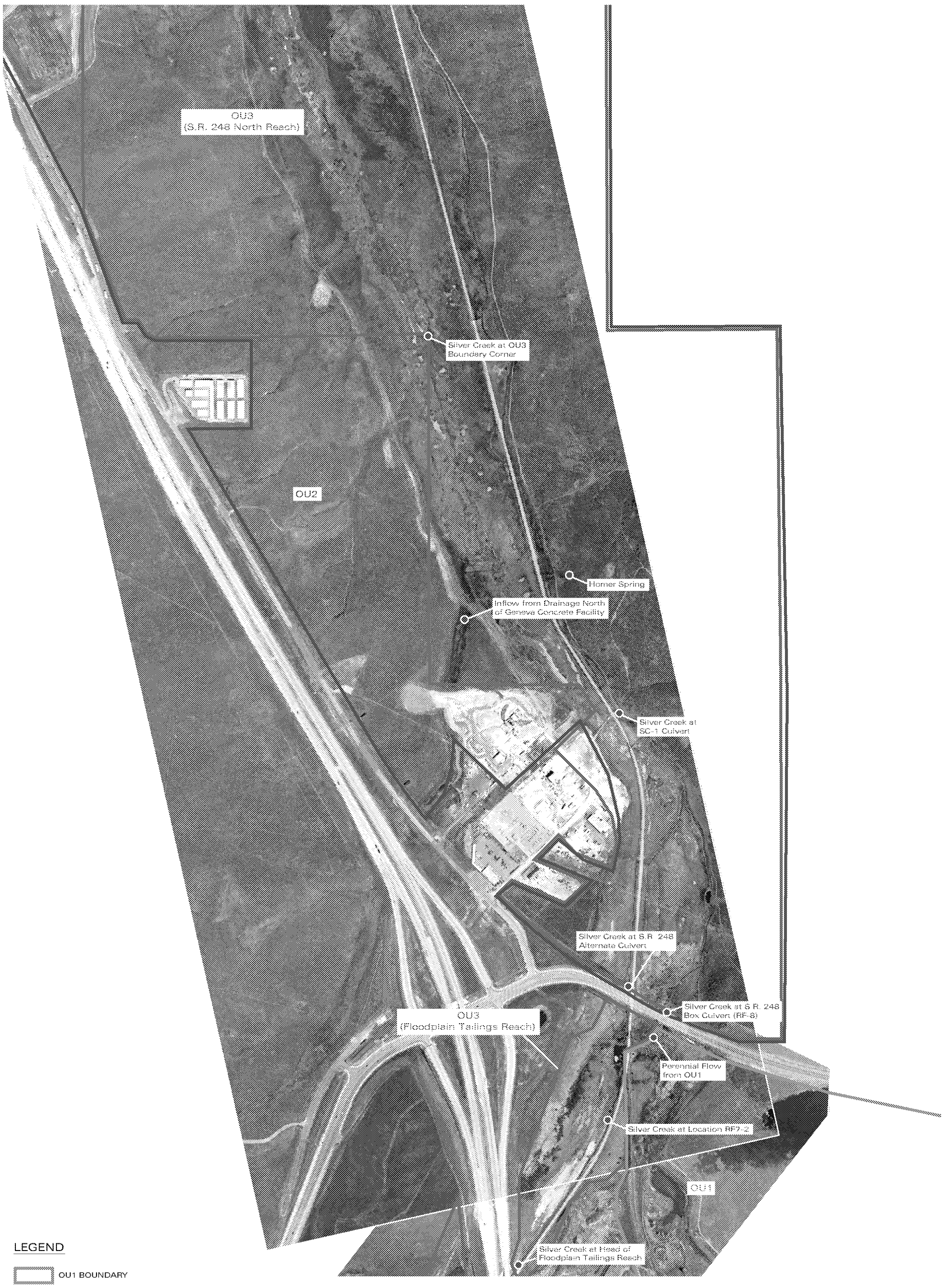
SURFACE WATER SAMPLE LOCATIONS

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

AUGUST 2014

ou23 sample locations-SW.dwg

Note: Locations and Operable Unit boundaries approximate.



LEGEND

- OU1 BOUNDARY
- OU2 BOUNDARY
- OU3 BOUNDARY
- PROPOSED SURFACE WATER SAMPLE LOCATION

SCALE
0 400 800
FEET

N

Note: Locations and Operable Unit boundaries approximate.

UNITED PARK CITY MINES

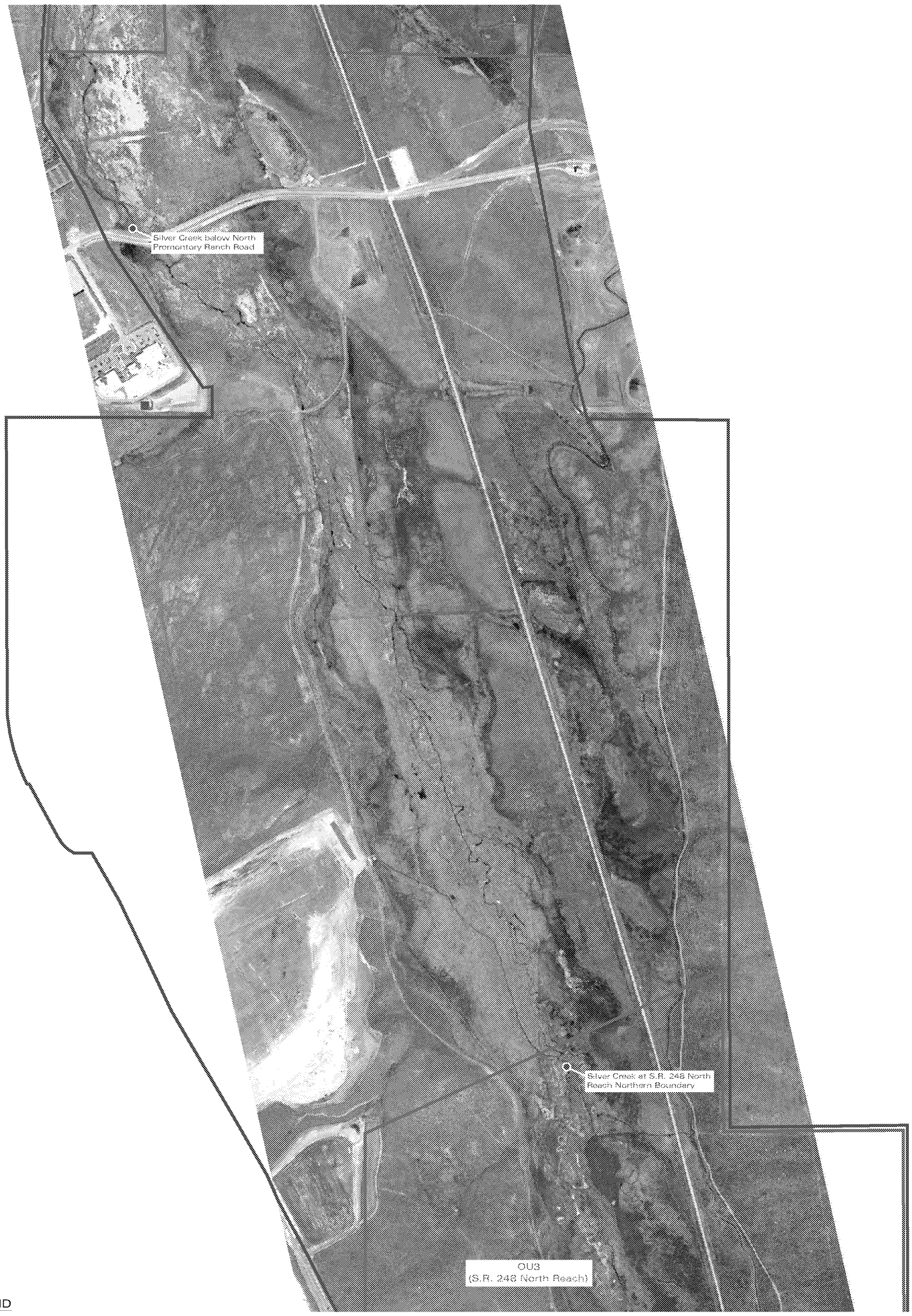
FIGURE 3-1 (SHEET 2 OF 4)

SURFACE WATER SAMPLE LOCATIONS

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

AUGUST 2014

ou23 sample locations-SW.dwg



LEGEND

OU2 BOUNDARY

OU3 BOUNDARY

PROPOSED SURFACE WATER SAMPLE LOCATION

SCALE
0 400 800
FEET

N

Note: Locations and Operable Unit boundaries approximate.

UNITED PARK CITY MINES

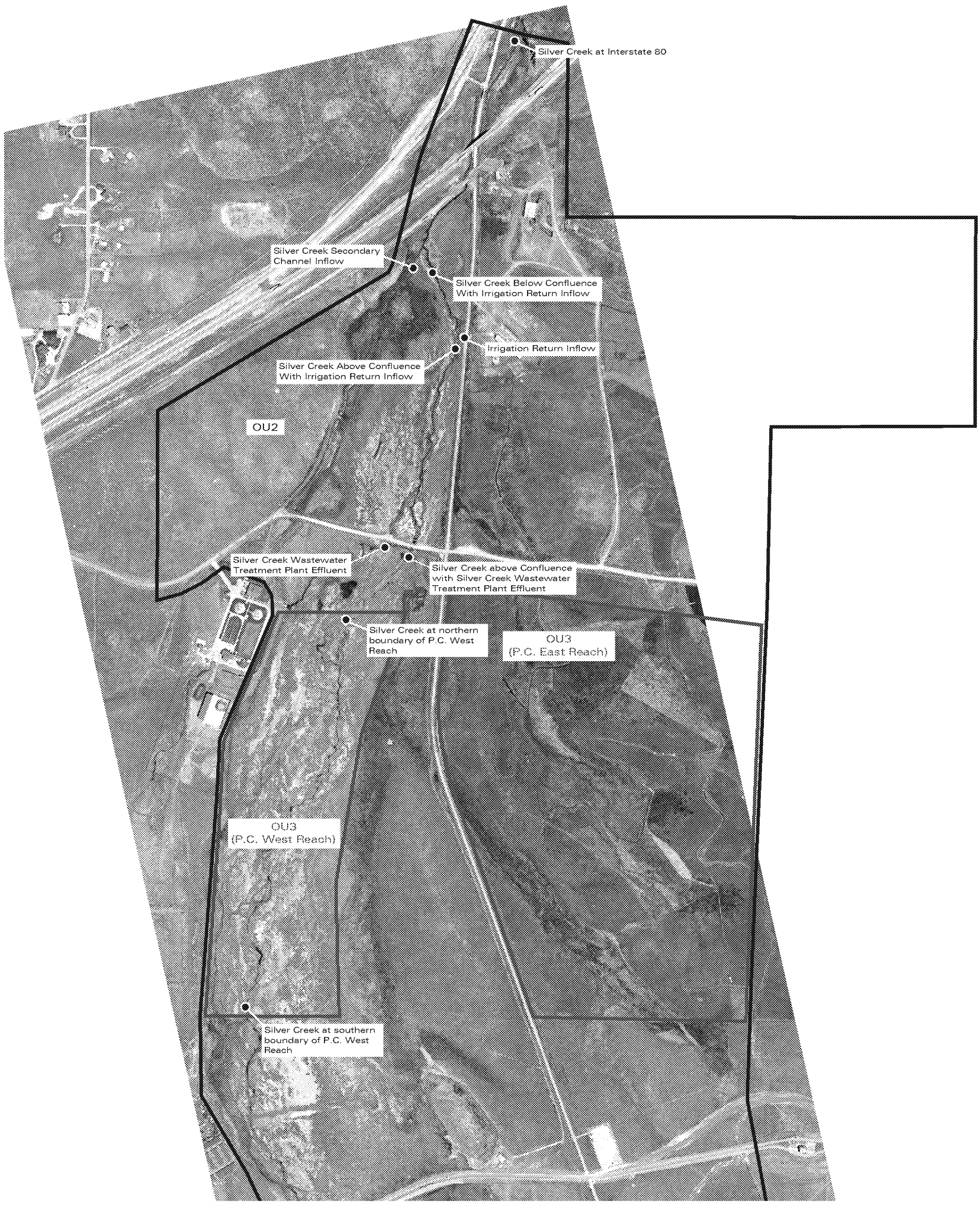
FIGURE 3-1 (SHEET 3 OF 4)

SURFACE WATER SAMPLE LOCATIONS

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

AUGUST 2014

ou23 sample locations-SW.dwg



LEGEND

- OU2 BOUNDARY
- OU3 BOUNDARY
- PROPOSED SURFACE WATER SAMPLE LOCATION

SCALE
0 400 800
FEET

N

UNITED PARK CITY MINES

FIGURE 3-1 (SHEET 4 OF 4)
SURFACE WATER SAMPLE LOCATIONS

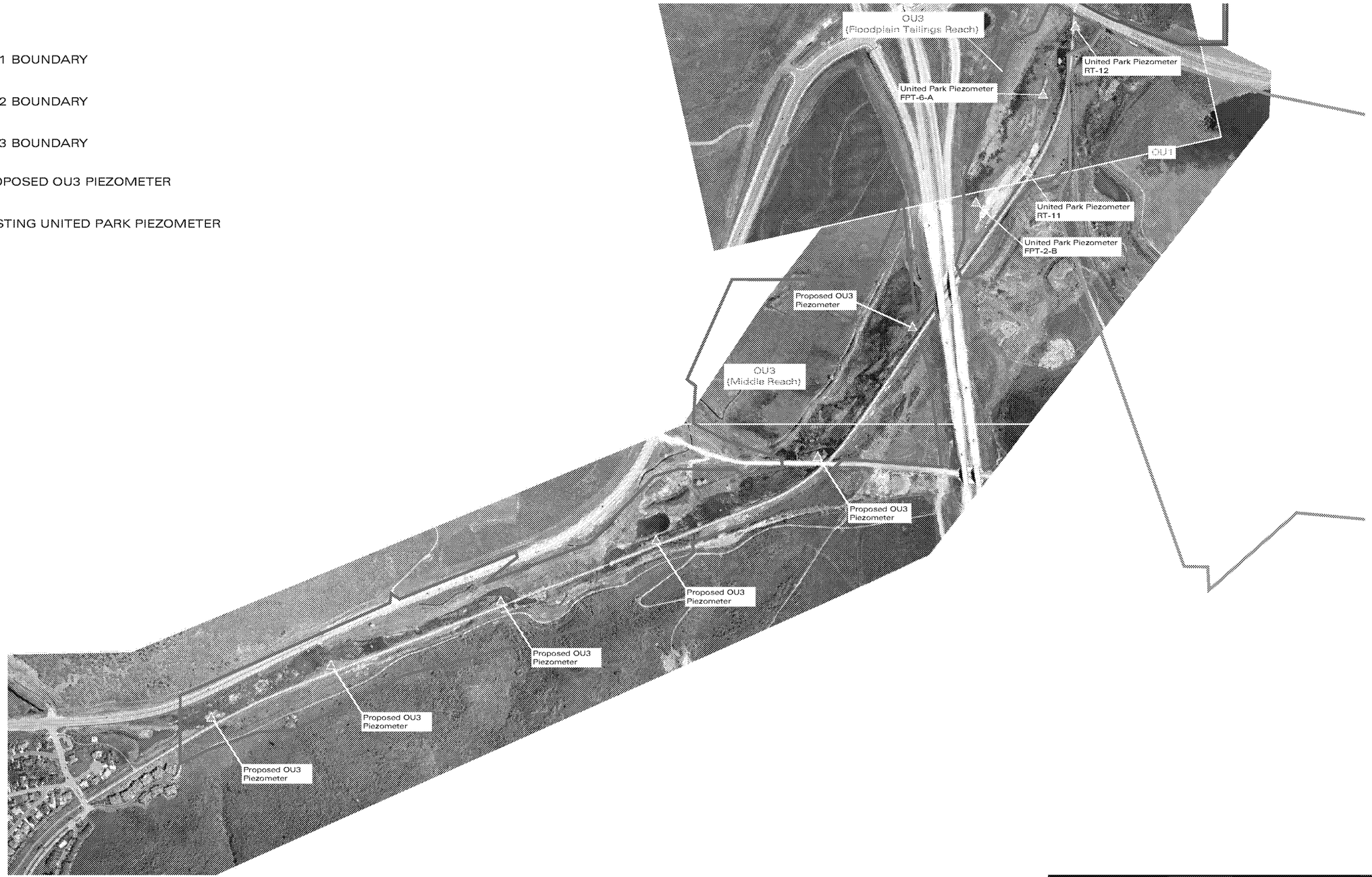
RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

AUGUST 2014

OU23 Sample locations—SW

LEGEND

- OU1 BOUNDARY
- OU2 BOUNDARY
- OU3 BOUNDARY
- PROPOSED OU3 PIEZOMETER
- EXISTING UNITED PARK PIEZOMETER



SCALE
0 400 800
FEET

N

Note: Locations and Operable Unit boundaries approximate.

Locations of proposed Middle Reach piezometers may be modified based on field conditions or EPA input.

UNITED PARK CITY MINES

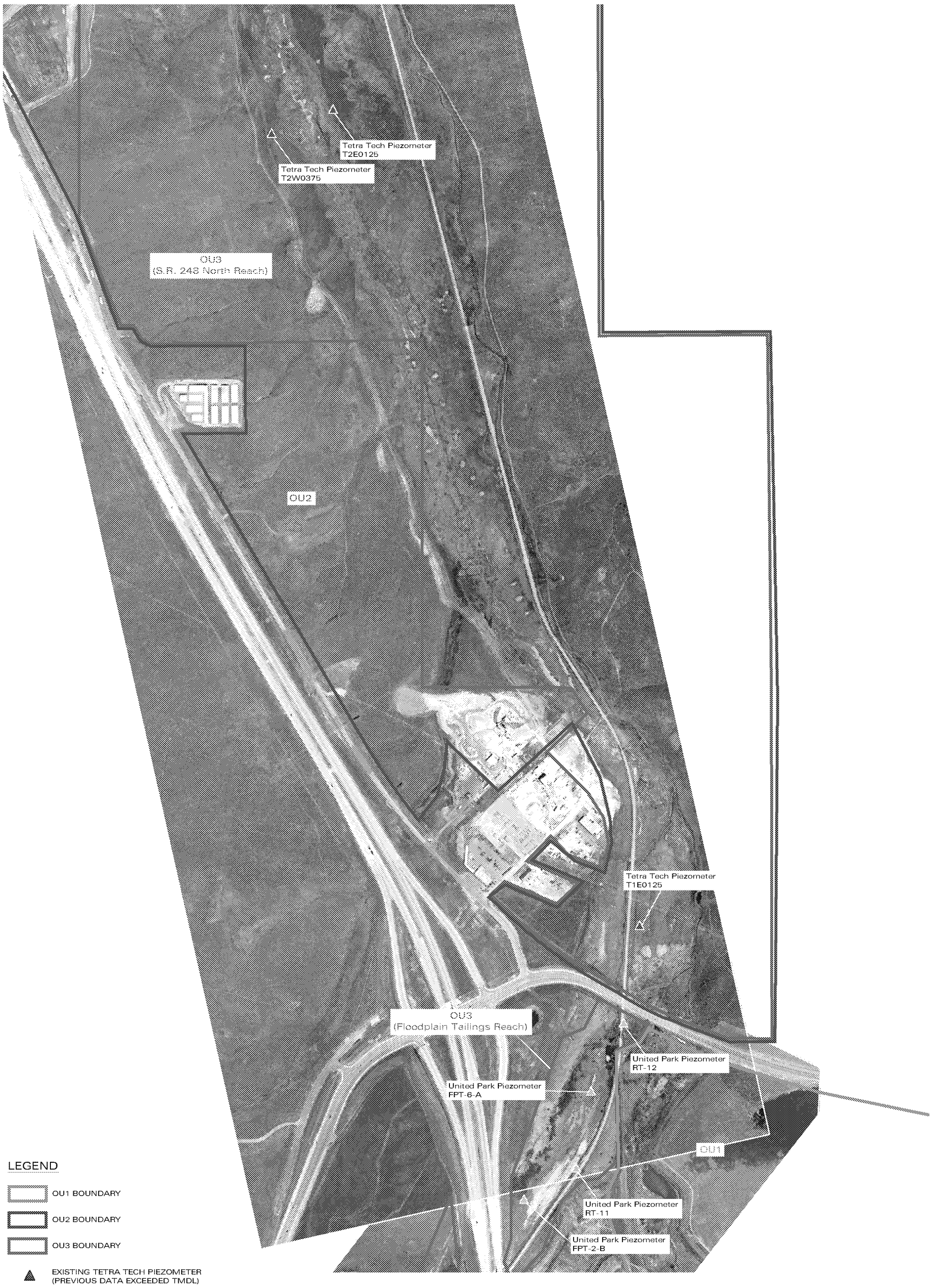
FIGURE 3-2 (SHEET 1 OF 4)

GROUNDWATER SAMPLE LOCATIONS

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

AUGUST 2014

ou23 sample locations-GW.dwg



LEGEND

- OU1 BOUNDARY
- OU2 BOUNDARY
- OU3 BOUNDARY
- EXISTING TETRA TECH PIEZOMETER (PREVIOUS DATA EXCEEDED TMDL)
- EXISTING TETRA TECH PIEZOMETER (PREVIOUS DATA BELOW TMDL)
- EXISTING UNITED PARK PIEZOMETER

SCALE
0 400 800
FEET

N

Note: Locations and Operable Unit boundaries approximate.

UNITED PARK CITY MINES

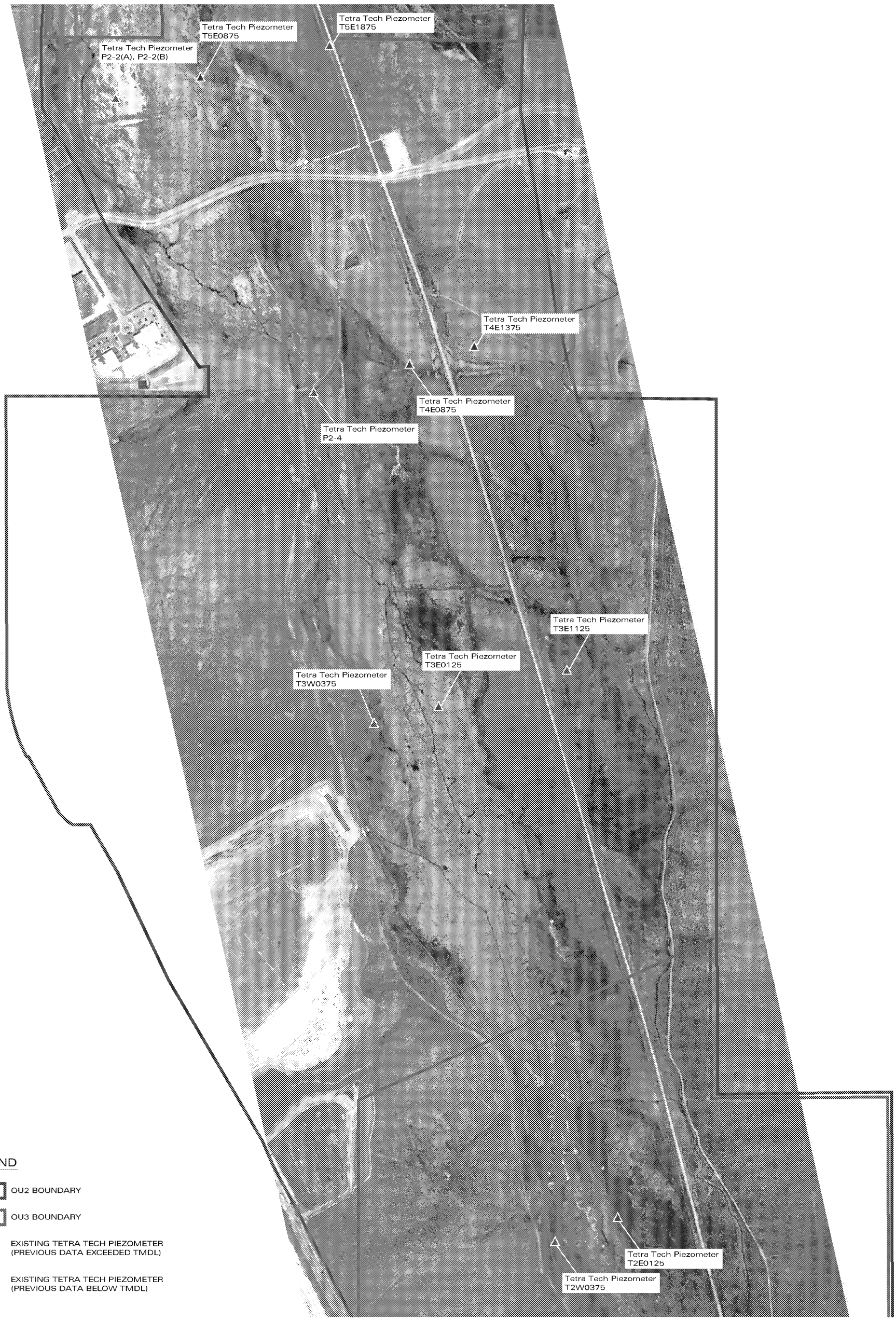
FIGURE 3-2 (SHEET 2 OF 4)

GROUNDWATER SAMPLE LOCATIONS

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

AUGUST 2014

ou23 sample locations-GW.dwg



LEGEND

OU2 BOUNDARY

OU3 BOUNDARY

EXISTING TETRA TECH PIEZOMETER (PREVIOUS DATA EXCEEDED TMDL)

EXISTING TETRA TECH PIEZOMETER (PREVIOUS DATA BELOW TMDL)

SCALE
0 400 800
FEET

N

Note: Locations and Operable Unit boundaries approximate.

UNITED PARK CITY MINES

FIGURE 3-2 (SHEET 3 OF 4)

GROUNDWATER SAMPLE LOCATIONS

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

AUGUST 2014

ou23 sample locations-GW.dwg

LEGEND

- OU2 BOUNDARY
- OU3 BOUNDARY
- EXISTING TETRA TECH PIEZOMETER (PREVIOUS DATA EXCEEDED TMDL)
- EXISTING TETRA TECH PIEZOMETER (PREVIOUS DATA BELOW TMDL)

Note: Locations and Operable Unit boundaries approximate.

SCALE
0 400 800
FEET

N

UNITED PARK CITY MINES

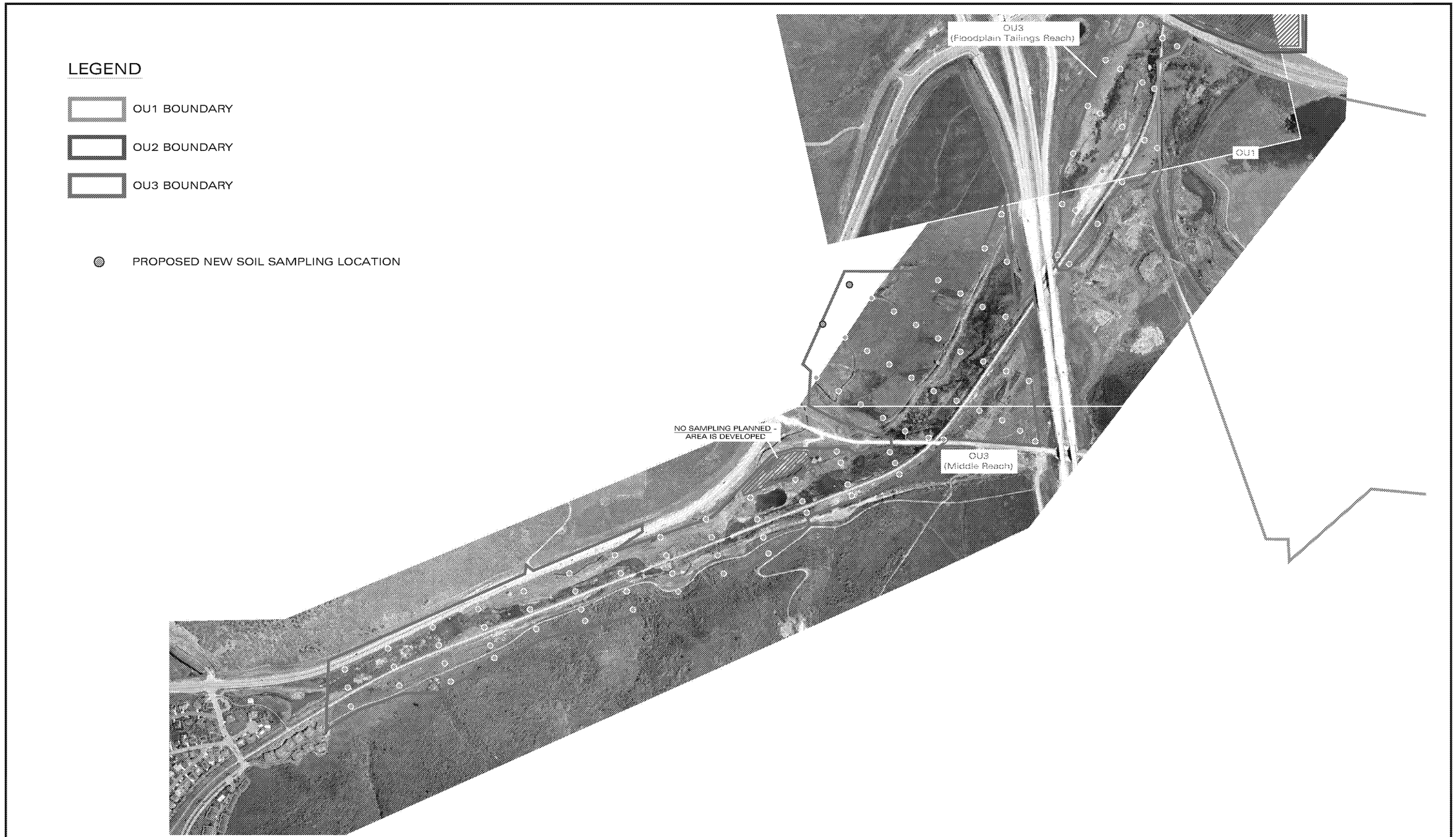
FIGURE 3-2 (SHEET 4 OF 4)

GROUNDWATER SAMPLE LOCATIONS

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

AUGUST 2014

ou23 sample locations-GW.dwg



Note: Locations and Operable Unit boundaries approximate.
Sample locations subject to change based on field
conditions observed at time of sampling.

UNITED PARK CITY MINES

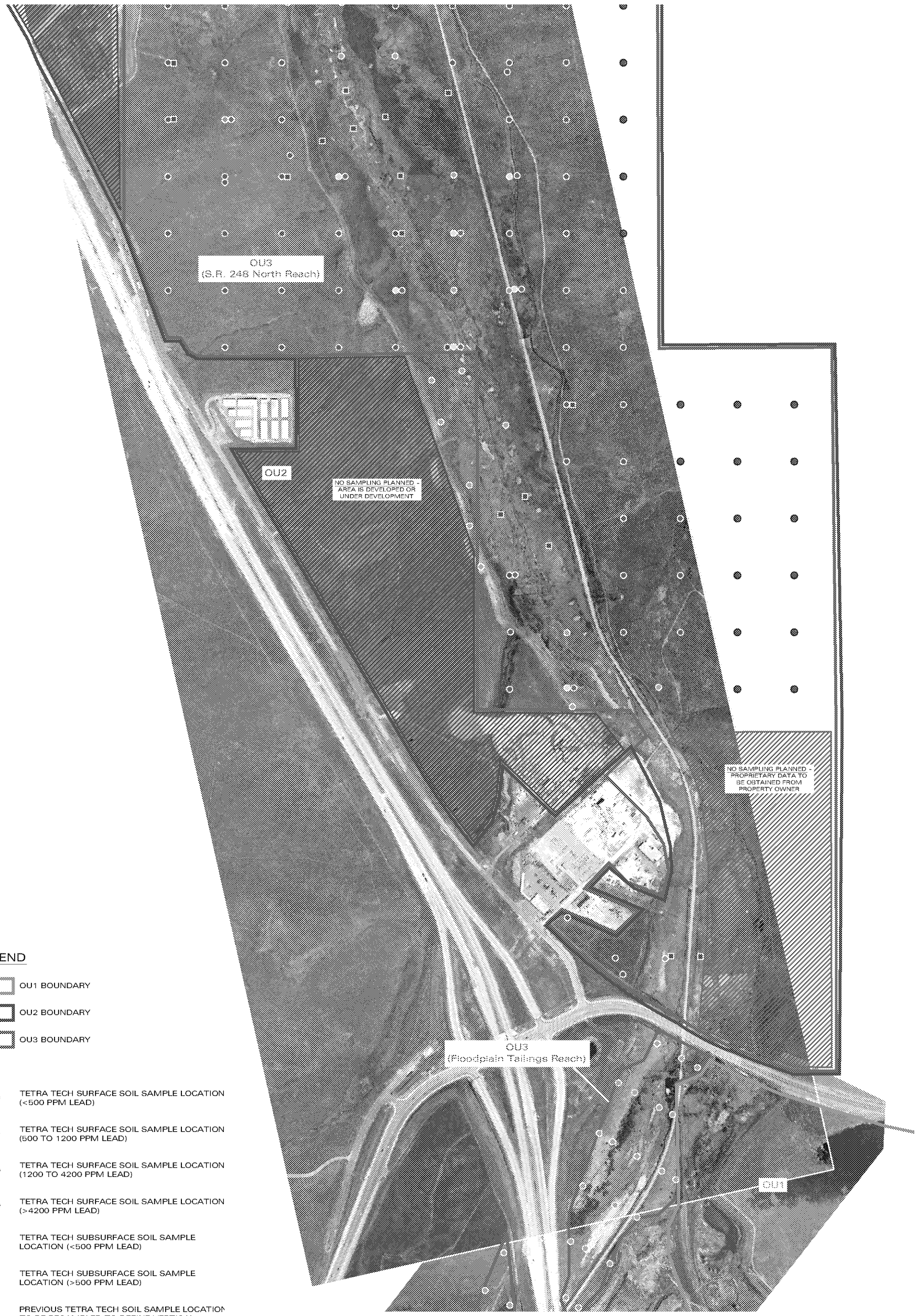
FIGURE 3-3 (SHEET 1 OF 4)

SOIL SAMPLE LOCATIONS

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

AUGUST 2014

ou23 sample locations-soil.dwg



LEGEND

- OU1 BOUNDARY
- OU2 BOUNDARY
- OU3 BOUNDARY
- TETRA TECH SURFACE SOIL SAMPLE LOCATION (<500 PPM LEAD)
- TETRA TECH SURFACE SOIL SAMPLE LOCATION (500 TO 1200 PPM LEAD)
- TETRA TECH SURFACE SOIL SAMPLE LOCATION (1200 TO 4200 PPM LEAD)
- TETRA TECH SURFACE SOIL SAMPLE LOCATION (>4200 PPM LEAD)
- TETRA TECH SUBSURFACE SOIL SAMPLE LOCATION (<500 PPM LEAD)
- TETRA TECH SUBSURFACE SOIL SAMPLE LOCATION (>500 PPM LEAD)
- PREVIOUS TETRA TECH SOIL SAMPLE LOCATION TO BE RESAMPLED TO DEFINE VERTICAL EXTENTS OF PREVIOUSLY DOCUMENTED CONTAMINATION
- PROPOSED NEW SOIL SAMPLING LOCATION

SCALE
0 400 800
FEET

N

Note: Locations and Operable Unit boundaries approximate. Sample locations subject to change based on field conditions observed at time of sampling.

UNITED PARK CITY MINES

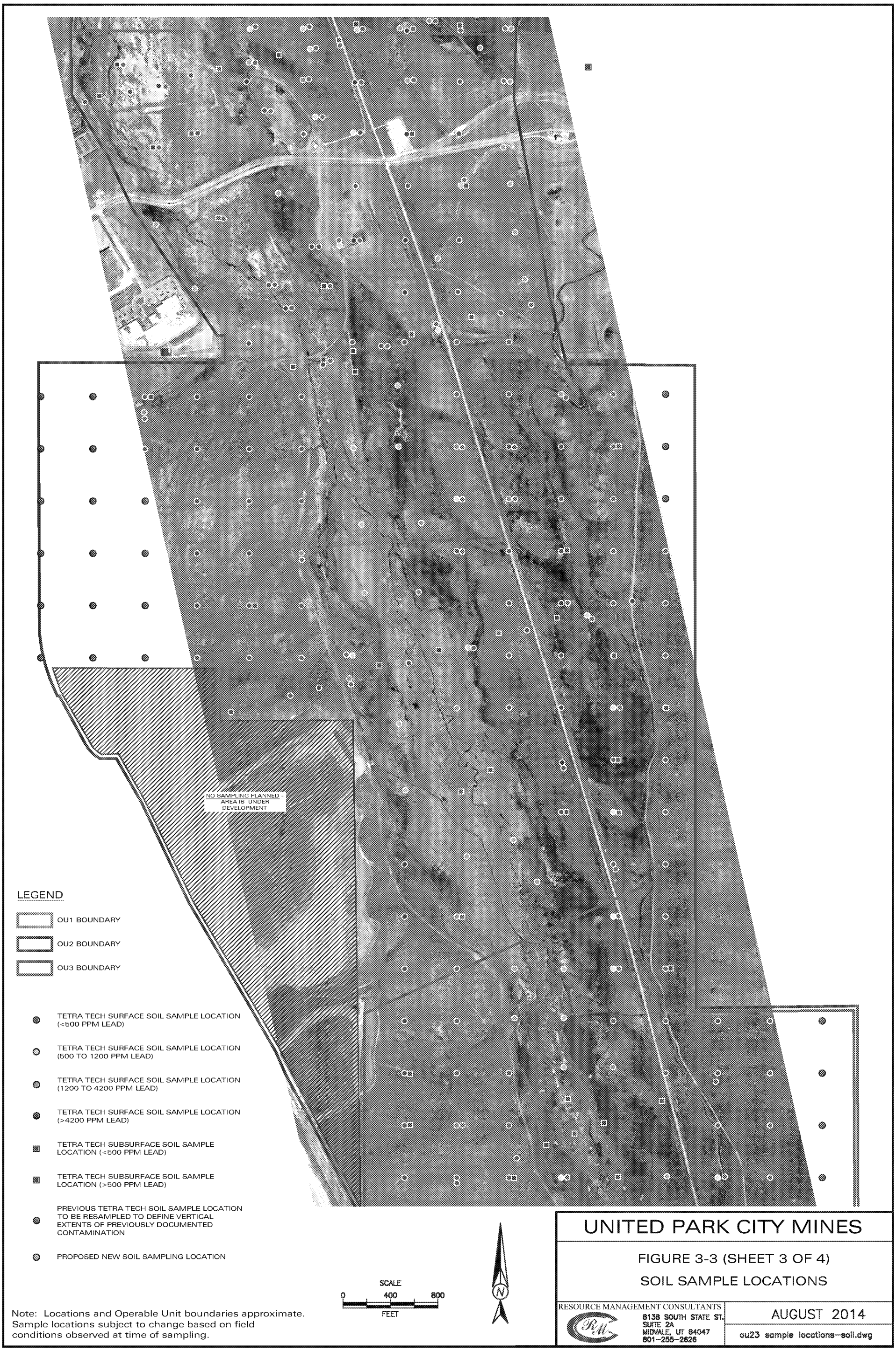
FIGURE 3-3 (SHEET 2 OF 4)

SOIL SAMPLE LOCATIONS

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

AUGUST 2014

ou23 sample locations-soil.dwg



Note: Locations and Operable Unit boundaries approximate. Sample locations subject to change based on field conditions observed at time of sampling.

UNITED PARK CITY MINES

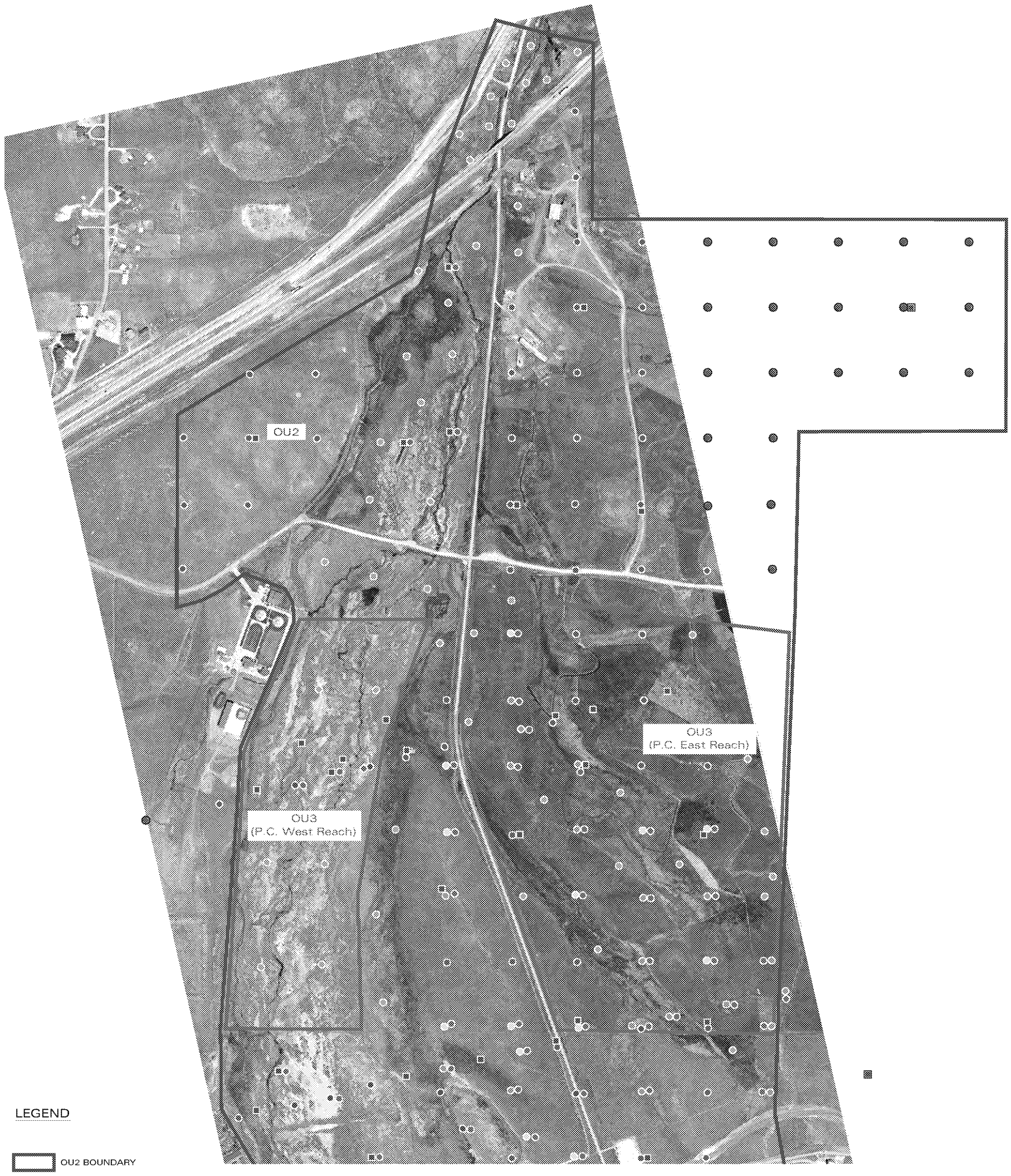
FIGURE 3-3 (SHEET 3 OF 4)

SOIL SAMPLE LOCATIONS

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

AUGUST 2014

ou23 sample locations-soil.dwg



LEGEND

OU2 BOUNDARY

OU3 BOUNDARY

TETRA TECH SURFACE SOIL SAMPLE LOCATION (<500 PPM LEAD)

TETRA TECH SURFACE SOIL SAMPLE LOCATION (500 TO 1200 PPM LEAD)

TETRA TECH SURFACE SOIL SAMPLE LOCATION (1200 TO 4200 PPM LEAD)

TETRA TECH SURFACE SOIL SAMPLE LOCATION (>4200 PPM LEAD)

TETRA TECH SUBSURFACE SOIL SAMPLE LOCATION (<500 PPM LEAD)

TETRA TECH SUBSURFACE SOIL SAMPLE LOCATION (>500 PPM LEAD)

PREVIOUS TETRA TECH SOIL SAMPLE LOCATION

SCALE
0 400 800
FEET

N

Note: Locations and Operable Unit boundaries approximate. Sample locations subject to change based on field conditions observed at time of sampling.

UNITED PARK CITY MINES

FIGURE 3-3 (SHEET 4 OF 4)

SOIL SAMPLE LOCATIONS

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

AUGUST 2014

ou23 sample locations-soil.dwg

TABLE 1-1
Previous Investigations
Richardson Flat OU2 and OU3
Field Sampling Plan

Study/Document	Author/Entity	Date	Conducted For	Soil	Groundwater	Surface Water	Sediments	Plants	Fish	Macroinvertebrates	Wildlife	Wetlands	Hydrology	Removal/Remediation	Risk Assessment	Location
Focused Remedial Investigation (RI) Report for Richardson Flat	RMC	2004	United Park	*	*	*	*	*	*	*			*		*	RF OU1-Adjacent to OU2 and OU3
Hydrogeologic Review of Richardson Flat Tailings Site.	MWH	2002	United Park										*			RF-Adjacent to OU3
Screening Ecological Risk Assessment	Syracuse Research Corporation	2003	EPA	*	*	*	*	*	*	*	*	*			*	RF OU1-Adjacent to OU2 & OU3
Baseline Ecolgical Risk Assesmment for the Richardson Flat Tailing Site	Syracuse Research Corporation	2004	EPA	*	*	*	*	*	*	*		*			*	RF OU1-Adjacent to OU2 & OU3
Baseline Human Health Risk Assessment for Recreational Visitors at Richardson Flat Tailings	Syracuse Research Corporation	2003	EPA												*	RF OU1-Adjacent to OU2 & OU3
Record of Decision, Richardson Flat Tailings Site	EPA	2005	EPA	*	*	*	*	*	*	*			*	*	*	RF OU1-Adjacent to OU2 & OU3
Richardson Flat Remedial Design Remedial Action Work Plan	RMC	2008	United Park											*		RF OU1-Adjacent to OU2 & OU3
Analytical Results for Surface Water Monitoring Activities Conducted May 2000,	RMC	2000	USCWG			*	*									Area-Wide
Analytical Results for Surface Water Monitoring Activities Conducted September and November 2000	RMC	2000	USCWG			*	*									Area-Wide
Innovative Assessment Analytical Results Report	Tillia, Ann M/UDERR	2002	UDERR	*		*	*									OU3 - Onsite
Silver Creek Total Maximum Daily Load for dissolved zinc and cadmium	Michael Baker Jr., Inc.	2004	UDWQ			*										Area-Wide
Water Resources of the Park City Area, Utah with Emphasis on Groundwater	UDERR/USGS Holmes, et al.	1986	UDERR/ USGS										*			Area-Wide
Geology of Synderville basin, Western Summit County, Utah, and its realation to Groundwater Conditions	UGS	2001											*			
Draft Lower Silver Creek Data Summary Report	Tetra Tech Inc.	2008	EPA	*	*	*	*									OU2 & OU3 - Onsite and Area-Wide

TABLE 1-1
Previous Investigations
Richardson Flat OU2 and OU3
Field Sampling Plan

Study/Document	Author/Entity	Date	Conducted For	Soil	Groundwater	Surface Water	Sediments	Plants	Fish	Macroinvertebrates	Wildlife	Wetlands	Hydrology	Removal/Remediation	Risk Assessment	Location
Lower Silver Creek Draft Wetland Delineation	Tetra Tech Inc.	2008	EPA									*	*			OU2 & OU3 - Onsite and Area-Wide
Lower Silver Creek, Utah, Reactive Transport Modeling Under High Flow Conditions for Cadmium and Zinc	Tetra Tech Inc.	2008	EPA			*							*			OU2 & OU3 - Onsite and Area-Wide
QuickSite Investigation for the Upper Silver Creek Watershed	Argonne National Laboratory	2003	EPA										*			OU2 & OU3 - Onsite and Area-Wide
Data Interpretation Report, Upper Silver Creek Watershed	Jim Christiansen/EPA	2001	EPA/USCWG			*	*									OU3 - Onsite and Area-Wide
Trace metal concentrations in sediment and water and health of aquatic Macroinvertebrate communities of streams near Park City	Giddings, et al./USGS	2001	USGS			*	*			*						OU3 - Onsite and Area-Wide
Quantification of metal loading to Silver Creek through the Silver Maple Claims	Kimball, et al./USGS	2004	USGS			*							*			OU3 - Onsite and Area-Wide
Principal Locations of Metal Loading from Floodplain Tailings	Kimball, et al./USGS	2005	USGS			*							*			OU3 - Onsite and Area-Wide
Final Silver Maple Wetland Functional Assessment	Dynamac Corporation	2003	BLM			*	*	*				*				OU3 - Onsite
Removal Site Inspection, Silver Maple Claims.	BLM	2005	BLM	*		*	*	*		*	*	*	*		*	OU3 -Onsite
Silver Maple Claims site inspection report	BLM	1989	BLM	*	*	*	*						*			OU3 -Onsite
Lower Silver Creek level II Riparian Survey	RMC	2009	United Park					*								OU2 & OU3 - Onsite

TABLE 3-1
Summary of Laboratory Analysis, Methods, and Bottles
Richardson Flat OU2 and OU3
Field Sampling Plan

Media	Parameters	Analytical Method	Container	Volume	Temperature[1]	Preservative	Hold Days
SURFACE WATER	Field Parameters:	RMC SOP 9	In-stream, flow cell, or polyethylene	Bottle 5	NA	None	1
	pH						
	Conductivity						
	Temperature						
	Dissolved Oxygen						
	Oxidation-Reduction Potential						
	Metals (Total and Dissolved):	SW846 6020 or 200.8	Polyethylene	Bottle 1, 2	4°C ± 2°C	HNO_3	180
	Aluminum						
	Antimony						
	Arsenic						
	Barium						
	Berylilium						
	Cadmium						
	Chromium						
	Cobalt						
	Copper						
	Iron						
	Lead						
	Manganese						
	Nickel						
	Selenium						
	Silver						
	Thallium						
	Vanadium						
	Zinc						
	Mercury	SW846 7470A					28
	Calcium	SW846 6020					180
	Magnesium						
	Potassium						
	Sodium						
	Hardness	2340B[2] (calculation)	N/A	N/A	N/A	N/A	N/A
	Phosphorus	E365.4	Polyethylene	Bottle 3	4°C ± 2°C	HNO_3	28
	Total Suspended Solids	SM2540D	Polyethylene	Bottle 4	4°C ± 2°C	None	7
	Nitrate	E300.0					2
	Chloride						28
	Sulfate						28
	Alkalinity	SM2420B					14
	Total Dissolved Solids	SM2540C					7
	Field Parameters:	RMC SOP 9	In-stream, flow cell, or polyethylene	Bottle 5	NA	None	1
	pH						
	Conductivity						
	Temperature						
	Dissolved Oxygen						
	Oxidation-Reduction Potential						
	Metals (Total and Dissolved):	SW846 6020 or 200.8					180
	Aluminum						
	Antimony						
	Arsenic						
	Barium						
	Berylilium						
	Cadmium						
	Chromium						
	Cobalt						
	Copper						
	Iron						

TABLE 3-1
Summary of Laboratory Analysis, Methods, and Bottles
Richardson Flat OU2 and OU3
Field Sampling Plan

Media	Parameters	Analytical Method	Container	Volume	Temperature[1]	Preservative	Hold Days
GROUNDWATER	Lead		Polyethylene	Bottle 1, 2	4°C ± 2°C	HNO_3	
	Manganese						
	Nickel						
	Selenium						
	Silver						
	Thallium						
	Vanadium						
	Zinc						
	Mercury	SW846 7470A					28
	Calcium	SW846 6020					180
	Magnesium						
	Potassium						
	Sodium						
	Hardness	2340B[2] (calculation)	N/A	N/A	N/A	N/A	N/A
	Phosphorus	E365.4	Polyethylene	Bottle 3	4°C ± 2°C	HNO_3	28
	Total Suspended Solids	SM2540D	Polyethylene	Bottle 4	4°C ± 2°C	None	7
	Nitrate	E300.0					2
	Chloride						28
	Sulfate						28
	Alkalinity	SM2420B					14
	Total Dissolved Solids	SM2540C					7
SOIL	Metals (Laboratory):	SW846 6020	Glass Jar	4 oz.	4°C ± 2°C	None	180
	Aluminum						
	Antimony						
	Arsenic						
	Barium						
	Berylilium						
	Cadmium						
	Calcium						
	Chromium						
	Cobalt						
	Copper						
	Iron						
	Lead						
	Magnesium						
	Manganese						
	Nickel						
	Potassium						
	Selenium						
	Silver						
	Sodium						
	Thallium						
	Vanadium						
	Zinc						
	Mercury	SW846 7470A					28
	Phosphorus	SW846 6010B					180
	Metals (XRF):	XRF - EPA 6200	Ground Shot or Polyethylene Bag	N/A	N/A	N/A	180
	Arsenic						
	Chromium						
	Cobalt						
	Copper						
	Iron						
	Lead						
	Manganese						
	Mercury						
	Nickel						
	Selenium						
	Zinc						
	Metals (Laboratory):						
	Aluminum						

TABLE 3-1
Summary of Laboratory Analysis, Methods, and Bottles
Richardson Flat OU2 and OU3
Field Sampling Plan

Media	Parameters	Analytical Method	Container	Volume	Temperature[1]	Preservative	Hold Days
SEDIMENT	Antimony	SW846 6020	Glass Jar	4 oz.	4°C ± 2°C	None	180
	Arsenic						
	Barium						
	Berylilium						
	Cadmium						
	Calcium						
	Chromium						
	Cobalt						
	Copper						
	Iron						
	Lead						
	Magnesium						
	Manganese						
	Nickel						
	Potassium						
	Selenium						
	Silver						
	Sodium						
	Thallium						
	Vanadium						
	Zinc						
	Mercury	SW846 7470A					28
	Methylmercury	EPA 1630					
	Phosphorus	SW846 6010B					180
	Metals (XRF):	XRF - EPA 6200	Ground Shot or Polyethylene Bag	N/A	N/A	N/A	180
	Arsenic						
	Cobalt						
	Copper						
	Iron						
	Lead						
	Manganese						
	Mercury						
	Nickel						
	Selenium						
	Zinc						
PLANT, MACROINVERTEBRATE, AND FISH TISSUE	Plants - Metals Per Soil or Sediment Lists Above Depending on Collection Location (upland or wetland, respectively) Fish and Macroinvetebrates - Metals Per Sediment List Above	Per Soil and Sediment Lists Above					
	Moisture Content	EPA 160.3	Glass Jar	4 oz.	4°C ± 2°C	None	28

Bottle List:
Bottle 1 - 500 ml bottle filtered to 0.45 µm and preserved with HNO_3
Bottle 2 - 500 ml bottle unfiltered and preserved with HNO_3
Bottle 3 - 250 ml bottle unfiltered and preserved with HNO_3
Bottle 4 - 1000 ml bottle unfiltered and unpreserved
Bottle 5 - 500 ml bottle unfiltered and unpreserved for field parameters.

[1] Upon receipt at analytical laboratory
[2] Standard Methods, 20th edition (APHA, 1989)

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Table 3-3
Field Equipment and Supplies
Richardson Flat OU2 and OU3
Field Sampling Plan

Sampling	Health & Safety	Decontamination (If Required)	General
Stainless steel spoons	Latex gloves (500 pr)	Plastic squirt bottles (2)	GPS
Steel shovels	Sunscreen	Plastic trash bags (1 boxes)	Wooden stakes (20)
Stainless steel bowls	Rubber boots	Deionized water (5 gallons)	Flagging (2 rolls)
Pruning shears	Copy of HASP	Nitric acid (10% solution - 1 gallons)	Coolers (2)
Stainless steel scissors	Steel-toe boots (if required)	Alconox (1 carton)	Copy of SAP
Self-sealing plastic bags (30 qt. size; 50 gal. size)	Clothing appropriate for daily conditions	Plastic buckets (3 5-gal)	1 or 0.75 square meter PVC grid
Paper grocery bags (for biomass samples)	Hard-hat (if required)	Scrub brushes (3)	Copy of SAP
Field Logbook		Sprayer (1-liter)	Consumables
Plastic buckets (3 5-gal)			
Plastic trash bags (1 box of large - 30 count)			
Peristaltic pump and tubing (for field filtering, if required)			
0.45 um filters (for field filtering, if required)			
Polyethylene bottles (1 liter, 0.5 liter)			
HNO3, H2SO4 (if required)			
Fish traps/seines			
Kick nets			
Specialized sample containers (as required)			

Note: Quantities will be dependent on each specified task.

Appendix A – Standard Operating Procedures

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RMC SOP 2C - GEOPROBE SAMPLING

RMC SOP 3A - HOLLOWSTEM AUGER DRILLING, SOIL SAMPLING AND MONITORING WELL INSTALLATION

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RMC SOP 3C - STANDARD PROCEDURES FOR GROUNDWATER SAMPLING

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EPA-600-R-92-111 – FISH FIELD AND LABORATORY METHODS FOR EVALUATING THE BIOLOGICAL INTEGRITY OF SURFACE WATERS

SERAS STANDARD OPERATING PROCEDURES FOR TERRESTRIAL PLANT COMMUNITY SAMPLING

RMC SOP 1
STANDARD PROCEDURES FOR COLLECTION OF SURFACE WATER SAMPLES AND GENERAL WATER SAMPLE HANDLING

1.0 Purpose

This SOP describes the procedures that will be used for collection of surface water samples. The procedures will ensure that samples are collected and handled properly and that appropriate documentation is completed.

2.0 Sampling Equipment:

- Log forms / Field notebook / Chain of Custody Forms (COC) – Documentation of sample activities, field notes and sample custody.
- Sample containers – Containers provided by laboratory for the collection, storage and transportation of samples.
- Direct reading instruments – field instruments to measure pH, DO, ORP, conductivity and temperature.
- Disposable sampling gloves – to prevent exposure to water and the prevention of cross-contamination.
- Custody seals – seals to be placed on sample containers to maintain sample integrity.
- 0.45 um filter apparatus with inert filters – for filtering samples in preparation for the analysis of dissolved metals.
- Nitric acid (HNO_3, supplied by the analytical laboratory) – for sample preservation.
- Water velocity meter and tape measure – to measure stream flow (where applicable).
- Laboratory grade reagent water – for preparation of bottle blanks (if required).
- Deionized water – for rinsing direct reading instruments.
- Custody seals – seals to be placed on sample containers to maintain sample integrity (where required).

3.0 Procedure

Samples will always be collected in a downstream to upstream direction except for synoptic events, where disturbance of the sediment during the water sampling is prevented and sampling is conducted without entering the stream (i.e., from the bank or a platform).

Sample bottles will remain sealed until the water sample is collected. At that time, the bottle lid will be removed and placed, top down, in an appropriate place. The sample bottle will be placed under the flow of water. If wading is required for sample collection, the sample must be collected upstream of wading personnel to avoid the sampling of suspended sediments. A dipping bottle or peristaltic pump may be used for difficult to access locations. Non pre-preserved containers will be rinsed three times. After rinsing, the container will be completely filled; any overflow of the sample container will be kept to a minimum. Sediment disturbance shall be kept to an absolute minimum. The sample cap will then be replaced on the sample bottle. All surface water samples will be collected in accordance with containers, volumes, preservatives, temperatures and holding times as outlined in the appropriate QAPP/SAP and FSP.

4.0 Dissolved Metals Analysis

Samples collected for analysis of dissolved metals will be filtered in the field at the time of collection or as soon thereafter as practically possible. Surface water samples collected for analysis of dissolved metals and filtered in the field will be a minimum volume of 500 ml, collected in a poly or glass container. The field filtering methodology will include the following steps:

1: Sample shall be collected in a new, clean bottle.

2: Sample is poured into the top flask of the disposable plastic filter. Use a portion of the sample to rinse the filter flask, discard this portion and proceed with filtering the required sample volume.

3: Vacuum pump is attached to the filter and pumped. A cartridge filter and peristaltic pump may also be used. If a cartridge filter is used the sample will be pumped through the filter using clean tubing.

4: When the bottom compartment of the filter is full, the water is to be transferred into a laboratory supplied pre-preserved sample container.

A peristaltic pump, disposable tubing, and in-line filter may also be used for field filtration of water samples.

5.0 Total Metals Analysis

Surface water samples collected for analysis of total metals will be a minimum volume of 500 ml or volume specified by the analytical laboratory, collected in a laboratory supplied pre-preserved sample container.

6.0 Other Analyses

Samples for other analyses shall be collected in accordance with the methodologies outlined in the Procedure section of this SOP. Sample preservation requirements will be dependent on the analytes to be analyzed. A list of analytes will be prepared as part of the project SAP/QAPP and/or FSP.

7.0 Stream flow Measurement

Stream flow rates shall be measured during surface water sampling activities. To minimize sediment disturbance during sampling, the stream flow measurements should be conducted either downstream from the sampling point or after the completion of sample collection. RMC uses an electronic flow meter. The procedure for measuring stream flows is as follows:

1: Measure the width of the stream and divide the width into 1.0 foot increments if the stream is 10 feet wide or less. If the stream is wider than 10 feet, divide the stream width into 10 equal width segments.

2: At the midpoint of each width increment, record the total depth of the stream. The water velocity shall be measured at 0.6 of the total depth of the water (e.g. if the water is one foot deep the velocity is measured at a depth of 0.4 feet from the surface or 0.6 feet from the streambed).

3: Turn the electronic stream flow meter on. Set the meter to record the average velocity. Insert the stream flow meter into the water at the midpoint of each segment with the arrow pointing in the direction of flow. Measure the velocity for approximately 20 seconds and record the average.

4: Calculate the stream flow by calculating the area of each segment by multiplying the width by the depth. To obtain the flow volume for each segment multiply the area of the segment by the average flow velocity for the segment. To obtain the total stream flow, add the total stream flow for each segment. An Excel spreadsheet is typically used for the calculations.

Calculations:

Segment flow volume = depth of segment x width x flow velocity (feet/sec.) = cubic feet/ second
Total flow volume = sum of segment flow volumes.

Culverts and other structures will be calculated by multiplying the velocity and area.

8.0 Labeling

Each sample will be labeled with the following information:

- Sample identification;

- Project number/name;
- Analyses requested;
- Preservatives (if required);
- Date/time collected; and
- Samplers initials.

9.0 Documentation

Field activities shall be recorded in a hard bound field notebook. Field notes shall include all pertinent information including but not limited to:

- Date and time samples were collected;
- Physical description of sample area;
- Identification of samples collected;
- Total number of samples collected;
- Total number of samples collected from each sample location;
- Physical description of samples;
- Preservatives used for samples;
- Sample container types;
- Filtered vs. Unfiltered samples (water);
- Analysis to be performed;
- Weather conditions;
- Hand sketches of subject area(s); and
- Description and date of any photograph(s) taken.

Sample handling and Chain of Custody documentation shall be in accordance with RMC SOP 5.

10.0 Demobilization

After Decontamination, sample equipment will be stored in the appropriate, clean containers. Any equipment that suffers damage or excessive wear while conducting sampling will be labeled and reported to the equipment manager for the necessary maintenance, repair and/or replacement.

11.0 References

http://www2.epa.gov/sites/production/files/documents/r8-src_eh-01.pdf

RMC SOP 2
STANDARD PROCEDURES FOR COLLECTION OF SURFACE AND NEAR SURFACE SOIL SAMPLES

1.0 Purpose

This SOP describes the procedures that will be used for sampling surface soils from ground surface to a maximum depth attainable by standard excavation equipment. Samples will be collected with new, disposable equipment or a decontaminated shovel or hand auger/probe. Specific soil sampling locations will be determined from the project work plan. Rock samples will be collected in accordance with this SOP.

2.0 Sampling Equipment:

- Hand Auger/Probe and/or Shovels – For the collection of soil samples below the ground surface.
- Log forms / Field notebook / Chain of Custody (COC) - Documentation of sample activities, field notes and sample custody.
- No. 10 (2 mm) sieve (for sieving 0-2" surface soil samples).
- Sample containers - Containers provided by laboratory for the collection, storage and transportation of samples. Plastic bags may also be used.
- Disposable sections of survey lath or stainless steel sample spoons – For the collection of surface soil samples and composite sample mixing. Other disposal sampling implements may also be used. The survey lathe is typically cut into six-inch sections and stored in plastic bags.
- Sample location staking – For the marking and identification of sample locations. Staking should be easily visible for surveying.
- Disposable sampling gloves – to prevent exposure to soils and the prevention of cross-contamination.
- Custody seals (if required) – seals to be placed on sample containers to maintain sample integrity.
- GPS – for recording the sample location (where required).

3.0 Decontamination Equipment:

- 5 gallon buckets – For washing and the collection of rinsate.
- Alconox - Soap
- Scrub brushes – For cleaning sampling equipment.
- Deionized water – For final equipment rinse.
- Culinary tap water – for equipment rinse.
- Garbage bags – for clean equipment storage.

4.0 PROCEDURE:

All samples shall be collected using new, clean disposable or decontaminated equipment. Decontamination procedures are detailed in RMC SOP 6.

4.1 Discrete Samples

If significant vegetation, rocks, or debris prevent collecting the surface samples then the materials will be scraped away from the sample location with survey lathe, a disposable trowel, a shovel or stainless steel spoon. Surface samples will be collected a depth of 0-2 inches and sieved using a No. 10 (2 mm) sieve. Subsurface samples collected from >6 inches do not need to be sieved. The soils will then be placed into sample containers with a new disposable sample collection device, stainless steel spoon or gloved hand. Composite samples will be homogenized as described below. Coarse grained soils, gravel and rock fragments will be removed wherever possible.

Discrete samples at depths greater than 2-3 inches may be collected as necessary. The samples may be collected from test pits excavated using backhoes or similar equipment. The depth of each sample will be noted in the sample ID and field notebook.

4.2 Composite Samples

Composite samples will be collected (as described above) by placing sub samples into a stainless steel mixing bowl or a clean plastic bag, or by hand with new, clean sampling gloves. The sample will be homogenized with a stainless steel spoon or gloved hand. The homogenized soil will be packaged in a laboratory-supplied sample container, labeled and placed in a cooler to maintain temperature.

4.3 Sediment Samples

Sediment samples will be collected from the upper one inch of sediment material using a procedure similar to that used for discrete surface soil samples.

5.0 Sample Preparation

Soil samples collected for human health risk assessment shall be sieved to <250 microns. The <250 micron fraction is then analyzed for metals. For ecological screening/risk assessment purposes, sieving should not occur. Sieving shall be performed by the laboratory.

6.0 Labeling

Each soil sample will be labeled with the following information:

- Sample identification;
- Project number/name;
- Analyses requested;
- Date/time collected; and
- Samplers initials.

7.0 Documentation

Field activities shall be recorded in a hard bound field notebook. Field notes shall include all pertinent information including but not limited to:

- Date and time samples were collected;
- Physical description of sample area;
- Identification of samples collected;
- Total number of samples collected per sampling event;
- Total number of samples collected from each sample location;
- Physical description of samples;
- Preservatives used for samples;
- Sample container types;
- Filtered vs. Unfiltered samples (water);
- Analysis to be performed;
- Weather conditions;
- Hand sketches of subject area(s); and
- Description and date of any photograph(s) taken.

Sample handling and Chain of Custody documentation shall be in accordance with RMC SOP 5 found in this document.

8.0 Demobilization

After decontamination, sample equipment will be stored in the appropriate, clean containers. Any equipment that suffers damage or excessive wear while conducting sampling will be labeled and reported to the equipment manager for the necessary maintenance, repair and/or replacement.

9.0 References

http://www2.epa.gov/sites/production/files/documents/r8-src_src-ogden-02.pdf

RMC SOP 2B

HAND AUGER SOIL SAMPLING

1.0 Introduction

Hand auger equipment will be used for collecting shallow soil samples to approximately 5 feet below ground surface. This SOP describes the procedures for collecting soil samples using hand auger equipment.

2.0 Sampling Equipment:

- Hand augers
  a. Auger barrel – for the collection of clay rich soils.
  b. Sand auger barrel – for the collection of sandy soils.
  c. Extension rods – For connecting the sample barrel to the handle
  d. T handle- for turning the auger assembly.
- Two crescent wrenches – For attaching/breaking down the hand auger.
- Tape measure – for the measurement of sample depths/intervals.
- No. 10 (2 mm) sieve.
- Log forms / Field notebook / Chain of Custody (COC) - Documentation of sample activities, field notes and sample custody.
- Sample containers – for sample storage and transportation.
- Disposable sampling gloves – to prevent exposure to soils and the prevention of cross-contamination.
- Surface patching supplies, if necessary (asphalt patch/post mix)
- Stainless steel bowl or sealable plastic bags for mixing composite samples.
- Custody seals – seals to be placed on sample containers to maintain sample integrity.

3.0 Decontamination Equipment:

- 5 gallon buckets – For washing and the collection of rinsate.
- Alconox - Soap
- Scrub brushes – For cleaning sampling equipment.
- Deionized water – For final equipment rinse.
- Culinary tap water – for equipment rinse.
- Garbage bags – for clean equipment storage.

4.0 Preliminaries

All boring locations will be determined using the project specific SAP/QAPP/FSP. Arrangements will be made for the location of underground utilities using Blue Stakes. A private locating service will be used for utilities that are not covered by Blue Stakes.

5.0 Procedures

If required, prior to hand auguring, a near surface sample will be collected at 0-2 inches and sieved using a No. 10 sieve. The borehole will then be advanced using the clay bucket for fine-grained soils and the sand bucket for coarse-grained soils. Each auger bucket of soil will be described and recorded on the soil boring log. Soil samples selected for laboratory analysis will be placed in a laboratory supplied container.

6.0 Labeling

Each soil sample will be labeled with the following information:

- Sample identification;
- Project number/name;
- Analyses requested;
- Date/time collected; and

- Samplers initials.

7.0 Documentation

Field activities shall be recorded in a hard bound field notebook. Field notes shall include all pertinent information including but not limited to:

- Date and time samples were collected;
- Physical description of sample area;
- Identification of samples collected;
- Total number of samples collected per sampling event;
- Total number of samples collected from each sample location;
- Physical description of samples;
- Preservatives used for samples;
- Sample container types;
- Filtered vs. Unfiltered samples (water);
- Analysis to be performed;
- Weather conditions;
- Hand sketches of subject area(s); and
- Description and date of any photograph(s) taken.

Sample handling and Chain of Custody documentation shall be in accordance with RMC SOP 5 found in this document.

8.0 Decontamination

All samples shall be collected using decontaminated equipment. Decontamination procedures are detailed in RMC SOP 6.

9.0 Demobilization

After decontamination, sample equipment will be stored in the appropriate storage containers. If any equipment is damaged while conducting soil sampling, the damaged equipment will be labeled and reported to the equipment manager for maintenance or replacement.

10.0 References

http://www2.epa.gov/sites/production/files/documents/r8-src_src-ogden-02.pdf

RMC SOP 2C

GEOPROBE SAMPLING

1.0 Introduction

Geoprobe™ sampling equipment will be used to advance shallow soil borings (30 feet or less) to collect soil and groundwater samples and for sites where access restrictions prevent mobilization of a drill rig. Standard operating procedures for geoprobe soil and groundwater sampling are described below.

2.0 Preliminaries

Geoprobe sample locations will be marked or staked in the field and coordinated with the RMC project manager and, if necessary, the client project manager. Blue Stakes utility clearance will be requested for each boring location prior to geoprobe sampling. Borings will be located at least two feet from marked underground utilities.

All sampling equipment will be decontaminated prior to mobilizing to the site. This equipment includes all geoprobe rods, geoprobe samplers, and stainless steel bowls and spoons.

3.0 Geoprobe Equipment and Procedures

If required, prior to soil boring a surface sample will be collected at 0-2 inches and the sample will be sieved using a No. 10 (2 mm) sieve. Soil borings will then be advanced and sampled using a geoprobe hydraulic hammer mounted to a truck, van, four-wheeler, or small tractor. Each borehole will be started by hydraulically hammering a 3 foot length of 1 inch outside diameter steel drill rod with a stainless steel sample collection tube into the ground. Each sample tube shall be decontaminated prior to use. The borehole will be advanced in 3 foot increments by adding 3 foot sections of flush threaded drill rod to the drill stem. No lubricants or additives will be used while advancing geoprobe borings.

4.0 Soil Sampling Equipment

The following equipment will used to conduct soil sampling:

- Log forms / Field notebook / Chain of Custody (COC) - Documentation of sample activities, field notes and sample custody.
- Geoprobe core sampler (supplied by the geoprobe contractor).
- New sample liners (supplied by the geoprobe contractor).
- New sample liner end caps (supplied by the geoprobe contractor).
- Disposable sampling gloves – to prevent exposure to soil and water as well as the prevention of cross-contamination.
- No. 10 (2 mm) sieve.
- Sealable plastic bags – for sample storage.
- Laboratory supplied glass soil sample jars and labels.
- Razor blade knife – for splitting open sample tubes.
- Stainless steel bowl and spoon – for mixing composite samples.
- Custody seals – seals to be placed on sample containers to maintain sample integrity.

5.0 Decontamination Equipment:

- 5 gallon buckets – For washing and the collection of rinsate.
- Alconox - Soap
- Scrub brushes – For cleaning sampling equipment.
- Deionized water –For final equipment rinse.
- Culinary tap water – for equipment rinse.
- Garbage bags – for clean equipment storage.

6.0 Decontamination

All samples shall be collected using decontaminated equipment. Decontamination procedures are detailed in RMC SOP 6.

7.0 Soil Sampling

Samples will be collected as specified in the site specific sampling plan. At a minimum, soil samples will be collected at 5 foot intervals if lithologic information is needed. Each soil sample will be collected in a 2 foot long lined core sampler. The sampler will be attached to the drill rod, lowered to the sample interval and then hydraulically hammered two feet into the subsurface.

8.0 Groundwater Sampling

To facilitate the collection of groundwater samples at sites where the water table is penetrated, a temporary well point will be installed in the geoprobe borehole. After the water table has been encountered, the borehole will be advanced at least three more feet to ensure adequate sample volume. The well point may consist of either a three foot long stainless steel screen, attached to polyethylene tubing, or a length of 3/8inch polyethylene tubing with perforations in the bottom 3 feet. New tubing and well screens will be used for each well point. After approximately 15 minutes, a peristaltic pump will be attached to the tubing to obtain groundwater.

Groundwater samples shall be handled in accordance to the methods detailed for the handling/treatment of surface waters samples in RMC SOP1.

9.0 Labeling

Each sample will be labeled with the following information:

- Sample identification;
- Project number/name;
- Analyses requested;
- Preservatives (water samples);
- Date/time collected; and
- Samplers initials.

10.0 Documentation

Field activities shall be recorded in a hard bound field notebook. Field notes shall include all pertinent information including but not limited to

- Date and time samples were collected;
- Physical description of sample area;
- Identification of samples collected;
- Total number of samples collected per sampling event;
- Total number of samples collected from each sample location;
- Physical description of samples;
- Preservatives used for samples;
- Sample container types;
- Filtered vs. Unfiltered samples (water);
- Analysis to be performed;
- Weather conditions;
- Hand sketches of subject area(s); and
- Description and date of any photograph(s) taken.

Sample handling and Chain of Custody documentation shall be in accordance with RMC SOP 5 found in this document.

11.0 Boring Abandonment

After all soil and groundwater samples have been collected, each soil boring will be backfilled with granular bentonite. Borings that were drilled through asphalt or concrete will be backfilled with granular bentonite to within six inches of the ground surface and the asphalt and concrete cores will be restored.

12.0 Demobilization

After the equipment has been rigged down and loaded, the site will be cleaned and restored as close to its original condition as possible. All sampling equipment will be decontaminated prior to mobilizing to the next geoprobe sample location.

RMC SOP 3A

HOLLOWSTEM AUGER DRILLING, SOIL SAMPLING AND MONITORING WELL INSTALLATION.

1.0 Introduction

Hollowstem auger drilling techniques will be used to advance intermediate depth borings of 100 feet or less. Standard operating procedures for hollowstem auger drilling and soil sampling are described below.

2.0 Preliminaries

Final soil boring locations will be marked or staked in the field and coordinated with the RMC project manager and, if necessary, the client project manager. Blue Stakes utility clearance will be requested for each drilling location to identify any subsurface utilities prior to drilling and sampling. If required, drilling and/or monitoring well permits will be requested by supplying the appropriate forms to the corresponding regulatory agency.

Boring locations will be located the following distances from overhead power lines:

Power Lines Nominal System (kV)	Minimum Required Clearance (ft)
0-50	10
51-100	12
101-200	15
201-300	20
301-500	25
501-750	35
751-1000	45

All drilling and sampling equipment will be decontaminated prior to drilling (RMC SOP 6). This equipment includes all drill pipe, auger flights, split-spoon samplers, brass sleeves, stainless steel bowls and spoons, tools, and non-packaged well screen and casing. No borings will be drilled within 5 feet of marked underground utility lines or within 10 feet of active overhead power lines. Boring locations will be adjusted, as necessary.

3.0 Drilling Equipment and Procedures

A truck mounted hollow stem auger drill rig will be used to drill borings of 100 feet or less. Augers will be sized to accommodate the well casing diameter, if a well is to be installed in the borehole. If flowing sands are encountered a center plug will be used to prevent liquefied sands from entering the inside of the auger string during monitoring well installation. No lubricants, circulating fluid, drilling muds, or other additives will be used during drilling.

4.0 Soil Sampling Equipment

The following equipment will be used to conduct soil sampling:

- Log forms / Field notebook / Chain of Custody Forms (COC) – Documentation of sample activities, field notes and sample custody.
- Split-spoon samplers and sand catcher (supplied by the driller)
- New sample liners (supplied by the drilling contractor).
- New sample liner end caps (supplied by the drilling contractor).

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- Disposable sampling gloves – to prevent exposure to soil and water as well as the prevention of cross-contamination.
- Sealable plastic bags – for sample storage.
- Laboratory supplied glass soil sample jars and labels (optional).
- Razor blade knife – for splitting open sample tubes.
- Stainless steel bowl and spoon – for mixing composite samples.
- Custody seals – seals to be placed on sample containers to maintain sample integrity.

5.0 Decontamination Equipment:

- 5 gallon buckets – For washing and the collection of rinsate.
- Alconox - Soap
- Scrub brushes – For cleaning sampling equipment.
- Deionized water –For final equipment rinse.
- Culinary tap water – for equipment rinse.
- Garbage bags – for clean equipment storage.

6.0 Monitoring Well Equipment

Monitoring well equipment shall be supplied by the drilling contractor.

- Well screen - materials and intervals to be based on site conditions or specified in Workplans and/or Sample analysis plans. Screen size to be determined based on specific site conditions.
- Well casing - materials and intervals to be specified in Workplans and/or Sample analysis plans.
- Sand and/or gravel pack – gradation to be determined based on site conditions.
- Betonite well seal – to provide annular well seal.
- Concrete – for well surface seal.
- Locking standpipe – to protect well assembly.
- Water proof locking well cap – to seal well and tamper prevention.
- Total depth probe – to measure the total depth of the open borehole and/or monitoring well annular pack.
- File – to cut a datum notch in the top of the well assembly.

7.0 Decontamination

All samples shall be collected using decontaminated equipment. Decontamination procedures are detailed in RMC SOP 6.

8.0 Soil Sampling Procedures

Samples will be driven at intervals specified in the work plan. At a minimum, samples will be driven at 5 foot intervals, if lithologic data is needed. If loose, unconsolidated soils are encountered, a sand catcher will be placed at the end of the sampler so that unconsolidated soils are not lost as the sampler is retrieved from the borehole. The sampler will be advanced by blows from a 140-pound downhole hammer. The number of blows required to drive the sampler 6 inches will be recorded on the Soil Boring Log Form.

Each site-specific sampling plan will identify the appropriate sample containers used to collect soil samples. If sample analytes do not include volatile or semi-volatile organic compounds, laboratory supplied glass jars may be used. Otherwise, samples should be submitted in brass or plastic (for inorganic analyses) sleeves.

Sleeves in the sampler will be separated using a stainless steel putty knife and the soil between the sleeves will be carefully cut so that the soil within the sleeve is flush at each end. Each sleeve will be sealed with an end cap. Each sleeve will be labeled with the sample identification and immediately placed in an iced

cooler to maintain a temperature of 4°C. The remaining sample(s) will be used for soil classification. Samples may be removed from the sleeves for the mixing of composite samples.

9.0 Soil Boring Abandonment Procedures

Soil borings not used for well installations will be backfilled. If water is not encountered in the boring, the boring will be backfilled with drill cuttings. If water is encountered, the saturated portion of the boring will be backfilled with granular bentonite. Cuttings will be used to backfill the remainder of the boring. Borings that were drilled through asphalt or concrete will be patched to match existing conditions.

10.0 Storage and Disposal of Drill Cuttings

Drill cuttings and unused soil samples will disposed of on-site.

11.0 Monitoring Well Installation

Monitoring well installation will occur in completed soil borings according to the procedure detailed below:

1: A soil boring shall be drilled to the anticipated total depth of the monitoring well.

2: The center tube and bit shall be removed from the auger assembly.

3: If flowing and/or heaving sands are encountered a center plug shall be used. If a center plug is required the auger assembly shall be removed from the hole and a new wood or plastic center plug will be placed at the base of the bottom section of auger. The auger will then be redrilled to the total depth of the borehole.

4: The monitoring well will assembly will be assembled and lowered into the center of the auger until the well is resting on the bottom of the borehole. The well casing will installed so that the top of the well assembly is approximately two to three feet above the ground surface. The well assembly will be handled using clean disposable gloves. If a center plug is used the well shall be lowered until the well assembly is resting on the center plug. The well will then be lifted slightly and dropped to release the center plug.

5: The sand/gravel pack will be poured into the annular space between the well assembly and the inner wall of the auger assembly. The sand/gravel pack shall be poured in three foot intervals. A decontaminated total depth probe shall be used to measure the depth of the sand/gravel pack. Upon the completion of a three foot section of sand/gravel pack the auger shall be lifted two feet. This will allow the sand pack to fill the annular space between the walls of the borehole and the well assembly while keeping a portion of the sand/gravel pack inside of the auger assembly. This will prevent the collapse of the borehole and assuring the complete filling of the annular space between the borehole and monitoring well assembly. The sand/gravel pack installation shall continue until the sand/gravel pack is two feet above the top of the well screen.

6: Upon the completion of the sand/gravel pack an annular bentonite well seal shall be installed. The annular well seal will consist of bentonite pellets or chips. The bentonite seal shall be installed using the same procedure as outlined above for the sand/gravel pack. The bentonite well seal shall be installed to a depth of two feet below ground surface.

7: Upon the completion of the bentonite well seal, a cement surface seal and stand-pipe shall be installed. A steel stand-pipe shall be inserted into the bore hole to a depth of two feet. The stand-pipe shall contain a locking cover. The standpipe and cover assembly will be used to prevent unauthorized access to the well. The cement well seal shall be installed to ground surface in the annular space between the well casing and the inner wall of the stand-pipe. Cement will also be placed in the annular space between the outer wall of the stand-pipe and the wall of the borehole. The outer cement seal shall be configured to slope away from the well and hence to aid in the prevention of surface water runoff flowing into the well.

8: Upon the completion of well construction a V-shaped notch shall be cut into the top of the well casing. This notch shall act as a permanent datum point for surveying. The stand-pipe shall be locked upon the completion of well construction activities.

9: The well shall be surveyed according to the datum requirements specified in individual Workplans and/or Sample Analysis Plans.

12.0 Labeling

Each sample will be labeled with the following information:

- Sample identification;
- Project number/name;
- Analyses requested;
- Date/time collected; and
- Samplers initials.

13.0 Documentation

Field activities shall be recorded in a hard bound field notebook. Field notes shall include all pertinent information including but not limited to:

- Date and time samples were collected;
- Physical description of sample area;
- Lithologic descriptions of soils encountered;
- Identification of samples collected;
- Total number of samples collected per sampling event;
- Total number of samples collected from each sample location;
- Physical description of samples;
- Preservatives used for samples;
- Sample container types;
- Analysis to be performed;
- Well construction details;
- Weather conditions;
- Hand sketches of subject area(s); and
- Description and date of any photograph(s) taken.

Sample handling and Chain of Custody documentation shall be in accordance with RMC SOP 5 found in this document.

14.0 Demobilization

After the site has been cleaned and restored as close to its original condition as possible. All drilling and sampling equipment will be decontaminated prior to drilling and sampling the next soil boring.

RMC SOP 3B
STANDARD PROCEDURES FOR MONITORING WELL DEVELOPMENT

1.0 Purpose

This SOP describes the procedures that will be used for developing monitoring wells after installation activities have been completed. Well development ensures that drilling fluids and/or sand pack materials are removed from the well prior to sampling and that water from the aquifer enters the well as designed.

2.0 Equipment

- Decontaminated peristaltic or submersible pump (for shallow and deep wells, respectively).
- Direct reading instruments – field instruments to measure pH, DO, ORP, conductivity and temperature.
- Water level probe – to measure water level.
- Total depth probe – to measure total depth of well.
- Disposable sampling gloves – to prevent exposure to water and the prevention of cross-contamination.
- Field notebook – for recording field data.

3.0 Decontamination Equipment

- 5 gallon buckets – For washing and the collection of rinsate.
- Alconox - Soap
- Scrub brushes – For cleaning sampling equipment.
- Deionized water – For final equipment rinse.
- Culinary tap water – for equipment rinse.
- Garbage bags – for clean equipment storage.

4.0 Procedure

After the monitoring well has been installed the well will require development to ensure that all materials introduced during installation are removed and that water entering the well is representative of the aquifer.

Measure the total depth of the well with a sounding device, measure standing water level and determine well bore volume (V):

V in gallons $=\pi r^2 h \times 7.48$

Where $\pi = 3.14$
r = radius of well casing converted to feet
h = Water level – total depth of well (determined from drillers log or previous well sounding)

Purge three (3) well volumes of water from the well and measure pH, DO, ORP, conductivity and temperature from the 3rd well volume. Continue to purge the well until there are three consecutive readings from the field measurements that have similar values and the water is clear and the turbidity is low. The pH, DO, ORP, conductivity and temperature should stabilize when the well is properly developed.

5.0 Documentation

Field activities shall be recorded in a hard bound field notebook. Field notes shall include all pertinent information including but not limited to:

- Water level at start and end of development activities;
- Calculated well volume;

- Log of field pH, temperature and conductivity readings;
- Physical characteristics of water (color and turbidity) during development process;

6.0 Decontamination

Clean well development equipment according to procedures outlined in RMC SOP 6.

7.0 Demobilization

After decontamination, sample equipment will be stored in the appropriate, clean containers. Any equipment that suffers damage or excessive wear while conducting sampling will be labeled and reported to the equipment manager for the necessary maintenance, repair and/or replacement.

RMC SOP 3C
STANDARD PROCEDURES FOR GROUNDWATER SAMPLING

1.0 Purpose

This SOP describes the procedures that will be used for collecting groundwater samples. Samples will be collected with a peristaltic pump from shallow piezometers (groundwater less than 25 feet below ground surface [bgs]) or a decontaminated submersible pump with dedicated or disposable tubing if groundwater is greater than 25 feet bgs. Specific monitoring well locations will be determined from the project work plans and or QAAP/SAP or FSP.

2.0 Sampling Equipment:

- Log forms / Field notebook / Chain of Custody Forms – Documentation of sample activities, field notes and sample custody.
- Sample containers – Containers provided by laboratory for the collection, storage and transportation of samples.
- Direct reading instruments – field instruments to measure pH, DO, ORP, conductivity and temperature.
- Disposable sampling gloves – to prevent exposure to water and the prevention of cross-contamination.
- Custody seals – seals to be placed on sample containers to maintain sample integrity.
- 0.45 um filter apparatus with inert filters – for filtering samples in preparation for the analysis of dissolved metals.
- Nitric acid (HNO_3, supplied by the analytical laboratory) – for sample preservation.
- Deionized water – for rinsing direct reading instruments.
- Water level probe – to measure water level
- Peristaltic pump
- Submersible pump (if required for deep wells).
- Tubing for pump.
- Field notebook – for recording field data.

3.0 Decontamination Equipment

- 5 gallon buckets – For washing and the collection of rinsate.
- Alconox - Soap
- Scrub brushes – For cleaning sampling equipment.
- Deionized water – For final equipment rinse.
- Culinary tap water – for equipment rinse.
- Garbage bags – for clean equipment storage.

4.0 Procedure

Read and follow the specific manufacturer's operating instructions before using any equipment. Prior to initiating sampling, check that all equipment to be used is in good operating condition. If possible and where applicable, start at those piezometers that are the least contaminated and proceed to those piezometers that are the most contaminated. Thoroughly decontaminate all required equipment entering the piezometer or well according to RMC SOP 6.

Unlock and open the well, obtain a water level by inserting a decontaminated water level probe into the well and measuring the standing water surface to the established datum point on the top of the well head. The established datum point can be installed by using a file to insert a notch in the PVC casing.

4.1 Purging

In order to obtain a representative sample of groundwater from a piezometer, the water that has stagnated and/or thermally stratified within the piezometers casing and filter pack must be purged. This procedure

allows representative formation water to enter the piezometers. The preferred method of ensuring representative formation water is to monitor groundwater parameters during purging and to remove at least three piezometer casing volumes.

- Wherever possible, purge and sample piezometers using "low-stress" techniques.
- To ensure groundwater is representative of the aquifer before samples are collected, purge each piezometer at a maximum rate of 500 milliliters per minute (ml/min) until three piezometers casing volumes have been evacuated and field-measured parameters stabilize.
- Exercise care during purging to not reduce the water column by more than 50% of initial height, to the extent practical.
- Monitor pH, specific conductivity, temperature, dissolved oxygen, and ORP during purging using portable meters according to RMC SOP 9. Field parameters will be considered stabilized when readings remain within the ranges stated below:
    - pH = ± 0.2 units
    - Specific Conductance = ± 10 percent
    - Temperature = ± 1° C
    - Dissolved Oxygen = ± 10 percent
    - ORP = ± 10 percent.

Determine the well volume (V) by the following formula:

V in gallons = $\pi r^2 h \times 7.48$

Where $\pi = 3.14$
r = radius of well casing converted to feet
h = Water level – total depth of well (determined from drillers log or previous well sounding)

Pump discharge during purging is directed to a bucket or container to verify the purge rate.

4.2 Sampling

With the exception of low-yield piezometers, groundwater samples shall be collected immediately after field-measured parameters have stabilized and three piezometers casing volumes removed. Groundwater samples shall be collected in containers supplied by the analytical laboratory. Specific sample collection procedures include:

- Locate the pump intake approximately midway in the water column, within the screened interval, during purging and sample collection;
- Set the sampling flow rate at 500 ml/min or less;
- Collect samples after field parameters (pH, specific conductance, temperature, dissolved oxygen, and ORP) have stabilized as described above; and
- Piezometers that have a slow recovery, and are purged dry during the purging process, shall be considered adequately purged. Sample piezometers having a slow recovery should be sampled once the water level reaches at least 70% of the original static water level, or within 24 hours of being purged dry.

Samples collected for analysis of dissolved metals will be filtered in the field at the time of collection or as soon thereafter as practically possible. Samples collected for analysis of dissolved metals and filtered in the field will be a minimum volume of 500 ml, collected in a poly or glass container. The field filtering methodology will include the following steps:

1: Sample shall be collected in a new, clean bottle.

2: Sample is poured into the top flask of the disposable plastic filter. Use a portion of the sample to rinse the filter flask, discard this portion and proceed with filtering the required sample volume.

3: Vacuum pump is attached to the filter and pumped. A cartridge filter and peristaltic pump may also be used. If a cartridge filter is used the sample will be pumped through the filter using clean tubing.

4: When the bottom compartment of the filter is full, the water is to be transferred into a laboratory supplied pre-preserved sample container.

5.0 Labeling

Each groundwater sample will be labeled with the following information:

- Sample identification;
- Project number/name;
- Analyses requested;
- Preservatives;
- Date/time collected; and
- Samplers initials

6.0 Documentation

Field activities shall be recorded in a hard bound field notebook. Field notes shall include all pertinent information including but not limited to:

- Date and time samples were collected;
- Physical description of sample area;
- Identification of samples collected;
- Total number of samples collected per sampling event;
- Total number of samples collected from each sample location;
- Physical description of samples;
- Preservatives used for samples;
- Sample container types;
- Analysis to be performed;
- Well construction details;
- Weather conditions;
- Hand sketches of subject area(s); and
- Description and date of any photograph(s) taken.

7.0 Decontamination

To ensure the groundwater sample is representative of formation water, it is important to minimize the possibility of cross-contamination by performing the following steps:

1. Use only new or dedicated silicon and/or polyethylene discharge tubing.
2. Decontaminate necessary sampling equipment prior to any sampling and between samples according to RMC SOP 6.
3. Collect equipment blanks as outlined in the QAPP to verify that cross-contamination has not occurred.
4. Design sampling to proceed from best quality water to the poorest quality water if possible.

8.0 Demobilization

After decontamination, sample equipment will be stored in the appropriate, clean containers. Any equipment that suffers damage or excessive wear while conducting sampling will be labeled and reported to the equipment manager for the necessary maintenance, repair and/or replacement.

9.0 References

http://www.epa.gov/Region9/qa/pdfs/finalsopls1217.pdf
http://www.epa.gov/region6/qa/qadevtools/mod5_sops/groundwater/sampling/r1_gw_sampling.pdf

RMC SOP 4
STANDARD PROCEDURES FOR COLLECTION OF WETLAND AND STREAM SEDIMENT SAMPLES

1.0 Purpose

This SOP describes the procedures that will be used for sampling stream and wetland sediments. Samples will be collected with a gloved hand, decontaminated shovel, disposable section of survey lathe or stainless steel spoon. Specific sampling locations will be determined from the project SAP and/or FSP.

2.0 Sampling Equipment:

- Log forms / Field notebook / Chain of Custody Forms (COC) – Documentation of sample activities, field notes and sample custody.
- Shovels – for the collection of near-surface samples.
- Log forms / Field notebook / COC – for field documentation.
- Sample containers – for sample storage and transportation.
- Plastic bag or Stainless steel mixing bowl – for mixing composite samples.
- Disposable survey lathe or stainless steel sample spoons – for the collection of surface samples and mixing composite samples. Other disposable equipment may also be used.
- Disposable sampling gloves – to prevent exposure to soils and water and the prevention of cross-contamination.
- Custody seals (if required) – seals to be placed on sample containers to maintain sample integrity.

3.0 Decontamination Equipment:

- 5 gallon buckets – For washing and the collection of rinsate.
- Alconox - Soap
- Scrub brushes – For cleaning sampling equipment.
- Deionized water – For final equipment rinse.
- Culinary tap water – for equipment rinse.
- Garbage bags – for clean equipment storage.

4.0 PROCEDURE

All samples shall be collected using new, clean disposable or decontaminated equipment. Decontamination procedures are detailed in RMC SOP 6.

4.1 Discrete Samples

If water samples are being concurrently sampled with stream sediment samples the water samples will be collected prior to the collection of the sediment samples. Sediment samples will be collected from streambeds with standing water or slow flow rates such that there will be no significant impact while sampling. Vegetation, rocks, and/or debris will be scraped away from the sample location with a shovel, disposable section of survey lathe, similar disposable scoop or stainless steel spoon. The underlying surface sediment material (upper one inch) will then be collected and placed into sample containers with a section of survey lathe, stainless steel spoon or gloved hand. Composite samples will be homogenized as described below. Coarse grained soils, gravel and rock fragments will be removed wherever possible.

4.2 Composite Samples

Composite samples will be collected (as described above) by placing sub samples into a stainless steel mixing bowl or a clean plastic bag, or by hand with new, clean sampling gloves. The sample will be homogenized with a stainless steel spoon or gloved hand. The homogenized soil will be packaged in a laboratory-supplied sample container, labeled and placed in a cooler to maintain temperature.

5.0 Labeling

Each soil sample will be labeled with the following information:

- Sample identification;
- Project number/name;
- Analyses requested;
- Date/time collected; and
- Samplers initials.

6.0 Documentation

Field activities shall be recorded in a hard bound field notebook. Field notes shall include all pertinent information including but not limited to:

- Date and time samples were collected;
- Physical description of sample area;
- Lithologic descriptions of soils encountered;
- Identification of samples collected;
- Total number of samples collected per sampling event;
- Total number of samples collected from each sample location;
- Physical description of samples;
- Preservatives used for samples;
- Sample container types;
- Analysis to be performed;
- Well construction details;
- Weather conditions;
- Hand sketches of subject area(s); and
- Description and date of any photograph(s) taken.

7.0 Demobilization

After decontamination, sample equipment will be stored in the appropriate, clean containers. Any equipment that suffers damage or excessive wear while conducting sampling will be labeled and reported to the equipment manager for the necessary maintenance, repair and/or replacement.

8.0 References

http://www2.epa.gov/sites/production/files/documents/r8-src_eh-02.pdf

RMC SOP 5
STANDARD PROCEDURES FOR SAMPLE HANDLING, DOCUMENTATION, AND SHIPPING

1.0 Purpose

This section describes the handling and documentation procedures that will be used once soil and water samples are collected. The procedures will ensure that samples are handled properly and that appropriate documentation is completed.

2.0 Sample Handling

All samples will be promptly placed into a cooler to maintain a temperature of 4°C. Typically, samples selected for chemical analysis will be delivered at the end of each day to the analytical laboratory. If they are not submitted to the laboratory on the same day, they will be stored in a refrigerator in a locked storage room until they can be delivered to the laboratory.

3.0 Sample Identification and Labeling

Where applicable, samples will be labeled in accordance with project SAPs and QAPPs and and/or Work Plans.

Soil samples will be labeled in such a way as to identify the area and depth from which they were taken. Water samples will be labeled as to identify when and where they were collected from. Duplicate samples will always be labeled in the same manner such that the laboratory cannot tell they are duplicate (i.e., as a "blind duplicate"). Each sample container will be immediately labeled with the following information:

- Project name
- Project number
- Sample identification
- Date and time collected
- Analysis requested
- Filtered or unfiltered (water)
- Samplers initials
- Preservative used (water)

This information will also be recorded in the field logbook.

5.0 Custody Seals

If required, custody seals shall be used to prevent tampering and to maintain sample integrity. A seal shall be placed across the top of sample jars or across the seals of plastic sample bags. The seal shall be signed and dated by the sampler who collected the sampler.

6.0 Chain-of-Custody (COC)

COC documentation will begin in the field for each sample submitted to the laboratory and will also be maintained by laboratory personnel. A COC for each sampling event will be completed and will accompany each sample batch to the analytical laboratory. Sample custody means that all samples will remain in the possession or observation of the sampler at all times, or in a locked facility until delivery to the analytical laboratory.

7.0 Field Book

RMC field personnel will maintain a field logbook to record all field activities. The field logbook will be a weather-resistant bound field book. All data generated during the project and any accompanying comments will be entered directly into the logbook in indelible ink; any corrections will be made with single line-out deletions. At no time will any pages be removed from the field logbook.

Each day's field activities will be documented, including the following minimum information:

- Date of field activity;
- Time of field activity;
- RMC field personnel's initials;
- Project name;
- Project number;
- Date and time samples were collected;
- Physical description of sample area;
- Identification of samples collected;
- Total number of samples collected per sampling event;
- Total number of samples collected from each sample location;
- Physical description of samples;
- Preservatives used for samples;
- Sample container types;
- Filtered vs. Unfiltered samples (water);
- Analysis to be performed;
- Weather conditions;
- Hand sketches of subject area(s); and
- Description and date of any photograph(s) taken.

RMC SOP 6
STANDARD PROCEDURES FOR SAMPLING EQUIPMENT DECONTAMINATION

1.0 Purpose

This SOP details the decontamination protocols for sampling equipment. In order to reduce the risk of transferring materials from one sample site to another, and to assure that there is no cross-contamination of samples, the following procedures will be used.

2.0 Decontamination Equipment:

- 5 gallon buckets – For washing and the collection of rinsate.
- Alconox - Soap
- Scrub brushes – For cleaning sampling equipment.
- Deionized water – For final equipment rinse.
- Culinary tap water – for equipment rinse.
- Garbage bags – for clean equipment storage.

3.0 DECONTAMINATION PROCEDURES:

RMC uses the following decontamination procedure for equipment:

3.1 Gross contaminant removal

This step involves scrubbing the equipment using an Alconox and water solution and a stiff scrub brush. The scrubbing will continue until all visible contaminants are removed from the equipment. This water will be changed as necessary. The Alconox and water solution is typically prepared and stored in a clean 5-gallon bucket.

3.2 Clean detergent wash

This step involves using a clean volume of Alconox and water solution. Equipment will be washed in this solution once all gross contaminants have been removed during Step 1. This solution will also be changed as necessary. The Alconox and water solution is typically prepared and stored in a clean 5-gallon bucket.

3.3 Clear water rinse

This step involves rinsing the equipment in clear, culinary tap water. This water will be changed as necessary to maintain its purity. The water solution is typically collected and stored in a clean 5-gallon bucket.

3.4 Deionized water rinse

Deionized water will be used as a final rinse for all decontamination procedures. The water will be poured from a new container, sprayed from a suitable container or the equipment will be submerged in a suitable container. Decontamination (equipment) blanks will be collected as required in the Sampling and Analysis Plan. The water solution is typically collected and stored in a clean 5-gallon bucket.

3.5 Decontamination fluid disposal

Decontamination fluids shall be disposed of on-site.

RMC SOP 8
STANDARD PROCEDURES FOR XRF FIELD SCREENING

1.0 Purpose

This SOP describes the procedures that will be used for the collection of X-Ray Fluorescence Spectrometry (XRF) field screening data. This procedure outlines the use of a hand held portable XRF to collect in real time, in situ "ground shots". The methodologies outlined in this SOP are based on EPA method 6200 "Field portable X-Ray Fluorescence Spectrometry for the Determination of elemental Concentrations in Soil and Sediment".

2.0 Sampling Equipment

- Field data sheets / Field notebook / Chain of Custody Forms (COC) – Documentation of sample activities and field notes.
- Field portable XRF
- Known standard samples.

3.0 Procedure

The XRF will be operated by trained personnel in accordance with the manufacture's operating manual. Prior to use the XRF will be calibrated against known standards. The first standard to be used will be an instrument blank consisting of silicon dioxide. The instrument blank is used to verify that no contamination exists in the XRF. The second set of standards will be precision measurement standards. The precision measurement standards will consist of samples with low, medium and high known concentrations of target analytes. A minimum of two precision measurements will be conducted daily. Each precision measurement will be conducted three times in replicate to measure consistency in sample readings. The results of calibration will be noted in the field notebook.

Field screening ground shots will be collected by placing the XRF unit on a smoothed, level section of the exposed soil to be tested. If required, a disposable piece of survey lathe will be used to provide a consistent level, smooth surface for analysis. The soil will be screened for enough time for the readings to stabilize, typically 20 seconds to one minute in each location. If required by the project, replicate measurements may be taken in each location. The XRF will be moved approximately one inch for each replicate. If required on a project specific basis, the target analyte concentration for each replicate measurement will be noted and recorded. If required on a project specific basis a pin flag with the screening results may be placed in each screening location.

Samples may also be analyzed as "bag shots". Samples will be collected as per RMC SOP 2. The bag will be shot with the XRF as described above for ground shots.

Definitive data collection will not be conducted on soils with excessive moisture contents (e.g. soils that appear wet or saturated). Samples may be oven dried. Data collected from XRF screening of wet or saturated samples will only be used as only screening level or approximate data.

4.0 Documentation

Field activities shall be recorded in a hard bound field notebook according to project specifications. Due to the large amounts of data collected only selected final screening data may be recorded. Field notes shall include all pertinent information including but not limited to:

- Date and time screening was conducted;
- Physical description of sample area;
- Soil moisture conditions;

- Analysis to be performed;
- Weather conditions;
- Hand sketches of subject area(s); and
- Description and date of any photograph(s) taken.

5.0 Demobilization

After completion of sampling, sample equipment will be stored in the appropriate, clean containers. Any equipment that suffers damage or excessive wear while conducting sampling will be labeled and reported to the equipment manager for the necessary maintenance, repair and/or replacement.

6.0 References

http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/6200.pdf

RMC SOP 9

STANDARD PROCEDURES FIELD WATER QUALITY METER CALIBRATION AND FIELD WATER QUALITY MEASUREMENTS

1.0 PURPOSE

This procedure outlines the types of field measurements and data requirements associated with the collection of either groundwater or surface water samples. Water quality parameters will be collected to assess groundwater and surface water chemistry at the site.

2.0 EQUIPMENT

- Log forms / Field notebook
- Direct reading instruments – field instruments to measure pH, conductivity and temperature.
- Distilled water – for rinsing direct reading instruments.
- Alconox - for decontamination of direct reading instruments.
- Replacement probes and proper storing solutions

3.0 PROCEDURE

- Read and follow the specific manufacturer's operating instructions before using any equipment.
- Calibrate all equipment as specified below prior to and at the commencement of sampling activities to ensure proper equipment operation.
- Record these measurements in the Equipment Calibration Form.

3.1 Temperature

- Calibrate electronic thermometers (if applicable) according to their manufacturer's specifications.
- Record actual and meter reading on the Equipment Calibration Form.
- Collect the sample in a clean flask or beaker and insert the temperature probe into the water as per the manufacturer's specifications.
- Read the temperature from the meter and record the reading on either Groundwater Sampling or Surface Water Sampling forms.
- Discard the sample and rinse the probe with Alconox wash and distilled water rinse.

3.2 pH

- Thoroughly decontaminate the pH probe prior to use with Alconox wash and distilled water rinse.
- Use a three point calibration, at a minimum, using pH 7.0, 4.0 and 10.0 buffer solutions according to the manufacturer's specifications.
- Record meter reading in pH buffer solutions 7.0, 4.0 and 10.0 on the Equipment Calibration Form. If reading is greater than ± 0.2 units, recalibrate the meter.
- Collect the sample in a clean flask or beaker and insert the pH probe into the water according to the manufacturer's specifications.
- Read the pH measurement from the meter approximately one minute from the time the sample was collected and record the reading on either Groundwater Sampling or Surface Water Sampling forms.
- Discard the sample and decontaminate the probe with Alconox wash and distilled water rinse.

3.3 Conductivity

- Thoroughly decontaminate the conductivity probe prior to use with Alconox wash and distilled water rinse. Calibrate the conductivity meter according to the manufacturer's specifications.
- Record meter reading in a known specific conductance calibration solution (such as 1.412 mS/cm) on the Equipment Calibration Form. If reading is greater than ± 10 percent, recalibrate the meter.

- Collect the water sample in a clean flask or beaker and insert the conductivity probe into the water according to the manufacturer's specifications.
- Wait for the reading to stabilize and record the reading on either Groundwater Sampling or Surface Water Sampling forms.
- Discard the sample and decontaminate the probe with Alconox wash and distilled water rinse.

3.4 Dissolved Oxygen

- Decontaminate the dissolved oxygen probe according to the manufacturer's specifications with Alconox wash and distilled water rinse. Because the probe membrane is very fragile and susceptible to dryness, keep it moist at all times.
- Calibrate the dissolved oxygen meter according to the manufacturer's specifications and record the results on the Equipment Calibration Form.
- Collect the water sample as close to the source as possible and place it in a clean flask or beaker. Be careful to minimize sample aeration during collection and transfer into a flask or beaker.
- Insert the dissolved oxygen probe into the sample so that the membrane is fully submerged. Very gently stir the probe through the sample. Do not agitate the probe as air bubbles cause erroneous measurements.
- When the reading stabilizes, record the reading on either Groundwater Sampling or Surface Water Sampling forms.
- Decontaminate the dissolved oxygen probe according to the manufacturer's specifications with Alconox wash and distilled water rinse.

3.5 Oxidation Reduction Potential

- Decontaminate the oxidation reduction potential (ORP) probe according to the manufacturer's specifications with Alconox wash and distilled water rinse.
- Calibrate the ORP probe according to the manufacturer's specifications. Correct for temperature according the calibration solutions specifications.
- Record meter reading in a known ORP calibration solution (corrected for temperature) on the Equipment Calibration Form. If reading is greater than ± 10 percent, recalibrate the meter.
- Collect the water sample in a clean flask or beaker and insert the ORP probe into the water according to the manufacturer's specifications
- When the reading stabilizes, record the reading on either Groundwater Sampling or Surface Water Sampling forms.
- Decontaminate the ORP probe according to the manufacturer's specifications with Alconox wash and distilled water rinse.

3.6 Review

The reviewer shall check Surface Water and Groundwater Sampling Forms for completeness and accuracy. Any discrepancies will be noted and the forms will be returned to the originator for correction. The reviewer will acknowledge that the review comments have been incorporated by signing and dating the Surface Water Sampling or Groundwater Sampling Form.

STANDARD OPERATING PROCEDURE FOR THE COLLECTION OF MACROINVERTEBRATES IN WETLANDS

WILLARD SPUR 2011 MONITORING ACTIVITIES

State of Utah
Department of Environmental Quality
Division of Water Quality

Revision 1
Effective 9/9/2011

Utah Division of Water Quality (DWQ) Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical experts. The primary purpose of this document is for internal DWQ use. This SOP should not replace any official published methods.

Any reference within this document to specific equipment, manufacturers, or supplies is only for descriptive purposes and does not constitute an endorsement of a particular product or service by the author or by DWQ. Additionally, any distribution of this SOP does not constitute an endorsement of a particular procedure or method.

Although DWQ will follow this SOP in most instances, there may be instances in which DWQ will use an alternative methodology, procedure, or process.

REVISION PAGE

Date	Revision #	Summary of Changes	Sections	Other Comments
9/9/2011	1	not applicable	not applicable	Adapted from GSL wetlands field manual and put into new standardized format, began document control/revision tracking

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1) SCOPE AND APPLICABILITY

This document presents the Standard Operating Procedure (SOP) for the collection of macroinvertebrate samples in the wetland areas of Willard Spur, and applies to any Utah Division of Water Quality (DWQ) monitor or non-DWQ cooperator performing wetlands sampling.

Macroinvertebrates are a primary component of wetland food webs, providing food to birds and other wildlife (e.g., amphibians) in the wetlands of Willard Spur. In addition, different taxonomic groups of macroinvertebrates are sensitive to different pollutants and can act as key indicators of disturbance caused by stressor gradients (e.g., nutrient gradients) in wetland ecosystems. Macroinvertebrate data is therefore used by the DWQ as a key component in a multi-metric index (MMI) tool used to assess wetland condition (Utah DWQ, 2009).

2) SUMMARY OF METHOD

Macroinvertebrate samples are collected at 5 (five) randomly selected locations along a 100 meter transect in the open water of the target wetland area. Samples are collected using a standard dip net and preserved with alcohol for taxonomic identification.

3) DEFINITIONS

m - meter(s)

SAV - submerged aquatic vegetation

µm - micrometer(s), also called micron(s)

4) HEALTH AND SAFETY WARNINGS

Field personnel should take appropriate precautions when operating watercraft and working on, in, or around water. All boats should be equipped with safety equipment such as personal flotation devices (PFD's), oars, air horn, etc. Utah's Boating Laws and Rules shall be followed by all field personnel.

Field personnel should be aware that hazardous conditions potentially exist at every waterbody. If unfavorable conditions are present at the time of sampling, the sample visit is recommended to be rescheduled. If hazardous weather conditions arise during sampling, such as lightning or high winds, personnel should cease sampling and move to a safe location.

5) CAUTIONS

Care should be taken to sample the water column and sediment-water interface without including excessive sediment in the sample. Areas with duckweed or surface mat algae should be avoided.

Rinse nets thoroughly with water between sites to avoid any potential cross contamination of samples and wetland systems.

Samples should be preserved in the field.

6) INTERFERENCES

Anything that makes the sample more difficult to visualize in the laboratory can cause interference with results. Try to minimize duckweed, algae, sediment, etc. in the sample.

High turbidity or dense SAV may also interfere with sample collection (net clogging or dragging).

Samples should not be exposed to freezing temperatures, extreme hot temperatures, or direct sunlight during storage.

Samples should be submitted to the lab in a timely manner (4-6 months suggested maximum holding time) to avoid degradation of benthic organisms and to aid identification.

7) PERSONNEL QUALIFICATIONS/RESPONSIBILITIES

Monitors collecting wetland macroinvertebrate samples must read this SOP annually and acknowledge they have done so via a signature page (see **Appendix 1**). New field personnel must also demonstrate successful performance of the method. The signature page will be signed by both trainee and trainer to confirm that training was successfully completed and that the new monitor is competent in carrying out this SOP. The signature page will be kept on-file at DWQ along with the official hard copy of this SOP.

8) EQUIPMENT AND SUPPLIES

_____Copy of this SOP

_____Plastic, high-sided utility sled or float tube (fishing type) for toting equipment

_____Laser range finder or reel tape and PVC posts to mark ends of transect

_____Meter stick made of PVC and marked in centimeters for measuring water depth

_____D-net 500 µm mesh such as Wildco D-frame Multifilment 500 µm (EPA) Net (425-D52) from Cole Parmer (cat# YO-05491-32)

_____Sieve bucket with 500 µm mesh

_____Regular plastic bucket
_____Deionized water squeeze bottle
_____Polyethylene sample jars with plastic lids, quart and gallon sizes
_____95% ethanol
_____Field sheet
_____Sample labels (for exterior) (**Figure 1**) and printed on "Rite in the Rain"® paper (for interior)
_____Chain of Custody (COC) forms
_____Printed list of sets of random numbers (from 0 to 100)
_____Clear strapping tape
_____Electrical tape
_____Pencils and Sharpies for labeling

Figure 1. Sample label for macroinvertebrate samples
(U:\WQ\PERMITS\MONITORS\Labels\ BENTHOS JAR TAG (INTERIOR).doc)

BENTHOS COMPOSITE SAMPLE
SITE ID_____
SITE NAME_____
_____
COLLECTION DATE_____
SAMPLER TYPE_____
COLLECTOR(s)_____
OF STATIONS_____
JAR_____OF_____

9) PROCEDURE

1) Prepare sample labels (Figure 1) and jars.

2) Walk out about 5 meters into the wetland (away from the boat) from where other types of samples have already been collected to avoid sampling an area that has been previously disturbed.

3) Using a 500 µm D-frame net, sample the target area with a 1-m "sweep". A "sweep" consists of passing the net back and forth over the same 1-m length three (3) times using a figure eight type motion. Aim for the water column down to the sediment level, careful to keep the net below the surface of the water while tapping the bottom to dislodge and collect organisms in the sediment.

4) Once you have made your first "sweep", pick the net up out of the water immediately to prevent backwash and loss of sample.

5) Repeat Steps 2 – 3 at 4 other sampling locations, so that at the end of the sampling effort there are 5 sweeps, forming one composite, in the net.

6) Empty all the contents of the net, including vegetation, into the sieve bucket.

7) Carefully swirl the sieve bucket in the water to rinse sediment/mud from the sample.

8) Place the contents of the sieve bucket in to the polyethylene sample jar(s).

***Note about field sheets:** Typically, aquatic vegetation measurements are performed in conjunction with macroinvertebrate samples in the wetlands and the field sheet accompanying the document "Standard Operating Procedure for determining Percent Cover of Aquatic Vegetation in Wetlands of Willard Spur" is used to record field observations). If vegetation measurements are not performed along with macroinvertebrate sampling, use the field sheet in **Appendix 3** to record field observations of aquatic vegetation during collection of macroinvertebrate samples.

9.1 SAMPLE PROCESSING AND PRESERVATION

1) Once the composite sample has been collected, return to the vehicle or staging area with the equipment and sample.

2) If the sample jar is greater than 50% full of material, the sample should be split into multiple jars (or the entire sample may be put into a larger jar) so that no one jar is more than 50% full. If the sample is divided into multiple jars, label sample appropriately to indicate the series of jars (e.g. jar 1 of 3, 2 of 3, and 3 of 3).

3) Fill out a "Rite in the Rain" label in pencil with the same information on it as the sample labels and place it in the each sample jar.

4) Fill each jar with 95% denatured alcohol (leaving little to no headspace) and replace lid.

5) Seal each jar with electrical tape around the lid to prevent leakage.

6) Fill out sample label(s) appropriately, put it on the exterior of the jar(s) and cover the label(s) with clear tape.

7) Place jar(s) in a cooler to protect them from direct sunlight exposure.

8) Before using the net and sieve bucket at the next site, rinse them thoroughly with deionized or tap water to avoid any potential cross contamination of samples and wetland systems.

9) After returning from the field, fill out a COC form, and store the samples with the form on a shelf or in a box at room temperature for storage until delivery (samples may be delivered to the laboratory in batches).

9.1 PHOTOGRAPHS

Photographs should be taken during macroinvertebrate sampling to gain a better understanding of the submerged aquatic vegetation habitat available for the macroinvertebrate community. First, take a photo of the field station ID on the field sheet before taking any site photos (in lieu of a photo logbook). Then, photograph the contents of the inside of the net, after it is pulled out of the water, for one or more sweeps along the transect (greater heterogeneity of net contents from one sample to another = more photos).

10.0 LABORATORY ANALYTICAL METHODS

Macroinvertebrate samples will be analyzed according to procedures outlined in "SOPs for analysis of aquatic macroinvertebrate samples collected from the Great Salt Lake freshwater wetlands" (Gray, 2009). Macroinvertebrate samples will be examined for taxa present and community composition. Taxa will be identified to the lowest practical taxon. The methodology and quality assurance and quality control procedures for this analysis and analyzing laboratory can be obtained from:

Dr. Lawrence J. Gray, Senior Ecologist (ESA)
Dept. of Biology, Utah Valley University, 800 W. University Parkway
Orem, UT 84058
(801) 863-8558
FAX: (801) 863-8054
grayla@uvu.edu
http://research.uvu.edu/Gray/

11.0 DATA AND RECORDS MANAGEMENT

Note the date, time, sampler(s), and sampling method on the field sheet and COC form as indicated. Monitors should review the field sheet and COC form for completeness and accuracy in the field before leaving the site. Make sure the information on the paperwork is consistent with the information on the sample container label(s).

Upon returning to the office, both the monitor collecting the sample and the field team leader sign/initial that they have reviewed the field sheet. The field sheet is then scanned and the PDF file saved into the shared "Monitors" folder. The original form is placed in the project file. Additionally, a copy of the signed COC form is provided to the database manager.

12.0 QUALITY ASSURANCE AND QUALITY CONTROL

Field replicates should be collected at a minimum rate of 1 replicate for every 10 regular samples, or at a frequency required by a program/project specific quality assurance plan or sampling and analysis plan. To perform the replicate sampling, conduct alternating sweeps along the same transect at ten (10) random sampling points instead of five (5). One set is for the regular composite sample; the other set is for the replicate composite sample. In other words, put the contents of one sweep into one sample jar; then put the contents of the next sweep into the second sample jar. Note on the field sheet or in the field notebook that a replicate was collected. Refer to the program/project specific quality assurance plan or sampling and analysis plan for performance goals for replicate samples.

13.0 REFERENCES

Gray, L.J. 2009. Macroinvertebrates in the wetlands of the Great Salt Lake 2007. Submitted to Utah DWQ. Online at http://www.deq.utah.gov/Issues/gslwetlands/docs/DEQ_GSLwetlands2007ReportLGray.pdf.

Gray, L.J. 2009. SOPs for analysis of aquatic macroinvertebrate samples collected from the Great Salt Lake freshwater wetlands. Submitted to Utah DWQ. Online at http://www.deq.utah.gov/Issues/gslwetlands/docs/appendixCLJGrayStandardMethodsJuly2009.pdf.

Utah Department of Environmental Quality, Division of Water Quality (DWQ). 2009. Development of an assessment framework for impounded wetlands of Great Salt Lake. Draft Report. November 2009. Online at http://www.deq.utah.gov/Issues/gslwetlands/docs/FinalReport122209.pdf.

14.0 APPENDICES

Appendix 1 - SOP Acknowledgment and Training Form (front and back)

(U:\WQ\PERMITS\MONITORS\QAQC\Helpful Templates\SOP Acknowledgement and Training Form.doc)

DWQ SOP Acknowledgement and Training Form
2/28/2011
Page 1 of 2

SOP Acknowledgement and Training Form

This SOP must be read and this form signed annually. This form must be kept with the current version of the SOP.

Document Title:	
Document Revision Number:	
Document Revision Date:	

Please sign below in accordance with the following statement: "I have read and understood the above referenced document. I agree to perform the procedures described in this SOP in accordance with the document until such time that it is superseded by a more recent approved revision."

Printed Name	Signature	Date

SOP Acknowledgement and Training Form (continued)

Trainee: Sign below to acknowledge that training on this SOP was received, understood, and all questions/concerns were addressed by the trainer.

Trainer: Sign below to acknowledge that training on this SOP was completed for the individual listed and that trainee is competent to perform the procedures described within.

Date of Training	Trainee Printed Name	Trainee Signature	Trainer Printed Name	Trainer Signature

Appendix 2 – COC form for macroinvertebrate samples analyzed by Dr. Larry Gray (U:\WQ\PERMITS\MONITORS\Willard Spur\Field Sampling\Chain of Custody Forms\COC_macroinvertebrates wetlands_Gray lab.doc)

UTAH DIVISION OF WATER QUALITY				MACROINVERTEBRATE CHAIN OF CUSTODY RECORD (Gray Lab. Utah Valley University)			
PROJECT: Willard Spur – Macroinvertebrate Sample Collection				**Net:** D-net 500 µm mesh		**Preservation:** Denatured Alcohol	
Sample Date Range:				**Method:** Open water, composite of 5 1-m sweeps		**Length of each sweep (m):** 1	
Sample Number	**Date Collected**	**Time Collected**	**STORET**	**Site Name**	**Water Depth (m)**	**Collector Initials**	**Remarks/Analysis Requested**
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
Relinquished By:				**Date:**	**Time:**	**REMARKS:**	
Received By:				**Date:**	**Time:**		

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Appendix 3 – Field sheet to be used if NOT performing aquatic vegetation measurements on the day of macroinvertebrate sampling

(U:\WQ\PERMITS\MONITORS\GSL wetlands\2011 Field Forms\GSL Wetlands Data Sheet.pdf)

GSL Wetlands Data Sheet:
Open Water Habitat Characteristics

Wetlands Area_____

Site				
Date				
Time				
Water depth, m				
Height of SAV, m				
SAV Cover Class				
SAV Condition				
Fil. Algae Cover Class				
Duckweed Cover Class				

Water Depth: measured to the nearest 0.1 meter

SAV Height: nearest 0.1 meter (if extending to the surface, use water depth value)

SAV Cover Class: extent of SAV coverage of pond bottom

SAV Condition: 1 = decomposing 2 = intact, but stressed 3 = healthy

Filamentous Algae: extent of algae on SAV and/or surface of pond

Duckweed: extent of duckweed on surface of pond

Cover Class	1 = <25%	3 = 50-74%
	2 = 25-49%	4 = 75-100%

Note: Record "0" for cover class if attribute is completely absent.

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United States
Environmental Protection
Agency

Office of Research and
Development
Washington, DC 20460

EPA/600/R-92/111
March 1993

EPA

Fish Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters

ED_006076_00000126-00126

EPA/600/R-92/111
March 1993

FISH FIELO AND LABORATORY METHOOS FOR EVALUATING THE BIOLOGICAL INTEGRITY OF SURFACE WATERS

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ENVIRONMENTAL MONITORING SYSTEMS LABORATORY - CINCINNATI
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CINCINNATI, OHIO 45268

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This document has been reviewed by the Environmental Monitoring Systems Laboratory - Cincinnati (EMSL-Cincinnati), U.S. Environmental Protection Agency (USEPA), and approved for publication. The mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ED_006076_00000126-00128

FOREWORD

Environmental measurements are required to determine the quality of ambient waters and the character of waste effluents. The Environmental Monitoring Systems Laboratory - Cincinnati (EMSL-Cincinnati) conducts research to:

- Develop and evaluate methods to identify and measure the concentration of chemical pollutants in drinking waters, surface waters, groundwaters, wastewaters, sediments, sludges, and solid wastes.
- Investigate and evaluate methods for the identification and measurement of viruses, bacteria and other microbiological organisms in aqueous samples and to determine the response of aquatic organisms to water quality.
- Perform ecological assessments and measure the toxicity of pollutants to representative species of aquatic organisms and determine the effects of pollution on communities of indigenous freshwater, estuarine, and marine organisms, including the phytoplankton, zooplankton, periphyton, macrophyton, macroinvertebrates, and fish.
- Develop and operate a quality assurance program to support the achievement of data quality objectives in measurements of pollutants in drinking water, surface water, groundwater, wastewater, sediment and solid waste.
- Develop methods and models to detect and quantify responses in aquatic and terrestrial organisms exposed to environmental stressors and to correlate the exposure with effects on biochemical and biological indicators.

This manual describes guidelines and standardized procedures for the use of fish in evaluating the biological integrity of surface waters. It was developed to provide biomonitoring programs with fisheries methods for measuring the status and trends of environmental pollution on freshwater, estuarine, and marine habitats in field and laboratory studies. These fish studies are carried out to assess biological criteria for the recognized beneficial uses of water, to monitor surface water quality, and to evaluate the health of the aquatic environment.

Thomas A. Clark
Director
Environmental Monitoring Systems
Laboratory - Cincinnati

ED_006076_00000126-00129

PREFACE

The Bioassessment and Ecotoxicology Branch, Ecological Monitoring Research Division, Environmental Monitoring Systems Laboratory - Cincinnati is responsible for the development, evaluation, and standardization of metbods for the collection of biological field and laboratory data by EPA regional, enforcement, and research programs engaged in inland, estuarine, and marine water quality and permit compliance monitoring, and status and/or trends monitoring for the effects of impacts on aquatic organisms, including the phytoplankton, zooplankton, periphyton, macrophyton, macroinvertebrates, and fish. The program addresses methods for sample collection; sample preparation; organism identification and enumeration; the measurement of biomass and metabolic rates; the bioaccumulation and pathology of toxic substances; bioassay; biomarkers; the computerization, analysis, and interpretation of biological data; and ecological assessments.

This manual contains field and laboratory fish methods for evaluating the health and biological integrity of fresh, estuarine, and marine waters. The manual is a revision and enlargement of the chapter on fish methods originally published in the document, "Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents," Environmental Monitoring Series, USEPA, 1973, EPA-670/4-73-001, which were developed by tbe Bioassessment and Ecotoxicology Branch, Environmental Monitoring Systems Laboratory - Cincinnati, at the request of the Biological Advisory Committee to provide biomonitoring programs with methods for assessing point and nonpoint sources of impacts, status and trends in water quality monitoring.

ED_006076_00000126-00130

ABSTRACT

This manual contains biocriteria and describes guidelines and standardized methods for using fish in evaluating the health and biological integrity of surface waters and for protecting the quality of water resources. Included are sections on quality assurance and quality control procedures; safety and health recommendations; fish collection techniques; specimen processing techniques; identification and taxonomic references; fish age, growth, and condition determinations; data recording; length-frequency; length-age conversion; annulus formulation; relative weight index; flesh tainting; fish kill investigation; bioassessment protocols for use in streams and rivers; family-level ichthyoplankton index; fish health and condition assessment; guidelines for fish sampling and tissue preparation for bioaccumulative contaminants; and an extensive bibliography for fisheries.

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SECTION 1

INTRODUCTION

1.1 This manual was prepared to assist biologists and managers in USEPA and other Federal, state, and private water monitoring organizations in the use of fish as indicators of ecosystem bealth and for evaluating the biological integrity of surface waters and protecting quality water resources. The manual contains biological criteria and laboratory and field methods that will aid in the monitoring and bioassessment of the effects of anthropogenic and environmental stresses on fish populations and communities. It will also facilitate the expansion and refinement of our knowledge of the ecological requirements of fish species in freshwater, estuarine, and marine habitats.

1.2 The manual includes sections on quality assurance and quality control, safety and health, sampling methods and techniques, sample preservation and identification, data analyses, special techniques, bioassessment protocols for use in streams and rivers, a family-level ichthyoplankton index method, fish health and condition assessment procedures, guidelines for fish sampling and tissue preparation for bioaccumulative contaminants, and a fisheries bibliography. Guidelines and procedures for fish kill investigations are provided.

1.3 Fish community evaluation and assessment should measure the overall structure (number of species and individuals within a community) and function (organism interaction in the utilization of food and other biological resources) of various aquatic habitats considered for study. These measurements should include such factors as habitat characteristics and quality, riparian vegetation, and hydraulic characteristics that are expected to influence fish community spatial and temporal variability. One must also distinguish the alterations induced by anthropogenic activities from natural variations which occur in the environment.

1.4 In North America, fish are the focus of economically important sport and commercial fisheries, and are an important source of food for humans. To the general public the size and species composition of a fish community is the most meaningful index of pollution.

1.5 In most aquatic ecosystems, fish are usually the most common vertebrates. Fish communities occupy the upper trophic levels of aquatic food webs, and they are dependent on the same or other trophic level life forms for food. In aquatic communities fish can be one of the most sensitive indicators of water quality assessment and biological integrity in aquatic environments (Angermeier et al., 1991; Fausch et al., 1990; Karr, 1981, 1987, 1990, 1991; Smith, 1971; McKenzie et al., 1992). The literature contains much data on fish species distribution, life histories, ecology, pollution tolerance, and environmental requirements. Fish are directly and indirectly affected by chemical and physical changes in the environment, and the population or community of fish in rivers, streams, lakes, estuaries, and oceans reflects the state of the health of the aquatic environment or watershed as a whole.

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Because they are conspicuous, fish populations or fish assemblages are commonly used as environmental indicators or as an index for water quality (Table 1).

1.6 Water quality conditions that significantly affect the lower levels of food webs (e.g., plankton and benthic invertebrates, including macroinvertebrates, USEPA, 1990a) will affect the abundance and species composition of the fish population. In some cases, fish may exhibit signs of being more sensitive to certain pollutants than are the lower animals and plants, and may be adversely affected even when the lower levels of food webs are relatively unharmed.

1.7 Karr (1981, 1987), Karr et al. (1986, 1987), Ohio EPA (1990), and USEPA (1990a,b) have indicated that five major sets of abiotic and biotic factors affect and ascertain biological integrity or water resource integrity (Table 2). To determine anthropogenic or natural impact on aquatic ecosystems, all monitoring or bioassessment programs must survey and evaluate in a methodical and systematic way all five sets of factors. Although a thorough discussion of all these factors is beyond the scope of this document, a discussion of how some of these factors influence the biological integrity of surface waters and several methods and procedures in evaluating these complex set of factors are presented here. For a more comprehensive discussion of all these factors, consult USEPA (1990a, 1990b), Ohio EPA (1990), and the references in Section 12, Fisheries Bibliography.

1.8 Many species of fish have stringent dissolved oxygen and temperature requirements and are intolerant to chemical and physical contaminants resulting from municipal, agricultural, industrial, forestry, and mining activities. Also, fish communities are sensitive to and good indicators of macrohabitat disturbances (Rankin, 1989).

1.9 The discharge of moderate amounts of degradable organic wastes may increase the nutrient levels (eutrophication) in the habitat and result in an increase in the standing crop (total amount of the biomass of organisms of one or more species within a locality) of fish. This increase usually occurs in one or a few species and results in an imbalance in the population. The discharge of large amounts of degradable organic materials may result in depressed oxygen levels which may reduce the number and kinds of fishes present and increase the standing crop of pollution tolerant species. In extreme cases the fishery may be eliminated in the affected area.

1.10 The effects of toxic wastes may range from the elimination of most fish to a reduction in reproductive capacity (fecundity) or resistance to disease and parasitism. Massive and complete fish kills are dramatic signs of abrupt, adverse changes in environmental conditions. Fish, however, can repopulate an area rapidly if the habitat is not destroyed and the water quality improves. The cause of the fish kill may be difficult to detect by examination of the fish community after it has recovered from the effects of the pollutant. Chronic pollution, on the other hand, is more selective in its effects, exerts its influence over a long period of time, and causes recognizable changes in the species composition and relative abundance of the fish.

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TABLE 1. ATTRIBUTES OF FISHES AND DESIRABLE COMPONENTS FOR BIOASSESSMENT AND BIOMONITORING PROGRAMS[1]

Goal/Quality	Attribute
Accurate Assessment of Aquatic Ecosystem Integrity	Fish populations and individuals generally remain in the same area during summer seasons.
	Communities are persistent and usually recover rapidly from natural disturbances. Comparable results can be expected from an unperturbed site at various times within a season.
	Fish have larger home ranges and are less affected by natural microhabitat differences than smaller organisms, such as macroinvertebrates. This makes fish extremely useful for assessing regional, macrohabitat, and mesohabitat differences.
	Most fish species have long life spans (3-10+ years) and can reflect both long term and current water resource quality.
	Fish continually inhabit the receiving water and reflect the chemical, physical, and biological histories of the water.
	Fish represent a broad spectrum of community tolerances from very sensitive to highly tolerant, and respond to chemical, physical, and biological degradation in characteristics response patterns.
Visibility	Fish are a highly visible component of the aquatic community, and so are of interest to the public.
	Aquatic resource uses and regulatory language are generally characterized in terms of fish (i.e., fishable and swimmable goals of the Clean Water Act).
Ease of Use and Interpretation	The sampling frequency for trend assessment is less than for short-lived organisms.
	The taxonomy of fishes is well established, allowing professional biologists the ability to reduce laboratory time by identifying many specimens in the field.
	The distribution, life histories, and tolerances to environmental stresses of most North American species are well documented in the literature.

[1]Adapted from Simon (1991).

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TABLE 2. FIVE MAJOR CLASSES OF ENVIRONMENTAL FACTORS WHICH INFLUENCE AND OETERMINE THE BIOLOGICAL INTEGRITY OF SURFACE WATERS WITH SOME OF THEIR IMPORTANT CHEMICAL, PHYSICAL, AND BIOLOGICAL COMPONENTS IN LENTIC ANO LOTIC SYSTEMS[1]

1. ENERGY SOURCE

STREAMS, RIVERS	LAKES, RESERVOIRS, ESTUARIES, OCEANS
Nutrient cycling	Nutrients cycling
Organic matter particle size	Organic matter particle size
Primary productivity	Primary productivity
Seasonal cycles	Seasonal cycles
Solar radiation	Solar radiation

2. WATER QUALITY/CHEMICAL VARIABLES

STREAMS, RIVERS	LAKES, RESERVOIRS, ESTUARIES, OCEANS
Adsorption	Adsorption
Alkalinity	Alkalinity
OO	OO
Hardness	Hardness
Metals, other toxic substances	Metals, other toxic substances
Nutrients	Nutrients
Organics	Organics
pH	pH
Solubility	Solubility
Temperature	Temperature
Turbidity	Turbidity
Water cycling	Water cycling

3. HABITAT QUALITY

STREAMS, RIVERS	LAKES, RESERVOIRS, ESTUARIES, OCEANS
Bank stability	Bank stability
Canopy	Shoreline vegetation
Channel morphology (riffles, pools)	Substrate types
Current velocity	Siltation
Gradient	Wave action
Instream cover (woody debris)	Width/depth
Riparian vegetation	Inwater abiotic/biotic cover
Siltation	
Sinuosity	
Substrate types	
Width/depth	

[1]Adapted from Karr (19B7, 1991), Karr and Oudley (1981), Karr et al. (1986, 1987), and USEPA (1990a; 1990b).

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TABLE 2. FIVE MAJOR CLASSES OF ENVIRONMENTAL FACTORS WHICH INFLUENCE AND DETERMINE THE BIOLOGICAL INTEGRITY OF SURFACE WATERS WITH SOME OF THEIR IMPORTANT CHEMICAL, PHYSICAL, AND BIOLOGICAL COMPONENTS IN LENTIC AND LOTIC SYSTEMS (CONTINUED)

4. FLOW REGIME	
STREAMS, RIVERS	LAKES, RESERVOIRS, ESTUARIES, OCEANS
Ground water	Ground water
High/low extremes	High/low extremes
Land use	Land use
Precipitation/runoff	Precipitation/runoff
Water volume	Water volume
5. BIOTIC ASSOCIATIONS	
STREAMS, RIVERS	LAKES, RESERVOIRS, ESTUARIES, OCEANS
Feeding	Feeding
Competition	Competition
Disease	Disease
Parasitism	Parasitism
Predation	Predation
Reproduction	Reproduction

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1.11 The utilization of biological components (structural and functional) to evaluate the ambient aquatic community of our nations surface water has been discussed and well documented in the literature. Some recent examples are Crowder (1990), Downing et al. (1990), Fausch et al. (1990), Hunsaker and Carpenter (1990), Karr et al. (1986), Karr, (1991), Ohio EPA (1987a, 1987b, 1989, 1990), Plafkin et al. (1989), Shuter (1990), Simon (1991), and USEPA (1990a, 1990b). Structural components of fish communities include diversity, taxa guilds, numbers, and biomass. Functional components of fish communities include the feeding or trophic strategy, reproductive behavior and guild classification, and environmental tolerance to perturbations.

1.12 The principal characteristics of interest in bioassessment studies of fish populations include: (1) species richness (number of species)--presence or absence; relative and absolute abundance of each species, (2) size distribution, (3) habitat guilds--pelagic, littoral, and benthic species, (4) trophic guilds--omnivores, piscivores, and invertivores, (5) growth rate, (6) condition factor, (7) reproductive guilds, egg production and success, (8) general tolerance guilds (indicator taxa)--intolerant, tolerant, and sensitive species, (9) incidence of disease and parasitism (10) fish kills, (11) palatability, and (11) fishability--catchability, desirability, and sustainability. Observations of fish behavior can also be valuable in detecting environmental problems, e.g., ventilation rates, position in the current, and erratic movement. Fish may also be utilized for field and laboratory bioassays (USEPA, 1991a, 1991b, 1992a, 1992b), for tissue analyses to measure the concentrations of metals and pesticides (see Section 10, Guidelines for Fish Sampling and Tissue Preparation for bioaccumulative Contaminants) for histopathologic examination (Hinton and Lauren, 1990), and biomarker studies (Adams, 1990a, 1990b; Anderson, 1990; Jimenez and Stegeman, 1990; Rice, 1990; Schreck, 1990; and Thomas, 1990).

1.13 Fisheries data are useful in enforcement cases and in long-term water quality status and trends monitoring (Tebo, 1965; Ohio EPA, 1990; USEPA, 1991a). Before fishery surveys are initiated, a careful and exhaustive search should be conducted for existing information on the fish populations or communities in question. State and Federal fishery agencies and universities may be potential sources of information. If data are not available and a field study must be conducted, State and other Federal agencies may assist in a survey and may provide needed expertise and specialized equipment for the collection of specific, local fishes. A joint effort is usually more economical and efficient and will promote continued cooperation between agencies and parties involved.

1.14 Fisheries data may have limitations. Even if the species composition of the fish in a specific area is known before and after the discharge of pollutants, the significance of changes in the catch might not be satisfactorily interpreted unless there are adequate data on spawning, seasonal migration, temperature requirements and stream-flow responses, feeding activities, diurnal movements, habitat preferences, and activity patterns. Without adequate data, fish presence or absence cannot be directly correlated with water quality. Furthermore, any existing data of known quality on the water quality requirements of fish would be of value in interpreting field data.

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1.15 Federal and state regulations usually require a fish collecting permit because some species of fish are protected by law, and the collection of others is regulated. The state fishery agencies must be contacted before fish can be taken in a field study. Investigators should confirm that they have complied with federal and state regulations before collecting samples of fish. The state should be contacted prior to any fish study to ensure that investigators comply with current regulations.

1.16 The design of fish studies should be based upon study goals and data quality objectives (DQOs) (see Section 2, Quality Assurance and Quality Control). To supplement the material contained in this manual, a number of basic references should be reviewed by investigators involved in fish sampling programs and studies. Useful references include Adams (1990), Angermeier et al. (1991), APHA (1992), Bartell (1990), Edwards and Megrey (1989), Evans et al. (1990), Everhart and Youngs (1981), Fausch et al. (1990), Gammon (1980), Gammon et al. (1990), Hankin and Reeves (1988), Hellawell (1986), Herricks and Schaeffer (1985), Hirsch et al. (1988), Hughes et al. (1986), Johnson and Nielsen (1983), Karr (1981, 1987, 1990, 1991), Karr and Dionne, 1991, Karr and Dudley (1981), Karr et al. (1983, 1986, 1987), Magnuson (1991), Manci (1989), Mangel and Smith (1990), Minshall et al. (1989), Ohio EPA (1986, 1987a, 1987b, 1989, 1990), Omernik (1987), Platts et al. (1983), Robins et al. (1991), Schreck and Moyle (1990), Templeton (1984), Tonn (1990), USEPA (1988), USEPA (1990a, 1990b), (USEPA, 1991c, 1991d, 1991e), Whittier and Paulsen (1992), Wooten (1990), and Yoder (1991).

1.16.1 If fish data are to be useful, they must be acquired according to standardized sampling methods and analyzed with appropriate statistical methods. Two very important qualities of sampling data are accuracy and precision. Accuracy refers to how well the sample represents the whole of the study. In fishery studies, collecting accurate (or unbiased) data may be difficult because studies are poorly designed. Precision refers to repeatability of data. To supplement the statistics in this document, investigators should consult the commonly cited statistical references (Cochran, 1977; Conover, 1980; Green, 1979; Hicks, 1982; Snedecor and Cochran, 1981; Sokal and Rohlf, 1981; Zar, 1984).

1.17 Literature Cited

Adams, S.M. (ed.). 1990a. Biological indicators of stress in fish. American Fisheries Symposium 8, American Fisheries Society, Bethesda, MD.

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SECTION 2

QUALITY ASSURANCE ANO QUALITY CONTROL

2.1 Introduction

2.1.1 Fish studies, like macroinvertebrate studies (USEPA, 1990a), require a strong quality assurance (QA) program and effective quality control (QC) procedures that encompass field and laboratory data collection activities. The term "quality assurance" refers to an integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence. The term "quality control" refers to the overall system of technical activities whose purpose is to measure and control the quality of a product or service so that it meets the needs of users. The aim is to provide quality that is satisfactory, adequate, dependable, and economical (modified from USEPA, 1974; 1978).

2.1.2 Quality assurance programs have two primary functions in a biomonitoring/bioassessment laboratory. First, the project or program should define the data quality needed for the program's goals in terms of accuracy, precision, representativeness, comparability, and completeness (see Subsection 2.6, Fish Collection). The second function is to provide information on the success with which the measurement data meet these goals.

2.1.3 Quality assurance and quality control (QA/QC) must be a continuous process in the biomonitoring/bioassessment program that includes all aspects of the program, including field collection and preservation, habitat assessment, sample processing, data analysis, and reporting. Otherwise, the data generated may not be reliable and useful for decision making, and the results will be of little use in assessing and establishing the conditions (health, biological integrity, and quality of the water resources) of the water body under study. Without an appropriate program of quality assurance and quality control, data will be of unknown quality, limiting its interpretation and usefulness. Quality must be assured before the results can be accepted with any scientific studies. As described below, quality assurance is accomplished through establishment of thorough investigator training, protocols, guidelines, comprehensive field and laboratory data documentation and management, verification of data reproducibility, and instrument calibration.

2.1.4 To support the operation of a consistent plan, the persons responsible for QA should consult the EPA Quality Assurance manual (USEPA, 1984a; 1984b; 1989; 1992b). All EPA QA programs are implemented and operated under the authority of EPA Order 5360.1. USEPA (1984b) serves as guidance and describes the policy, objectives, and responsibilities of all USEPA programs, regional offices, and laboratories producing data for USEPA to institute a specific QA program. Each office or laboratory that generates data under USEPA's QA/QC program must implement, at a minimum, the prescribed procedures to ensure that precision, accuracy, completeness, comparability, and representativeness of data are known and documented.

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2.1.4.1 Information and discussion of statistical tools, data quality objectives, comparison of good laboratory and field practices, and other quality assurance considerations in the context of ecological research are found in USEPA (1992b). Each agency should have a designated QA/QC officer (or a person in charge of the program) responsible for reviewing project plans, SOPs, etc. and auditing the program for improving performance, etc.

2.1.5 The Fish Bioassessment Protocols for Use In Streams and Rivers, Section 8, can be modified to achieve various data quality objectives. A different habitat assessment approach, replicate sampling, more intensive sample enumeration, or modified analytical metrics may be preferred by a particular State over the approaches in this Section. Such refinements can be accommodated, provided they are clearly documented in an USEPA approved QA program and/or project plan.

2.1.6 Components of the QA program (Khalil and Tuckfield, 1992; USEPA, 1984a; 1984b; 1990a; 1991a; 1992a; 1992b) should include the following:

2.1.6.1 Approved methodology and documentation for the collection, preservation, and analysis of data.

2.1.6.2 Documentation and manufacturer's instructions for sampling equipment, flow measuring devices, and other measuring instruments such as pH, DO, and conductivity meters.

2.1.6.3 Methods and documentation to assure that representative samples are collected (See Subsection 2.2, Data Quality Objectives and Subsection 2.8, Standard Operating Procedures).

2.1.6.4 Methods and documentation to assure the precision of sampling and analysis procedures. Collecting precise fish data usually requires extensive sampling as well as careful design.

2.1.6.5 Methods to assure accurate and timely recording, storage, and retrieval of data.

2.1.6.6 Documentation to assure sample evaluation, statistical evaluation, and performance evaluation of laboratory procedures.

2.2 Data Quality Objectives

2.2.1 A full assessment of the data quality needed to meet the study objectives should be made prior to preparation and implementation of the QA plan. Data quality is a measure or description of the completeness, type, and amount of error associated with a data set. Determination of data quality is accomplished through the development of data quality objectives (DQOs), which are statements of the level of uncertainty a decision-maker is willing to accept or the quality of the data needed to support a specific environmental decision or action and the rationale behind those statements and levels of data quality. Both qualitative and quantitative descriptors of data quality must be considered to determine whether data are appropriate or adequate for a particular application. However, DQOs are target values and not necessarily

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criteria for the acceptance or rejection of data (Table 1). Table 1 is a summary listing QA objectives for precision and completeness. Oata quality requirements should be based on prior knowledge of the sampling procedures or measurements system by use of replicate (duplicate) analyses, reference conditions (site-specific or ecoregional), or requirements of the specific project (USEPA, 1989).

2.2.2 Oata quality objectives are developed in three stages. During the first stage, the decision-maker determines what information is needed, reasons for the need, how the information will be used, and specifies time and resource constraints. The second stage involves the technical staff and the decision-maker interacting to establish a detailed and clarified specification of the problem, how the information will be used, any constraints imposed on the data collection, and what limitations of the information will be acceptable. The third stage involves the examination of the possible approaches to collection and analysis of the data and a determination of the quality of the data that can be expected to result from each approach. The best approach is selected based upon the criteria agreed upon in the second stage. It may be necessary to modify the objectives of the study during the development of the OQOs. Oetails for developing DQOs are described in USEPA (1986; 1989). These documents are available from the Quality Assurance Management Staff, Office of Research and Development, Washington, DC 20460 and the Center For Environment Research Information (CERI), U.S. Environmental Protection Agency, Cincinnati, OH 45268. The CERI information and document ordering phone number is (513) 569-7562. Johnson and Nielsen (1983), Ohio EPA (1989), and Simon (1991) discuss sampling considerations for collecting fish data.

2.2.3 After the DQOs are established, the detailed project QA plan should be finalized stating specific quantitative and qualitative data quality goals and QC procedures that will be used to control and characterize error (USEPA, 1980; 1989; 1992b). These goals, based on the OQOs, will be the criteria for measuring the success of the QA program.

2.2.4 The Quality Assurance Management Staff, Office of Modeling, Monitoring Systems, and Quality Assurance, is responsible for providing general guidance for the inclusion of DQOs in quality assurance program and project plans, and for providing guidance to the regions on the application of the DQOs development process. The EPA regional offices are responsible for ensuring that state QA programs and project plans are in conformance with grant requirements specified in 40 CFR Part 30, and for assisting the states in developing DQOs requirements and Quality Assurance Program Plans (QAPP) that meet state needs (USEPA, 1989).

2.2.5 Regional and state laboratories or monitoring personnel in need of specific guidance in preparing Quality Assurance Project Plans or development of DQOs for bioassessment projects can contact personnel of the 8ioassessment and Ecotoxicology 8ranch in the Ecological Monitoring Research Division, Environmental Monitoring Systems Laboratory-Cincinnati, OH for assistance ((513) 533-8114, FAX (513) 533-8181).

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TABLE 1. EXAMPLE DF SUMMARY TABLE FDR DATA QUALITY REQUIREMENTS[1]

Measurement Parameter	Reference	Precision (RPD[2], RSD[3])	Completeness (%)
Benthos	Plafkin et al. (19B9)		
No. Individuals		50	95
No. Taxa		15	95
Fish	Karr et al. (1986)		
No. Individuals		25	95
No. Species		15	95
Dissolved Oxygen (mg/L)	ASTM (1992)	5	90
Water Temperature °C	ASTM (1992)	5	90

[1]From USEPA (1992b).
[2]RPD = Relative percent difference.
[3]RSD = Relative standard deviation.

2.3 Facilities And Equipment

2.3.1 Laboratory, field facilities, and equipment must be in place and operating consistently with their designed purposes so that quality environmental data may be generated and processed in an efficient and cost-effective manner. Suitability of the facilities for the execution of both the technical and QA aspects of the study should be assessed prior to initiation of the study. Adequate environmental controls (space, lighting, temperature, noise levels, and humidity) should be provided. Satisfactory safety and health maintenance features must also be provided (see Section 3, Safety and Health).

2.3.2 Equipment (boats, sampling gear, etc.) and supplies necessary to adequately collect, preserve and process fish and other biological samples must be available and in good operating condition. See Section 4, Sample Collection for Analysis of the Structure and Function of Fish Communities, Table 3, General Checklist Of Fish Field Equipment And Supplies.

2.3.3 To ensure data of consistently high quality, a plan of routine inspection and preventive maintenance should be developed for all facilities and equipment. All inspections, calibrations, and maintenance must be documented in individual bound notebooks. This documentation should include detailed descriptions of all calibrations performed, adjustments made, and parts replaced, and each entry should be signed and dated.

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2.4 Calibration, Documentation, and Record Keeping

2.4.1 Quality assurance plans should contain mechanisms for demonstrating the reproducibility of each measuring process. Regular calibration of instruments, proper documentation, and permanent record keeping are essential aspects of such plans.

2.4.2 Each measuring device (pH and DO meters, etc.) must be calibrated before each use according to the manufacturer's instructions, and routine checks using National Institute of Standards and Technology standards, or other standards of known accuracy, should be made to demonstrate that variables are within predetermined acceptance limits. Permanent records giving dates and details of these calibrations and checks must be kept. Documentation is necessary to identify each specific measuring device, where and when it is used, what maintenance was performed, and the dates and steps used in instrument calibration. All samples collected and field data sheets should also be assigned a unique identification number and label. Data should be documented to allow complete reconstruction, from initial field record through data storage system retrieval.

2.4.3 Sample tracking is important, but whenever samples are collected to be used as evidence in a court of law, it is imperative that laboratories and field operations follow written chain-of-custody procedures for collecting, transferring, storing, analyzing, and disposing of the samples. The primary objective of chain-of-custody procedures is to create a written record (Figures 1 and 2) can be used to trace the possession of the sample from the moment of collection through the introduction of the analytical data into evidence. Explicit procedures must be followed to maintain the documentation necessary to satisfy legal requirements. All survey participants should receive a copy of the study plan and be knowledgeable of its contents prior to implementing the field work. A presurvey briefing should be held to reappraise all participants of the survey objectives and chain-of-custody procedures. After all chain-of-custody samples are collected, a debriefing should be held in the field to check adherence to chain-of-custody procedures. Chain-of-custody procedures are discussed in four USEPA manuals (USEPA, 1974; 1990b; 1991a; 1992b).

2.4.4 Field and laboratory personnel should keep complete, permanent records of all conditions and activities that apply to each individually numbered sample sufficient to satisfy legal requirements for any potential enforcement or judicial proceedings. The field data sheets and sample tags (see Section 4, Sample Collection for Analysis of the Structure and Function of Fish Communities; Section 5, Fish Specimen Processing; Section 8, Fish Bioassessment Protocols For Use In Streams and Rivers) should be filled out as completely and as accurately as possible to provide a record in support of the survey and analysis conclusion. Abbreviations commonly used in documentation (e.g., scientific names) should be standardized to decrease data manipulation error. Field and laboratory data sheets and final reports should be filed. All field and laboratory data sheets should be dated and signed by the sampler and analyst, respectively. Notebooks, data sheets, and all other records that may be needed to document the integrity of the data should be permanently filed in a secure fireproof location.

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Project No.	Station I.D.	Month Day Year	Time	Designate: Comp.	Designate: Grab

Tag No. 4A20543	Station Location	Samplers (Signatures)
Lab Sample No.		

Remarks:						Cyanide	Volatile Organics	Pesticides/PCB's	Extractable Organics	Metals	BOD, Solids	COD, TOC, Nutrients	ANALYSES	Preservative: No ☐ Yes ☐: ____

Figure 1. Example of sample identification tag. From USEPA (1990b) and USEPA (1991a).

2.5 Habitat Assessment

2.5.1 Because the habitat characterization procedures (see Section 4, Sample Collection for Analysis of the Structure and Function of Fish Communities and Section 8, Fish Bioassessment Protocols for Use in Streams and Rivers) are primarily a qualitative evaluation, final conclusions are potentially subject to variability among investigators. This limitation can be minimized however, by ensuring that each investigator is appropriately trained in the habitat evaluation techniques and periodic cross-checks are conducted among investigators to promote consistency. Also, bioassessment laboratories should institute one or two day training courses on habitat characterization and evaluation followed by periodic refresher training. For additional information and discussion on habitat evaluation and a Qualitative Habitat Evaluation Index (QHEI), see Barbour and Stribling (1991), Plafkin et al., (1989), Ohio EPA (1989), Rankin (1989), and USEPA (1990a; 1991b) for additional information and discussion on habitat evaluation and a Qualitative Habitat Evaluation Index (QHEI), regarding rationale, methods, and application for fish bioassessment. Also, see Section 4, Sample Collection for Analysis of the Structure and Function of Fish Communities, Subsection 4.1.5, Habitat Evaluation and Section B, Fish Bioassessment Protocols For Use In Streams and Rivers, Subsection 8.13.3, Habitat Quality and Assessmemt.

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PROJECT NO.	PROJECT LEADER	REMARKS
PROJECT NAME/LOCATION		

SAMPLE TYPES

1. SURFACE WATER
2. GROUND WATER
3. POTABLE WATER
4. WASTEWATER
5. LEACHATE
6. SOIL/SEDIMENT
7. SLUDGE
8. WASTE
9. AIR
10. FISH
11. OTHER _____

SAMPLERS (SIGN)

CIRCLE/ADD parameters desired. List no. of containers submitted

ANALYSES: COD, TOC, NUTRIENTS; BOD, SOLIDS; METALS; EXT ORG/PEST/PCBs; VOA; CYANIDE

STATION NO.	SAMPLE TYPE	19 ___ DATE	TIME	COMP	GRAB	STATION LOCATION/DESCRIPTION	TOTAL CONTAINERS	COD, TOC, NUTRIENTS	BOD, SOLIDS	METALS	EXT ORG/PEST/PCBs	VOA	CYANIDE				TAG NO./REMARKS	LAB USE ONLY

RELINQUISHED BY: (PRINT) / (SIGN)	DATE/TIME	RECEIVED BY: (PRINT) / (SIGN)	RELINQUISHED BY: (PRINT) / (SIGN)	DATE/TIME	RECEIVED BY: (PRINT) / (SIGN)
RELINQUISHED BY: (PRINT) / (SIGN)	DATE/TIME	RECEIVED BY: (PRINT) / (SIGN)	RELINQUISHED BY: (PRINT) / (SIGN)	DATE/TIME	RECEIVED BY: (PRINT) / (SIGN)

DISTRIBUTION: White and Pink copies accompany sample shipment to laboratory; Pink copy retained by laboratory; White copy is returned to samplers; Yellow copy retained by samplers.

*U.S. GPO: 1989-732-186

4-20043 (10/89)

Figure 2. Example of a chain-of-custody record form. Modified from USEPA (1990b), USEPA (1991a), and USEPA, Region 4.

2.6 Fish Collection

2.6.1 Ensuring that fish field survey data are representative of the fish assemblage at a particular site requires careful regional analysis and station evaluation. Data comparability is maintained by using similar collection methods and sampling effort in waterbodies (lakes, reservoirs, estuaries, wetlands, streams, rivers, etc.) of similar size . Also, where possible, major habitats in streams (riffle, run, pool) are sampled at each site, and the proportion of each habitat type sampled should be noted.

2.6.2 Precision, accuracy, and completeness should be evaluated in pilot studies along with sampling methods and site size. Variability among replicates from the same site or similar sites should not produce differences exceeding 10 percent at minimally impacted sites and 15 percent at highly impacted sites (Plafkin et al., 1989). Index of Biological Integrity (IBI) differences at the same site should not exceed 4 (Karr et al., 1986).

2.6.3 Data reproducibility may be ensured by having a variety of investigators periodically resample well characterized sites. Investigator precision and accuracy for use of the Index of Biological Integrity (IBI) and the Index of well-being (Iwb) may be determined by having investigators evaluate a standard series of data sets or preserved field collections.

2.6.4 Taxonomists, fishery staff, and aquatic biologists should be capable of identifying fish to the lowest possible level (species, subspecies) and should have at their disposal adequate taxonomic references to perform the level of identification required. See Section 12, Fisheries Bibliography, for a list of selected taxonomic references. Fishery and aquatic biologists should check this list and obtain those references that will be needed for the identification of specimens.

2.6.5 Field identifications are acceptable, but laboratory voucher specimens are always required for new locality records, new species, and any specimens that cannot be identified in the field. All specimens should be retained for laboratory examination if there are any doubts about the correct identification. Biomonitoring laboratories that do not identify fish and other taxa on a regular basis or that have difficulty identifying organisms should have representative specimens of all taxa verified by a specialist who is a recognized authority in that particular taxonomic group. These specimens must be properly labeled as reference or voucher specimens, including the name of the verifying authority, permanently preserved, and stored in the laboratory, or voucher specimens should be offered to regional and state natural history museums for future reference.

2.6.6 Quality control of taxonomic identifications is accomplished by a second qualified individual.

2.7 Qualifications and Training

2.7.1 All personnel need to have adequate education, training, and experience in the areas of their technical expertise, responsibilities, and in quality

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assurance (QA). Because no formal academic programs in research QA exist, most QA experience must be acquired through on-the-job training.

2.7.2 At least one professional biologist with training and experience in fish sampling methods and fish identification should be involved directly in the field work or should be involved for at least the first two weeks of the field sampling season (and thereafter if necessary), instructing other less qualified staff in all aspects of the field sampling as well as the laboratory analysis of the samples to ensure data quality. Additionally, the investigators should be familiar with the objectives of each site investigation. Periodic conferences with the sampling crew to assure the sampling effort is being conducted in accordance with the standard operating procedures are also advisable. Statistical expertise should be readily available and consulted during every phase of the project.

2.7.3 Management should periodically assess the training needs of all personnel engaged in QA, and recommend and support their participation in appropriate and relevant seminars, training courses, and professional meetings.

2.7.4 Project personnel should have on file an up-to-date resume for each person who is responsible for the collection, analysis, evaluation and reporting of biological data.

2.8 Standard Dperating Procedures (SDPs)

2.8.1 Each laboratory should define the precise methods to be used during each step of the collection, analysis, and data evaluation process. These written procedures become the standard operating procedures (SOPs) describing the operation of the laboratory (USEPA, 1991a). Standard operating procedures for a fish laboratory should describe in stepwise fashion, easily understood by the potential user, at least the following:

1. Sampling methodology, including maintenance of electrofishing gear and seines

2. Replication (duplication)

3. Habitat assessment methodology

4. Sampling site and station selections (including reference sites)

5. Details of preservation and labeling of the samples

6. Use of taxonomic keys

7. Use and calibration of measuring instruments (e.g., DD, pH, and conductivity meters, etc.) and QC requirements

8. Sample chain-of-custody and handling procedures

9. Data analysis, evaluation, and handling

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2.8.2 The SOPs must include a listing of the taxonomic keys and references that should be used for each level of identification required and for each taxonomic group. Field experience and taxonomic expertise requirements of personnel for the particular level of bioassessment performed must be defined in the preparation of DQDs. It should also provide an outline of the steps to be taken to assure the quality of the data.

2.8.3 The SOPs must stress the need for the traceability of the fish samples. At a minimum it should specify that the fish sample be assigned a unique identification number and be properly labeled with the sample number, sampling location, date, and name of the collector (see Section 5, Specimen Processing Techniques for an example of sample tags). It should describe procedures to ensure that each sample collected, as accurately and precisely as possible, represents the fish community sampled.

2.8.4 The SOPs should be approved by the proper authority and must be easily accessible to all appropriate personnel for referral.

2.8.5 The laboratory SOPs must be followed as closely as possible. Any deviations should be documented as to the reason for the deviation and any possible effect the deviation might have on the resulting data.

2.8.6 Field validation, conducted at a frequency to be determined by each agency, should involve two procedures: (1) collection of replicate samples at various stations to check on the precision and accuracy of the collection effort, and (2) repeat field collections and analyses performed by separate field crews to provide support for the bioassessment. In addition, field crews should occasionally alternate personnel with the same field training to maintain objectivity in the bioassessment study.

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SECTION 3

SAFETY AND HEALTH

3.1 Introduction

3.1.1 Collection and analysis of fish samples can involve significant risks to personal safety and health (drowning, electrical shock, pathogens, etc.). While safety is often not considered an integral part of a fish sampling routine, the biologist must be aware of unsafe working conditions, hazards connected with the operation of sampling gear, boats, and other risks (Berry et al., 1983). Management should assign health and safety responsibilities and establish a program for training in safety, accident reporting, and medical and first aid treatment. The laboratory safety document and standard operating procedures (SOPs) containing necessary and specific safety precautions should be available to all persons involved in fish sample collecting and processing. Field and laboratory safety requirements for biomonitoring laboratories are found also in USEPA (1986) and Ohio EPA (1990).

3.2 General Precautions

3.2.1 Good housekeeping practice should be followed both in the field and in the laboratory. These practices should be aimed at protecting the staff from physical injury, preventing or reducing exposure to hazardous or toxic substances, avoiding interferences with laboratory operations, and producing valid data.

3.2.2 Field personnel and sampling crew must have mandatory training in Red Cross first aid, cardiopulmonary resuscitation (CPR), boating and water safety, field survey safety (weather conditions, personal safety, and vehicle safety), presurvey safety requirements (equipment design, equipment maintenance, reconnaissance of survey area), and electrofishing safety (Ohio EPA, 1990). It is the responsibility of the group safety officer or field sampling leader to ensure that the necessary safety courses are taken by all field personnel and that all safety policies and procedures are followed.

3.2.3 Operation of fish sampling devices involves potential hazards that must be addressed by the individuals using the equipment. Electrofishing equipment should be operated carefully. Electrofishing should always be done with at least three individuals, and all safety procedures must be followed. Persons using these devices should become familiar with the hazards involved and establish appropriate safety practices prior to using them (Reynolds, 1983; Ohio EPA, 1990). **Note:** Individuals involved in electrofishing must be trained by a person experienced in this method or by attending a certified electrofishing training course (See Section 4, Sample Collection for Analysis of the Structure and Function of Fish Communities, Subsection 4.3 Electrofishing and Ohio EPA, 1990).

3.2.4 Field personnel should be able to swim. Waders should always be worn with a belt to prevent them from filling with water in case of a fall. The

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use of a life jacket is advisable at dangerous wading stations if one is not a strong swimmer because of the possibility of sliding into deep water.

3.2.5 Individuals sampling with scuba gear must be certified. The hazards of sampling with scuba gear are sufficiently great that certification is mandatory.

3.2.6 Many hazards lie out of sight in the bottoms of lakes, rivers and streams. Broken glass or sharp pieces of metal embedded in the substrate can cause serious injury if care is not exercised when walking or working with the hands in such environments. Infectious agents and toxic substances that can be absorbed through the skin or inhaled may also be present in the water or sediment.

3.2.7 Personnel must consider and prepare for hazards associated with the operation of motor vehicles, boats, winches, tools, and other incidental equipment. Boat operators should be familiar with U.S. Coast Guard rules and regulations for safe boating contained in a pamphlet, "Federal Requirements for Recreational Boats," available from your local U.S. Coast Guard Director or Auxiliary, or State Boating Official (U.S. Coast Guard, 1987).

3.2.8 Prior to a sampling trip, personnel should determine that all necessary equipment is in safe working condition and that the operators are properly trained to use the equipment.

3.2.9 Safety equipment and first aid supplies must be available in the laboratory and in the field at all times. All motor vehicles and boats with motors must have fire extinguishers, boat horns, cushions, and flares or communication devices.

3.3 Safety Equipment and Facilities

3.3.1 Necessary and appropriate safety apparel such as waders, lab coats, gloves, safety glasses, and hard hats must be available and used in accordance with the project safety plan.

3.3.2 First aid kits, fire extinguishers and blankets, safety showers, and emergency spill kits must be readily available in the laboratory at all times.

3.3.3 A properly installed and operating hood must be provided in the laboratory for use when working with carcinogenic chemicals (e.g., formaldehyde) that may produce dangerous fumes.

3.3.4 Communication equipment and posted emergency numbers must be available to field personnel and those working in mobile labs in remote areas for use in case of an emergency.

3.3.5 Facilities and supplies must be available for cleaning of exposed body parts that may have been contaminated by pollutants in the water. Soap and an adequate supply of clean water or ethyl alcohol, or equivalent, should be suitable for this purpose.

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3.4 Field and Laboratory Operations

3.4.1 At least two persons (three persons for electrofishing) must be present during all sample collection activities.

3.4.2 All surface waters should be considered potential health hazards due to toxic substances or pathogens and exposure to them should be minimized as much as possible. Exposed body parts should be cleaned immediately after contact with these waters.

3.4.3 All electrical equipment must bear the approval of Underwriters Laboratories and must be properly grounded to protect against electric shock.

3.4.4 Use a winch for retrieving large fish nets, trawls, etc., for samples collected with heavy sampling devices, and use care in lifting heavy items to prevent back injury.

3.4.5 Persons working in areas where poisonous snakes may be encountered must check with the local Drug and Poison Control Center for recommendations on what should be done in case of a bite from a poisonous snake. If local advice is not available and medical assistance is more than an hour away, carry a snake bite kit and be familiar with its use. Any person allergic to bee stings or other insect bites must take proper precautions and have any needed medications handy.

3.4.6 Personnel participating in field activities on a regular or infrequent basis should be in sound physical condition and have a physical exam annually or in accordance with Regional or State Safety requirements.

3.4.7 All field personnel should be familiar with the symptoms of hypothermia and know what to do in case symptoms occur. Hypothermia can kill a person at temperatures much above freezing (up to 10°C or 50°F) if he or she is exposed to wind or becomes wet.

3.5 Disease Prevention

3.5.1 Unknown pollutants and pathogens in surface waters and sediments should be considered potential health hazards and exposure to them kept to a minimum.

3.5.2 Personnel who may be exposed to water known or suspected to contain human or animal wastes that carry causative agents or pathogens must be immunized against tetanus, hepatitis, typhoid fever, and polio. Field personnel should also protect themselves against the bite of deer or wood ticks because of the potential risk of acquiring pathogens that cause Rocky Mountain spotted fever and Lyme disease.

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SECTION 5

FISH SPECIMEN PROCESSING

5.1 Introduction

5.1.1 After fish are collected, they must be either examined and identified in the field or if voucher specimens are required, they must be fixed immediately for subsequent identification in the laboratory. If the sampling crew have difficulty identifying any specimens in the field, those specimens must be fixed and later identified in the laboratory. The decision to preserve specimens should depend on study objectives. One set of specimens should be preserved during the study (especially in the early stages) so that a vouchered, archived reference collection of each species from different study areas or ecoregions will be available to investigators. The study team should be become familiar with characteristics of the specimens difficult to identify. For general purposes, formalin is usually used as a fixing agent (ASIH, 1988). This fixative solution helps retain chromatophore patterns which aid in species identification. When using formalin, care must be taken because it is highly allergenic, toxic, and dangerous to human health (carcinogenic) if used improperly.

5.1.2 If specimens are to be kept alive, they should be placed in a live well, container, or bucket and processed upon completion of sampling at each site or when the live well container or bucket are full. To minimize fish mortality in the live well or bucket, water should be changed periodically or aerated with a battery-powered pump. Fish should be handled carefully and released immediately after they are identified to species, examined for external anomalies, and weighed if necessary. Every effort should be made to minimize fish handling and holding times.

5.1.2.1 If a large number of the fish specimens are to be kept alive for later study, see Stickney (1983) for a discussion and guidelines on caring for and handling live fish.

5.2 Fixation and/or Preservation of Fish Samples

5.2.1 Fixation is the process of rapidly killing and chemically stabilizing fish tissues to maintain anatomical form and structure. Preservation is the process by which fixed tissues are maintained in that condition for an indefinite period of time.

5.2.2 Fish and ichtyoplankton should be fixed and preserved (Table 1) in the field in neutral buffered 10% formalin or borax buffered 10% formalin (a 9:1 ambient water dilution of 100% formalin) for 24 hours or longer, depending on size of fish (Haedrich, 1983, Lagler, 1956, Lagler et al., 1962, Humason, 1974, and Knudsen, 1966). The sodium phosphate monobasic and sodium phosphate dibasic, or borax, acts as a buffer which neutralizes the acidic effect of the formaldehyde. This mixture retards shrinkage in fish, prevents the hardening of soft body parts, and prevents decalcification of the tissues (Lagler et al., 1962). Fish should remain in the formalin solution for at least 1-2

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weeks to fix the tissue. Fixation may take from a few days with small specimens to a week or more with large forms. Large fish or containers with closely packed fish or temperatures greater than 26.7°C (80°F) require a stronger solution of one part formalin to seven or eight parts water for fixation. Stronger solutions of formalin can cause gaping or distortion of the mouth and gills, thus care should be taken to obtain correct concentrations when making up the formalin solution (Ohio EPA, 1989).

TABLE 1. FORMULATION OF FORMALIN FIXATIVE SOLUTION

37% formaldehyde (100% formalin)	100 mL
Oistilled water	900 mL
and	
Sodium phosphate monobasic ($NaH_2PO_4 \cdot H_2O$)	4 g
Sodium phosphate dibasic (Na_2HPO_4)	6.5 g
or	
Add one teaspoon of borax per 1/2 gallon of the formalin	

5.2.3 Since the volume of collected fishes must be taken into account upon fixation, formalin for field use should be stronger than 10%, and even 20% will not hurt. Formaldehyde gas reaches saturation in water at about 37% by weight; this saturated solution is called 100% formalin. Isopropyl alcohol and ethyl alcohol are preservatives, not fixatives. These preservatives do not fix the tissues, a necessary procedure for tissue preparation, staining, etc.

5.2.4 After fixation in the formalin, some scientists transfer the specimens to a preservative for storage. Ethyl alcohol (70-75%) or isopropanol (40-45%) preservation keeps specimens more pliable than formalin and makes working with them easier. Specimens should be rinsed in water to wash off any excess formalin, placed in a 35% alcohol wash for 2-3 weeks, switched to a 50% alcohol wash for 2-3 weeks, and placed in a 70%-75% aqueous solution of ethyl alcohol or 40-45% isopropanol alcohol for permanent preservation and storage (Haedrich, 1983; Ohio EPA, 1989). Fish should be stored in glass or plastic containers or stainless steel vats for large specimens. Metal containers should not be used. It is important that the containers be tightly sealed to prevent evaporation of the preservative.

5.2.5 Specimens are kept in tightly sealed museum jars, along with their field data. The preservatives will always modify the color, and light will further bleach the fish specimens so the various markings and colors of fish

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should be documented if the specimens are to be identified later. It is advisable to store specimens in the dark at 1B°C to minimize evaporation and bleaching.

5.2.6 Specimens larger than 7.5 cm should be slit on the side at least one-third of the length of the body cavity or injected with a hypodermic syringe to permit the preservative to reach the internal organs. Large and heavy fish (1-2 pounds) should also be injected in the muscles on each side of the backbone with formalin. Fish should be slit on the right side, because the left side is generally used for measurement, scale sampling and photographic records.

5.2.7 Samples for fish tissue contaminant analysis or electrophoresis must be iced, placed in dry ice, or liquid N_2 for temporary storage or shipping. Fish samples for pesticide analysis should be wrapped in aluminum foil, see Section 10, Guidelines for Fish Sampling and Tissue Preparation for Bioaccumulation Contaminants, and placed in a cooler with ice. The sample must be frozen as soon as possible after collection. Fish collected for metals analysis should be placed in plastic bags. All samples should be doubled tagged, with one tag attached outside the foil or plastic bag and one tag inside.

5.2.B Special preservation techniques must be used for histological, histochemical, or biomarker analyses, and the investigator should be aware of such techniques before collecting tissue samples (Humason, 1974).

5.3 Labelling of Specimens in Field and Laboratory

5.3.1 Each specimen or specimens from a collecting site should be carefully labelled with at least the information asked for in the examples of labels in Figure 1.

5.3.1.1 Collection information should be both on and in the container, a tag, or a paper label. If paper labels are used, they should be made of 100% rag (waterproof) and labelled with India ink or a No. 2 soft lead pencil.

5.4 Species Identification

5.4.1 Many fish can be field identified with certainty. However, the following procedures for fish identification and verification of difficult specimens are recommended by Lowe-McConnell (1978):

1. Assemble and use the best available keys and checklists (see Section 8, Fish Bioassessment Protocols for Use in Stream and Rivers, Subsection B.14, Selected References for Determining Fish Tolerance, Trophic, Reproductive, and Origin Classifications and Section 12, Fisheries Bibliography, Subsection, 12.5 Fish Identification).

2. Key fish to species level.

3. Maintain a voucher collection in the laboratory for comparison of specimens.

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4. Verify difficult species identifications with pictures, published descriptions, known geographic range, museum and lab voucher specimens, or have the specimen identified or verified by a specialist.

FIELD SAMPLE DATA LABEL

Project _____

Date _____ Time _____ Collection No. _____

Location _____

_____

County _____ State/Country _____

Collector(s) _____

Type of sample _____ Preservative(s) _____

Method of collection _____

A. Long Form

FIELD SAMPLE DATA LABEL

Date _____ Collection No. _____

Location _____

_____

Collector(s) _____

Type of sample _____ Preservative(s) _____

B. Short Form

Figure 1. Examples of field sample data labels. A. Long form, B. Short form.

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5.4.2 Scientific nomenclature of all specimens should follow the recommendations of the American Fisheries Society (Robins et al., 1990).

5.4.4 Biomonitoring laboratories should maintain a fish reference collection. Unique specimens should also added to the collection. The collection should be archived in a computer data base which cross-references field data and other pertinent information about the study.

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SECTION 6

SAMPLE ANALYSIS TECHNIQUES

6.1 Introduction

6.1.1 One of the major concerns of USEPA, other federal, state and private agencies or laboratories is to describe water quality and habitat quality in terms which are easily understood by the nonbiologist. Fish studies frequently include the number of specimens captured per unit area or unit time. Also, the fish can be measured, weighted, aged, and sexed to provide comparative data between populations in different habitats. The purpose of this section is not to recommend one particular data evaluation method, but to point out a number of more common methods. Some of these methods may not be applicable to every stream, lake, or water body in the United States. Methods, techniques, and biological criteria used to study fisheries biology and to analyze fisheries data are described in this manual, elsewhere in Bagenal (1978), Lager (1956, 1978), Carlander (1969), Everhart et al. (1975), Gulland (1983), Nielsen and Johnson (1983), Schreck and Moyle (1990), USEPA (1990, 1991), and also in other current literature. To supplement the statistics and data evaluation methods in this section and for additional biometrics, consult the statistical references listed in Section 1, Introduction, Subsection 1.16.1. For other multivariate analyses and other techniques to relate distribution to environmental variables and gradients, confer with Matthews (1985), Matthews and Robison (1988), Mayden (1985; 1988), and McAllister et al. (1986).

6.1.2 Water quality and habitat quality are reflected in the species composition and diversity, population density and biomass, and physiological condition of indigenous communities of aquatic organisms, including fish. A number of data interpretation methods have been developed based on these community characteristics to indicate the health and water quality of the aquatic environment, the degree of habitat degradation, and also to simplify communication problems regarding management decisions.

6.2 Oata Recording

6.2.1 The sample records should include collection number, name of water body, date, locality, names of sample collectors, and other pertinent information associated with the sample. Make adequate field notes for each collection. Use water-proof ink and paper to ensure a permanent record. Place the label (Figure 1; also see Section 2, Quality Assurance and Quality Control; Section 5, Fish Specimen Processing) inside the container with the specimens only when fixing or preserving fish for physical examination (**Note: do not place the label with fish if they are to be chemically analyzed.**) and have the label bear the same number or designation as the field notes, including the locality, date, and collector's name. Place a numbered tag on the outside of the container to make it easier to find a particular collection. Place any detailed observations about a collection on the field data sheet (see Section 4, Sample Collection for Analysis of Structure and Function of Fish Communities and Section 8, Fish 8ioassessment Protocols for

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Use in Streams and Rivers for examples of field data sheets). Record fishery catch data in standard units such as number or weight per area or unit of effort. Use the metric system for length and weight measurements. Designate any chemical analyses to be performed, e.g., toxaphene analysis.

6.3 Fish Identification

6.3.1 Proper identification of fish to species level is mandatory in analysis of the data for water quality interpretation. A list of regional and national references for fish identification is located in Section 8, Fish Bioassessment Protocols for Use in Streams and Rivers; Section 12, Fisheries Bibliography. Assistance in confirming questionable identification is available from State, Federal, and university fishery biologists or ichthyologists. In the Quality Assurance Project Plan (see Section 2, Quality Assurance and Quality Control), key(s) used for fish identification should be specified.

Collection No. _____

Project _____

Location _____

_____

Date _____ Time _____ Mile _____

Sampling Device _____

Collected by _____

Observations _____

_____

Preservation(s) _____

Figure 1. Example of fish sample label information for preserved specimen container.

6.4 Species Composition (Richness)

6.4.1 A list of species can be compiled using any sampling device, technique, or combinations of the two. The method used should not select against one or more species. Also, sampling effort should be thorough enough so that all species are collected from the study area, and the sampling should be

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conducted several times during the year to include seasonal species. The calculations for percent species composition in a sample is:

$$= \frac{\text{Number of individuals of a given species}}{\text{Total number of all fish collected}} \times 100.$$

6.5 Length and Weight

6.5.1 Rate of change in length of fish, length frequency distribution, and weight of fish are important attributes of fish populations. These measurements can provide an estimation in growth, standing crop, and production of fish in surface waters.

6.5.1.1 Three length measurements as described by Lagler (1978) are sometimes used in monitoring studies, but total length is used most often. The three length measurements (Figure 2) are standard length, fork length, and total length. Standard length of fish is measured from its most anterior extremity (mouth closed) to the hidden base of the caudal fin rays, where a groove forms naturally when the tail is bent from side to side. Fork length is measured from the most anterior extremity of the fish to the notch in the center of the tail. It is the center of the fin when the tail is not forked. Total length is the greatest length of the fish from the anterior most (mouth closed) and caudal rays squeezed together to give the maximum length measurement. For fish with a forked tail, the two lobes are squeezed together to give a maximum length. If the lobes are unequal, the longer lobe is used.

6.5.1.2 A fish measuring board is commonly used to measure length. Fish measuring boards contain a graduated scale and is usually made of wood or plastic. Lagler (1978) identifies and discusses factors that can cause possible errors and inconsistency in taking length measurements. When taking fish measurements, standard procedures should be written so that the measurements are done the same way if different individuals are involved in this procedure.

6.5.1.3 Measurement of fish weight is taken with an accurate scale that can be used in field studies. Lagler (1978) indicated that precision in weight measurements is not possible because of variation in the amount of stomach contents and the amount of water engulfed at capture of the fish. The weights of live and preserved specimens are not comparable because the percentage of shrinkage is unknown.

6.5.1.4 Additional information on length, weight, and associated structural indices are discussed in Anderson and Gutreuter (1983).

6.6 Age, Growth, and Condition

6.6.1 Changes in water quality can, at times, be detected by studying the age, growth, and condition of fishes taken from a body of water. These studies require extensive knowledge of the life histories of fish and of the area being studied, experience in aging fish, sufficient time and manpower to

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adequately sample and analyze the data, and sufficient age, growth, and condition historical data for comparison.

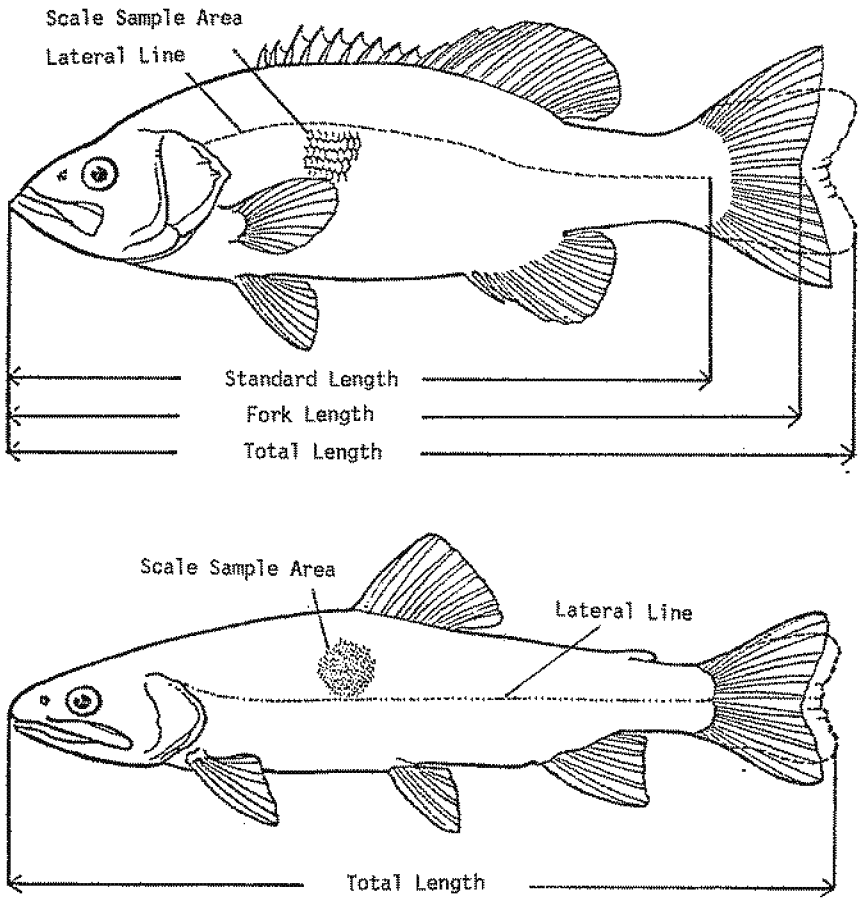

Figure 2. Fish measurements (using a fish measuring board) and scale sampling areas. A. spiny-rayed fish. B. soft-rayed fish. Total length measurement requires compressed tail to give maximum elongation. Modified from Lagler (1956).

6.6.2 A problem in using fish for any type of study is their high mobility. However, Gerking (1959) indicated that many species are relatively sedentary in summer. Depending on the species, there may be no practical way to determine with a first time visit how long an individual fish has been in a given area. Any changes detected in age, growth, or condition are not necessarily attributable to conditions prevailing at the capture site. Some

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information on fish movement may be obtained from previous State or Federal studies. Only a carefully planned, long-term study may provide beneficial data, and only if used in conjunction with other biological, physical, and chemical data, e.g,, benthic invertebrates (macroinvertebrates), periphyton, water flow, habitat, and water chemistry.

6.6.3 The methods most commonly used in studying the age and growth of fishes are: (1) length-frequency, (2) annulus formations in hard parts, such as otolith, bone, spine rays, and scales.

6.6.3.1 The knowledge of the age and rate of growth of fish is extremely useful in fishery management. The processes of determining fish age and assessing fish growth rates are different, but they are closely related and are usually done at the same time. Table 1 was compiled by the Institute for Fisheries Research, the University of Michigan, Ann Arbor, Michigan from samples taken of Michigan fish during a period of approximately 30 years. The samples were collected mostly during the summer months but all months of the year are represented. Variations occur among states in sample size according to species and age groups, and some averages are more reliable than others. Busacker et al. (1990) discuss various techniques that are used in the study of fish growth, and they provide guidance to the appropriate uses of specific growth methods.

6.7 Length-Frequency Method

6.7.1 The length-frequency method for making age determinations is based on the assumption that fish increase in size with age. When the number of fish per length is plotted on graph paper for a given species if comparing a population. Peaks generally appear for each age group.

6.7.2 For this method to provide meaningful data it is important that the following criteria be met during sampling: (1) the fish must be collected over a short period; (2) large numbers must be obtained, including fish of all sizes; (3) the affected area and a control (unaffected) area must be sampled simultaneously within the same time frame.

6.7.3 For some studies, the length-frequency method may be of limited value because: (1) it is considered not reliable in aging fish beyond their second or third growing season (2) acquiring a large number of fish generally requires several experienced field biologists utilizing different sampling techniques.

6.8 Length-Age Conversion Method

6.8.1 In certain studies, it may be desirable to know the age of fish of a given length (e.g., selection data are normally in terms of length, but for incorporation in yield equations need to be expressed in terms of age.) Length can be converted to age (Gulland, 1983) by fitting all the observed data of mean length at age to a growth equation, such as the von Bertalanffy equation.

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$$l_t = L_\infty \, [1 - e^{-K(t-t_0)}]$$

6.8.2 To calculate age (t) in terms of length (l), divide both sides by L_∞, and subtract from unity, resulting in

$$\frac{L_\infty - l_t}{L_\infty} = e^{-K(t-t_0)}$$

taking natural logs of both sides gives

$$\log_e \frac{L_\infty - l_t}{L_\infty} = -K(t-t_0)$$

therefore,

$$t = \frac{1}{K} \log_e \frac{L_\infty}{L_\infty - l_t} + t_0$$

where:

t = age (present)

l = length of individual specimens (length at time (t))

L_∞ = maximum length expected for a particular species

t_0 = the age at which the fish would be zero size

r = growth rate constant

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TABLE 1. AVERAGE TOTAL LENGTHS IN INCHES FOR EACH AGE GROUP OF SEVERAL FISHES IN MICHIGAN[1]

Species	Age Group													
	0	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Bluegill	2.3	3.4	4.4	5.5	6.4	7.0	7.5	7.9	8.6	8.8	9.1	9.8	9.7	...
Pumpkinseed	2.8	3.3	4.4	5.2	5.9	6.4	7.9	7.3	7.8	7.4	8.1	9.8	...	...
Black Crappie	3.6	5.1	6.8	8.2	9.0	9.5	10.6	10.9	11.8	12.2	...	...	...	...
Rock bass	1.5	3.1	4.5	5.6	6.5	7.4	8.2	8.9	9.6	9.9	10.1	11.6	11.7	...
Warmouth	....	3.1	4.4	5.2	5.5	6.2	6.7	6.9	6.6	7.5	7.3	...	...	...
Green sunfish	...	3.0	3.9	4.7	5.1	5.7	5.7	5.0	...	...	...	...	...	...
Largemouth bass	3.6	6.1	8.6	10.6	12.2	13.6	15.1	16.7	17.7	18.8	19.8	19.6	20.8	...
Smallmouth bass	3.4	6.1	9.2	11.3	13.3	14.9	15.7	16.8	17.5	18.5	19.2	...	19.2	...
Yellow perch	3.1	4.6	6.1	7.0	8.0	9.0	9.9	10.7	11.3	11.8	12.3	12.3	13.9	13.2
Walleye	7.1	9.5	13.3	15.2	17.2	18.6	19.2	19.6	21.6	21.4	25.2	23.7	26.5	...
Northern pike	10.2	15.6	19.4	22.2	24.6	26.5	28.9	32.7	33.4	38.7	39.6	42.0	48.0	...
Muskellunge	6.8	15.7	19.9	25.4	31.9	34.7	36.8	39.2	41.7	45.3	48.7	47.5	49.7	...
Smelt	...	5.3	6.9	7.7	8.1	8.8	9.6	...	...	...	...	...	...	...
Brook trout	3.0	6.4	9.0	11.5	15.1	18.8	21.3	23.9	...	...	...	...	...	...
Rainbow trout (inland lakes and streams)	2.2	6.3	8.4	10.3	11.0	...	...	...	...	...	...	...	...	...
Steelhead (lake-run rainbow)	...	13.4	17.0	18.7	23.6	25.4	28.1	30.0	30.4	...	...	...	...	...

[1]From Laarman (1964), Length of common Michigan sport fishes at successive ages, Michigan Fisheries No. 7, Department of Fisheries, School of Natural Resources, The University of Michigan, Ann Arbor, MI.

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6.9 Annulus Formation Method

6.9.1 This technique is based on the fact that fish are poikilothermic animals and the rate at which their body processes function are affected by the temperature of the water in which they live. Growth is rapid during the warm season and slows greatly or stops in winter. This seasonal change produces a band (annulus) in such hard bony structures as scales, otoliths (ear stones), fin rays and spines, and vertebrae each year the fish lives. Scales (Figure 2) are most commonly used in determining the age and yearly rate of growth because they lengthen throughout the life of the fish at a predictable ratio to the annual increment in body length. The location of the body from where the scales are obtained is important. Each species of fish has a specific body area from which scales should be removed for optimum clarity and ease of identifying the annuli and a size at which scale formation begins (Jearld, 1983; Lagler, 1956; Weatherley, 1972). Coin envelopes are frequently used for holding scales and for recording field data (Figure 3).

Collection No. _____

Species _____

Location _____

Date _____ Time _____ Mile _____

Sampling Device _____

Collected by _____

S.L. _____ T.L._____ Wt. _____

Sex ___ Maturity/and state of organs ____

_____

Annuli _____ Condition _____

Figure 3. Example of recording field data information of scale samples for age and growth studies.

6.9.2 Aging can be accomplished by use of a side-field, low-powered microscope, but a microprojector is preferred for determining the rate of growth. Computer assisted microprojectors have been developed for reading scales more rapidly and accurately.

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6.9.3 It is important that the investigator realize that not all annuli-like markings are valid. "Spawning-checks", "false annuli", or other annuli-like marks may be present because of disease, body injury, spawning, etc.

6.9.4 The duration of sampling and the number of fish that must be collected are not as critical as the length-frequency method. Sampling can cover a considerable period and only a single method need be used for capturing the fish. Specialized equipment and trained personnel are needed, however, to identify, analyze, and interpret the data.

6.9.5 To determine any changes in the growth rate of a fish population, it is essential to use both the length-frequency and annulus methods and have samples from unaffected localities and/or sufficient background data from the sampling area. Any changes detected may be attributed to a single or a combination of natural or man-associated activities that altered the environment. Some of the most obvious natural modifications are a change in the average annual water temperature, fluctuating water levels, and availability of food. Man may also influence the water temperature and levels, physically alter the environment and fish habitat by damming or dredging activities, surface mining activities, and introducing substances that directly or indirectly affect the well-being of the fish population. It is evident, therefore, that it may be impossible to pin-point what or who was responsible for the change in the growth rate of a fish population except in a small lake.

6.10 Condition Factor (Coefficient of Condition)

6.10.1 The condition of fish can be estimated mathematically or by evaluating physical appearance.

6.10.2 Mathematically, the coefficient of condition is utilized to express the relative degree of well-being, robustness, plumpness or fatness of fish. It is based on a length-weight relationship and is calculated by the formula:

$$\text{Coefficient of Condition} \quad K_{TL} = \frac{W\ 10^5}{L^3}$$

W = weight in grams
L = length in millimeters
10^5 = factor to bring the value of K near unity
TL = designation of measuring system used (fork, standard, or total length)

6.10.2.1 The coefficient of condition is "K" when the metric system is used in expressing the length and weight, and "C" when the English system is used.

6.10.3 The coefficient of condition has been used by ichthyologists and fishery biologists to determine the suitability of the environment for a species. However, it is not recommended for use in short term water quality studies because any non-environmental factors influence the values derived,

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e.g., changes due to age, sexual differences, and changes with seasons. These natural fluctuations make it extremely difficult to attribute any change to the quality of the water from which the fish are collected and must be taken into account when designing long term studies and evaluating data.

6.10.4 The observance of the physical appearance or condition of fish will usually indicate the general state of their well being and give some broad indication of the quality of their environment. When fish are captured they should be examined to see if they appear emaciated, are diseased, or contain parasites. The condition of their gills should also be checked. Healthy fish will be active when handled and are reasonably plump. Dissect a few specimens and check the internal organs for disease or parasites. The stomach of fish should also be examined to determine if the fish were actively feeding prior to capture.

6.10.5 For more detailed information on age, growth, and conditions of fish, see Anderson and Gutreuter (1983), Bagenal and Tesch (1978), Calhoun (1966), Carlander (1969), Everhart et al. (1975), Goede (1991), Jearld (1983), Lagler (1956), Lux (1971), Norman (1951), Ricker (1975), Schram et al. (1992), Summerfelt (1987), and Weatherley (1972).

6.11 Relative Weight Index

6.11.1 Usefulness of typical fisheries metrics for evaluating sensitive indicator organisms at the population level provide useful information in comparing subtle differences between sites. The drawbacks to using standard fisheries approaches are the limitations of either state developed or regional expectations and the lack of resolution linked with causes. The assessments require a large sample for site comparison and a large number of reference stations for determining the expected population regression line. The traditional approach to the assessment of condition involves the use of a Fulton-type (Anderson and Guetreuter, 1983) condition factor. This is calculated as:

$$K = W/L^3$$

where W is weight (g) and L is length (mm). These factors are both length and species dependent. Therefore, it is improper to compare fish of different species or fish of the same species at different lengths. Le Cren (1951) developed the relative condition factor:

$$K = W/W' \times 100$$

where W is the observed weight and W′ is the length specific expected weight for fish in the populations under study as predicted by a weight-length regression equation calculated for that population. This approach solved the problem of comparing fish of different lengths and species but, because a different weight-length regression was calculated for each population, interpopulational comparisons were not possible. The relative weight (W_r) index (Wege and Andrson, 1978) enabled interpopulational comparisons by making

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the standard weight-length (W_s) regression species-specific rather than population specific or location specific. Relative weight is calculated as:

$$W_r = W/W_s \times 100$$

where W_s is the length-specific standard weight predicted by a weight-length regression constructed to represent the species as a whole.

6.11.2 W_s equations have been defined in most cases to represent populations in better than average conditions (reference conditions) based on the assumption that attempting to produce fish populations that attain only average condition generally does not represent a typical management goal. W_s should be considered a benchmark for comparison of samples and populations. Comparisons are based on the 75th percentile of the weight. An alternative technique, regression-line-percentile (RLP), is based on comparison of $\log_{10}$weight-$\log_{10}$length regression equations for each population whereas the typical W_r equation is based on pooled length-weight data.

6.11.3 Murphy et al. (1991) discussed the development of the index and expounded upon the status and W_r regression equation for 27 species. To calculate W_r properly requires data from representative or reference stations over a broad range for the species of interest. Slopes of less than 3.0 are considered inappropriate for most species because such a slope indicates the species becomes thinner with increased length. Low slopes may also results from including small fish in the regression. Differences of weighing small fishes and the inherent problems of weighing small fishes in the field may preclude development of a single equation for an entire species life history. A minimum applicable length is used to determine the minimum size which should be weighed. For other species the minimum length is a function of the variance:mean ration for $\log_{10}$ weight where it sharply increased.

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SECTION 10

FISH HEALTH ANO CONOITION ASSESSMENT METHOOS[1]

10.1 Introduction

10.1.1 The fish health and condition assessment methods provide relatively simple and rapid indication of how well fish live in their environment. They are manifestations of biochemical and physiological alterations expressed at the organism level. Goede and Barton (1990) and Goede (1992) review various types of condition indices that can be used to assess stress in fish, and they also describe an empirical necropsy-based system of organ and tissue indices that provides a fish health and condition profile of fish populations. External aspects, blood parameters, and the normal appearances of internal vital organs are assumed to indicate that a fish population is in harmony with its environment, or if the fish have been challenged, that the animals have not been stressed enough to cause obvious structural changes. When the necropsy system is applied in the field, departure from normal growth, bioenergetic state, and general homeostasis can be detected, as well as the presence of infectious agents in fish. Advantages of these methods over physiological monitoring or community analyses are that they are simple to use, requires little training, and does not need costly, sophisticated equipment. The fish health and condition assessment could be used routinely in research, culture, management, and regulatory programs to establish a data base for evaluating whether a fish population is coping successfully with its environment.

10.1.2 Novotny and Beeman (1990) evaluated the fish health and condition assessment methods on juvenile chinook salmon (*Oncorhynchus tshawytscha*) that were reared in net pens in the Columbia River, Washington, and they found the procedures were efficient in assessing the condition of fish held under various rearing conditions. They, furthermore, concluded that the simplicity of the methods makes them useful for monitoring fish in culture facilities and fish from wild stocks. These methods are meant to be used by investigators who routinely work in the field and for determining the general health and condition of a group of fish.

10.1.3 It is important that the investigator be able to use the minimum of equipment needed for these methods and to be able to recognize gross appearance or differences of systems in tissues and organs. The investigator does not specifically have to be able to diagnose the cause or causes of the condition. If a departure from normal condition is evident in a significant proportion of the fish population, it is appropriate that a specialist be called to help determine the cause of the variation.

10.1.4 A list of equipment and materials for the fish health and condition assessment is found in Table 1.

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[1]Adapted from Goede and Barton (1990) and Goede (1992).

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TABLE 1. EQUIPMENT AND MATERIALS FOR FISH HEALTH AND CONDITION ASSESSMENT

- Microhematocrit Centrifuge
- Microhematocrit tubes[a,b]
- Critoseal clay to seal hematocrit tubes
- Microhematocrit tube reader
- 1.0 percent sodium or ammonia heparin solution
- Hand held serum protein refractometer
- Lens paper
- Bunsen Burner to sharpen hematocrit tubes
- Sharp/blunt scissors
- Dissecting forceps (preferably a small "mouse tooth type")
- MS-222 or comparable anesthetic[c]
- Metric scale to weigh individual fish
- Fish measuring board
- Hand held magnifying glasses for small fish
- Buckets and tubs to handle fish
- Calculators with standard deviation button

Heart puncture:

[a]Using capillary tubes: Sharpen capillary tubes and re-heparinize sharpened end at least 1/3 to 1/2 of tube.

[b]Heparin:

Use 0.1 gm of heparin to 10 mL distilled water. Fill capillary tube 1/3 to 1/2, then drain back into heparin solution. This solution can be reused again for rest of tubes. Remove all heparin from tubes and dry tubes overnight.

[c]MS-222 Mixture:

To incapacitate but not kill. A solution in excess of 50 mg/L (ppm) MS-222 is recommended. Use 4 times this amount for lethal dosage.

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10.2 Sampling and Collection of Fish

10.2.1 The desired sample size for this procedure is 20 fish of the same species. When working with free-ranging populations, it is not always easy to obtain fish. In the field, the samples often are collected from fish captured in routine netting or electrofishing operations. In some sampling situations 20 fish of the same species might be difficult to collect. In this circumstance the investigator must work with what is caught.

10.2.2 The composition of the fish sampled (e.g., age class, length grouping, etc.) depends upon the data quality objectives (DQOs) of the investigation and upon what fish are available (see Section 2, Quality Assurance and Quality Control).

10.3 Handling of Fish

10.3.1 The ideal collection is taken alive and handled carefully until they can be anesthetized. The fish should be immobilized shortly after capture with an appropriate anesthetic, e.g., tricaine MS-222 (see Table 1).

10.4 Sampling and Reading of Blood

10.4.1 Blood should be collected by cardiac puncture with a sharpened, heparinized microhematocrit tube. If blood is needed for purposes in addition to those of this procedure, a larger volume can be sampled with a syringe and needle from the caudal vasculature. The microhematocrit tube can then be filled from that volume with the syringe. The tube, once filled, is plugged on one end using a commercial clay, prepared and sold for that purpose. It is advised that you place the filled tubes upright in a rack with numbered holes to await placement into a centrifuge. Every effort should be made to keep the tubes in order so that they can be accurately matched to the fish from which they were taken. The tubes are then placed in the numbered slots of a microhematocrit centrifuge and spun for five minutes. A typical microhematocrit centrifuge develops approximately 13,000 G. Erythrocytes (red blood cells) have been shown to "swell" when exposed to carbon dioxide. Thus, it is important that the tubes be spun within one hour of sampling. Once the tubes have been centrifuged they can be transported and read in a more convenient location but they should be read within two hours and definitely before the plasma begins to coagulate. Once the blood fractions have been separated by centrifuging, you can remove the tubes and place them again in the numbered rack. Always keep them in the order in which they were collected so they can be matched with the individual fish from which they were collected. The tubes can be kept until later or one can proceed to read the hematocrit, leucocrit, and plasma protein.

10.4.2 Hematocrit is the packed red cell volume of the blood and is expressed as a percentage of the total column. It is obtained by placing the centrifuged tubes on a microhematocrit reader. These are available in several styles and costs but the simple plastic reader cards containing a nomograph are preferred. The tube is placed on the card so that the bottom of the red (erythrocytes) portion of the column is at the zero line and the meniscus of the clear plasma portion of the column is on one hundred percent. The

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location of the top of the red portion indicates the volume percentage of red blood cells or hematocrit.

10.4.3 There is usually a small "buffy or gray" zone just above the red zone. This is composed of the leucocytes or white blood cells and is used to estimate the leucocrit or percent leucocytes in the packed column. The card reader can be used to read this, and a small magnifying glass is helpful.

10.4.4 Next, the protein content of the plasma is determined. This is done by carefully breaking the hematocrit tube just above the "buffy" zone to obtain only the clear plasma fraction. Be sure that there are no small glass fragments on the broken end and then express the clear plasma onto the glass surface of the hand-held protein refractometer. Read the weight/volume percent of protein. The refractometer must be calibrated before use. To do this, place a few drops of distilled water on the prism surface and adjust the boundary line to the "w" or "wt" mark with the adjusting screw. Some instruments have a thumbscrew and some require a small screwdriver. The investigator should consult the manual supplied with the unit in question. The instrument should be cleaned between readings with lens paper to avoid scratching the surface. The surface should be cleaned with water and dried with lens paper after every use.

10.5 **Length and Weight Measurements**

10.5.1 The lengths and weights can be measured immediately after the blood samples have been collected for hematocrit determinations.

10.5.2 The total length of each fish should be determined in millimeters and the weight in grams. This is fairly straight forward but might be pointed out that the length and weight were initially included in the procedure to see if there was any correlation between fish size and the other parameters.

10.5.3 If it is desired to obtain an accurate estimate of size of the fish in the population, more lengths and weights should be taken through non-lethal sampling. The computer program, discussed later, will accommodate 60 fish.

10.6 **External Examination**

10.6.1 When the fish (Figure 1. External features of a composite fish) are laid out in front of you it is the best time to make general observations about the fish. Record general remarks about fins, skin, and other external features before you begin the specific observation of particular organs and systems. Important conditions to note are deformities, scale loss, and external parasites. These observations are carried as remarks in the data base. It must be noted here that primary observations included in this procedure were intended to permit some inference with respect to health and condition of the fish. This is only one aspect of "quality". Observations relative to esthetics are included as remarks only. Fish species (e.g., Catostomidae, Cyprinidae) develop cornified epithelial tubercles and engage in nuptial bouts. If external lesions or scars are observed in some specimens, the possibility of external anomalies related to spawning behavior should be noted.

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10.6.2 Begin the observations as outlined in the classification system (Table 2). Be sure to record all observations using the abbreviations or codes listed on the classification scheme. This is necessary for subsequent entry into the computer program (see AUSUM PROGRAM USE, page 270). If the observation does not seem to fit any of the listed categories, list it as OT which indicates "other". If you use this category be sure to describe it in the remarks column. It is much easier for the recorder if you proceed routinely in the same order laid out on the fish necropsy (postmortem examination) worksheet (Figure 2). There are many systematic approaches to the order of the procedures, but Goede (1992) has found it more efficient to "open" all of the fish first with the use of sharp/blunt scissors by making a ventral cut from the anal vent forward to the pectoral girdle, cutting closely to one side of the pelvic girdle. A short distance of the "hind gut" is opened with this first cut to permit later observation. Oo not insert the scissors so far that the internal organs are damaged. The fish are opened and laid down in front, in proper order, to wait the final inspection.

10.6.3 Take into consideration the circumstances of the collection. If the fish were collected dead, you must be aware of the often subtle differences this can make in appearance of organs and tissues while still permitting valid observation within the context of this procedure. A photographic, colored atlas (Goede, 1988) of necropsy classification categories has been prepared and may be obtained from Ronald W. Goede, Utah Oivision of Wildlife Resources, Fisheries Experiment Station, 1465 West 200 North, Logan, Ut. 84321-6233. The cost of the atlas is $80.00.

10.7 **External Organs**

10.7.1 Eyes

10.7.1.1. Normal (N) - no aberrations in evidence. Good "clear" eyes.

10.7.1.2 Exopthalmia (E1 or E2) - Swollen, protruding eye. More commonly referred to as "popeye". It is coded as E1 or E2. This refers to the presence of exopthalmia in one eye or two eyes.

10.7.1.3 Hemorrhagic (H1 or H2) - Refers to bleeding in the eye. "Blind" (B1 or B2) - This is a very graphic category and you need not know whether the eye is functionally blind. It generally refers to opaque eyes, and the opacity is not important here.

10.7.1.4 "Missing" (M1 or M2) - An eye is actually missing from the fish.

10.7.1.5 "Other" (OT) - Any manifestations which do not "fit" the above. Oescribe in the remarks column.

10.7.2 Gills

10.7.2.1 Normal (N) - no apparent aberrations in gills. Be very careful in this observation. The gill can easily be effected by the manner in which the fish is handled during and after collecting.

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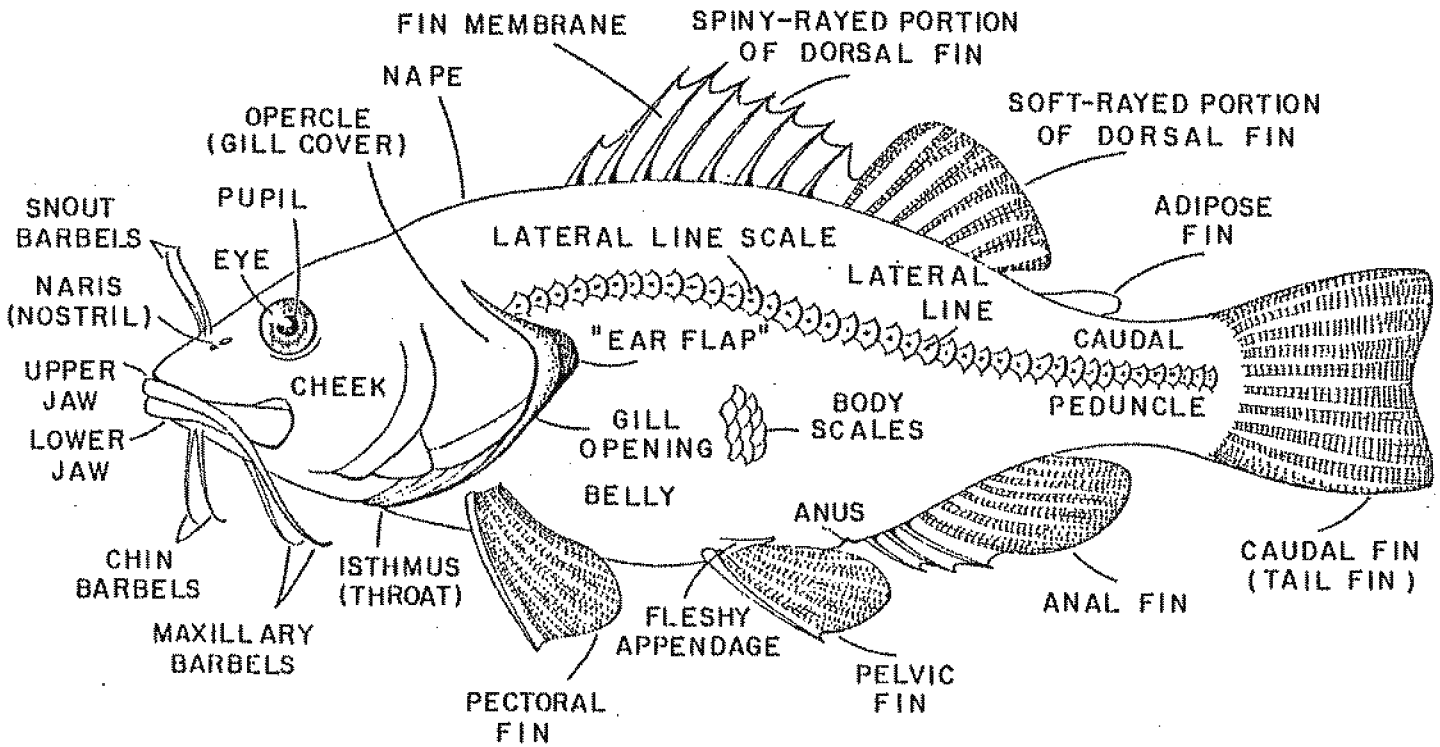

Figure 1. External features of a composite fish. From Lagler (1962), Atlas of Fish Anatomy, Plate 1, Michigan Fisheries No. 5, Department of Fisheries, School of Natural Resources, The University of Michigan, Ann Arbor, MI.

TABLE 2. NECROPSY CLASSIFICATION OUTLINE

Length:	Total length in millimeters
Weight:	Weight in grams
Ktl:	$= \frac{W \times 10^5}{L^3}$ See Subsection 10.9.
Eyes:	Normal (N), Exopthalmia (E1, E2), Hemorrhagic (H1, H2), Blind (B1, B2), Missing (M1, M2), Other (OT)
Gills:	Normal (N), Frayed (F), Clubbed (C), Marginate (M), Pale (P), Other (OT)
Pseudobranch:	Normal (N), Swollen (S), Lithic (L), Swollen and Lithic (S&L), Inflamed (I), Other (OT)
Thymus:	No Hemorrhage (0), Mild Hemorrhage (1), Severe Hemorrhage (2)
Fins:	No active erosion or previous erosion healed over (0), Mild active erosion with no bleeding (1), Severe active erosion with hemorrhage and/or secondary infection (2)
Opercles:	No shortening (0), Mild shortening (1), Severe shortening (2)
Mesentery Fat:	Internal body fat expressed with regard to amount present: 0 - None 1 - Little, where less than 50% of each cecum is covered 2 - 50% of each cecum is covered 3 - More than 50% of each cecum is covered 4 - Ceca are completely covered by large amount of fat
Spleen:	Black (B), Red (R), Granular (G), Nodular (NO), Enlarge (E), Other (OT)
Hind Gut:	No inflammation (0), Mild inflammation (1), Severe inflammation (2)
Kidney:	Normal (N), Swollen (S), Mottled (M), Granular (G), Urolithic (U), Other (OT)
Liver:	Red (A), Light red (B), "Fatty" liver, "Coffee with cream" color (C), Nodules in liver (0), Focal discoloration (E), General discoloration (F), Other (OT)

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TABLE 2. NECROPSY CLASSIFICATION OUTLINE (CONTINUEO)

Bile:	0 -	Yellow or straw color, bladder empty or partially full
	1 -	Yellow or straw color, bladder full, distended
	2 -	Light green to "grass" green
	3 -	Oark green to dark blue-green
Blood:	Hematocrit -	Volume of red blood cell (erythrocytes) expressed as percent of total blood volume. "Buffy" zone of the packed cell column.
	Leucocrit -	Volume of white blood cells (leucocytes) expressed as percent of total blood volume. "Buffy" zone of the packed cell column.
	Plasma Protein -	Amount of protein plasma, expressed as gram percent (grams per 100 mL).

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Fish Necropsies

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Date_____ Unit_____ Strain_____ Quality Control #_____
Location_____ Fish Source_____ Age_____ Case History #_____
Mark/Lot_____ Hat. Date_____ Tissue Collection #_____
Investigator(s)_____ Water Temp._____ Water Hardness_____
Reason for Autopsy_____ Remarks_____

Smp no	Lgth mm	Wght gm	Kil	Eye	Gill	Pshr	Thy	Fat	Spl	Hind Gut	Kid	Liv	Bile	Sex	Hem	Leu	PL Pro	Fin	Opl	Remarks
1																				
2																				
3																				
4																				
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19																				
20																				

GENERAL REMARKS

Fins_____ Gonads_____

Skin_____ Other_____

Figure 2. Fish necropsy worksheet.

10.7.2.2 "Frayed" (F) - This generally refers to erosion of tips of gill lamellae resulting in "ragged" appearing gills. Mere separation of gill lamellae can be construed to be "frayed" but that condition may have been caused by something as simple as the manner in which the gill was exposed by the investigator.

10.7.2.3 "Clubbed" (C) - This refers to swelling of the tips of the gill lamellae. They can often appear bulbous or "club-like". The causes are not pertinent until interpretation is considered.

10.7.2.4 "Marginate" (M) - a graphic description of a gill with a light discolored margin along the distal ends or tips of the lamellae or filaments. Margination can be and often is associated with "clubbing". If both (C) and (M) seem to apply, it is not a problem. It is important that you note that it was not normal. Use the one which seems most appropriate.

10.7.2.5 "Pale" (P) - This refers to gills which are definitely very light in color. Severe anemia can result in gills which are discolored to the point of being white. Severe bleeding induced during sampling of blood can also result in somewhat pale gills. Gills begin to pale somewhat after death also. This is not uncommon in fish taken from nets. All of this should be considered in making the observation.

10.7.2.6 Other (OT) - Any observation which does not fit above. Oescribe in remarks.

10.7.3 Pseudobranchs (The pseudobranch is located dorsally and anterior to the gills in the branchial cavity and can be easily observed under the opercula.) Some species lack pseudobranchia entirely.

10.7.3.1 Normal (N) - The normal pseudobranch is quite "flat" or even concave in aspect and displays no aberrations.

10.7.3.2 Swollen (S) - The "swollen" pseudobranch is convex in aspect and not difficult to discern upon close examination.

10.7.3.3 Lithic (L) - Mineral deposits in pseudobranchs, manifested by appearance of white, somewhat amorphous spots or foci.

10.7.3.4 Swollen and Lithic (S&L) - Lithic pseudobranchs are often also swollen.

10.7.3.5 Inflamed (I) - This is a generic use of the term, inflamed, and would more appropriately be termed "redness" because it also includes observations of hemorrhage and any other cause of redness. The term, "inflamed" has been traditionally used to describe this condition and is thus contained for that reason.

10.7.3.6 Other (OT) - This term will cover any manifestation observed in the pseudobranch which is not covered in the categories. Be sure to describe in remarks.

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10.7.4 Thymus (Assessment of the thymus involves degree of petechial or "pinpoint" hemorrhage).

10.7.4.1 No Hemorrhage (0) - The thymus displaying no hemorrhage is considered to be a normal condition, although this assumption is still under investigation. Caution must be exercised here because when the thymus involutes or ceases to function there is no observable petechial hemorrhage. This happens normally as the fish mature. In salmonids involution of the thymus is thought to happen at two or three years of age but there is considerable disagreement among investigators about this point.

10.7.4.2 Mild Hemorrhage (1) - A few red spots or petechial hemorrhages in evidence. This might be only two or three small spots.

10.7.4.3 Severe Hemorrhage (2) - Many "pin point" hemorrhages in evidence with some of them coalescing. The general area may also have a swollen tumescent appearance but that should be recorded in remarks.

10.7.5 Fins - It must be remembered that this particular assessment procedure is concerned primarily with health and condition. It is not concerned with aesthetic values. Eroded or "ragged" fins are definitely indicative of a departure from normal condition and health. Previously eroded fins which are completely healed over and showing no evidence of the active erosion are, for the purposes of this assessment, considered normal. The evaluation of fins is relative to the degree of active erosion process in evidence. For the purposes of this procedure the number and location of fins involved is not significant. If only one fin is displaying active erosion, the observation must be ranked and recorded. If several fins are displaying erosion with unequal severity, the observation must refer to the most severe in evidence. This unequal nature of the observations, in this case, is less significant in a full 20 fish sample. The classification is as follows:

10.7.5.1 No Active Erosion (0) - Normal appearing fins with no active erosion. This would include previously eroded fins which were completely healed over.

10.7.5.2 Mild active erosion (1) - Active erosion process but no hemorrhage or secondary infection in evidence.

10.7.5.3 Severe Active Erosion (2) - Active erosion with hemorrhage and/or secondary infection in evidence.

Note: Make a general remark relative to which fins were involved and any other observation of special significance. There is a space for this type of entry at the bottom of the data collection worksheet. This is particularly important in the summary.

10.7.6 Opercles (It is necessary only to observe the degree of shortening of the opercles. The classification is as follows:)

10.7.6.1 Normal Opercle (0) - No shortening; gills completely covered.

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10.7.6.2 Slight Shortening (1) - Slight shortening of the opercle with a very small portion of the gill exposed

10.7.6.3 Severe Shortening (2) - Severe shortening of the opercles with a considerable portion of the gill exposed.

10.8 Internal Examination (or Necropsy)

10.8.1 Figure 3 reveals the key internal anatomical features of a typical soft-rayed fish (brook trout), and Figure 4 displays the anatomical features of a characteristic spiny-rayed fish (largemouth bass).

10.8.1.1 If the fish was not "opened" as suggested above, it should be done now to permit access to the internal systems. Remember to proceed, where possible, in the order listed on the data sheets. This facilitates recording. The order was established beginning posteriorly with the mesenteric fat depot, proceeding anteriorly through the spleen and hindgut, to the kidney, liver, and gall bladder, to the gonads for determination of gender and state of development. At this point, it is wise to observe the mesentery tissue for hemorrhage or inflammation and record in remarks if not normal.

10.8.2 Mesenteric Fat

10.8.2.1 The ranking of mesenteric fat depot has been developed around salmonid fishes with prominent pyloric caeca. It must be noted here that there is great variation among the different fish species in the way that they store this fat. If the system is to be applied to other groups of fishes, alternate ranking criteria will have to be developed. It should be further noted that as long as the ranking is 0 through 4 the computer program, AUSUM, for summarizing data, can still be used. The following ranking system was developed for the rainbow trout but has been applied with minor variations to all major groups of salmonids.

0 - No fat deposited around the pyloric ceca. If there is no fat deposit in evidence anywhere in the visceral cavity it is clearly a "0" fat.

1 - Slight, where less than 50% of each cecum is covered with fat. There are cases where there will be no fat in evidence on the ceca, but there will be a slight fat currently classes as a "1".

2 - 50% of each cecum is covered with fat.

3 - More than 50% of each cecum is covered with fat.

4 - Pyloric ceca are completely covered by a large amount of fat.

10.8.3 Spleen

Black (B) - The "black" is actually a very dark red color of the spleen.

Red (R) - Red coloration of the spleen. There is subjective variation among

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SECTION 1I

GUIOELINES FOR FISH SAMPLING AND TISSUE PREPARATION FOR BIOACCUNULATIVE CONTANINANTS

11.1 Introduction

11.1.1 Sampling of fish and shellfish for bioaccumulative contaminants has been conducted for over 35 years. Most fish sampling for contaminants has focused on contaminants of local concern, so data results and program conclusions have not always been comparable. The issues surrounding management of chemical contaminants in fish are of increasing concern for fishery management, environmental and public health agencies. The interdisciplinary multiagency problems caused by chemical contaminants suggests the need for standard sampling protocols. There have been inconsistent warnings given to the public by local, state, and federal regulatory agencies regarding the consumption of sport fish. This has been particularly evident on bodies of water shared by two or more states and on international waters. The Great Lakes States (Great Lakes Fish Consumption Advisory Task Force) and those States and EPA Regions bordering the Mississippi (Mid-America Fish Contaminants Group) and Ohio Rivers (Ohio River Valley Water Sanitation Commission) have endeavored to provide consistent sampling and advisory information but a standard protocol has yet to be agreed upon.

11.1.2 The application of quantitative risk assessment including hazard assessment, dose response assessment, exposure assessment and risk characterization functions best with a standardized protocol. The development of human health fish consumption advisories, whether based on quantitative risk assessment or some other methodology, is fundamentally affected by the procedures used in sampling. This section presents guidance for the sampling and preparation of fish for contaminant analysis, which is a key component of exposure assessment in quantitative risk assessment.

11.1.3 The purpose and goals of each study should be clearly stated prior to the initiation of fish collection for contaminant analysis. One should consider the overall long-term development of a fish contaminant database in each jurisdiction. Frequently short term goals have been the only consideration, where as long term trend assessments may provide a better understanding of the problem because the long view is the only way of gauging important changes occurring in water quality.

11.1.4 Various federal, state, and local agencies have responsibilities for the collection and preparation of fish samples. Thus, numerous collection protocols are available. Fish sampling for contaminant analysis will often be included in other biological surveys to maximize use of the resource and to minimize costs. It must be recognized that any sample collected represents the future expenditure of significant dollar amounts by the time a decision is reached, and can have significant effects on major sectors of our society.

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11.1.5 These guidelines present a basic fish sampling protocol designed to give comparable results between studies. Some additional requirements are pointed out which may be needed in special studies where different sizes or species of fish might be targeted or where special collections for spike samples might be needed. A partial discussion of sampling strategy including statistical concerns can be found in USEPA (1989), which should be reviewed during any planning effort.

11.2 Site Selection

11.2.1 Collecting sites should be established according to the specific requirements of each study. Sites may be designed as short- or long-term depending on the frequency with which they are sampled. Most sampling designs for short-term (synoptic) studies will be structured to determine the extent of contamination in a water body or a section of a water body. The determination of contamination gradients extending away from point sources or industrial/urban areas with point and non-point sources provides important information needed to manage contaminant burdens in fish. Some sites will be selected by individual states to address intrastate needs while other sites will be selected to address interstate needs through cooperative programs. Regardless of the various reasons for site selection, long-term comparability is of utmost importance to provide trend information needed to place bioaccumualtive contaminants in perspective.

11.2.2 Sites should be described as sport, commercial, or having both types of fisheries, and additional sites may be identified for ecological risk assessment. Special watershed information should be indicated, including urban areas, mining, manufacturing, agriculture, etc., and any known point or non-point sources of pollution at or near the site in the watershed. Additional information should include average width, depth, and velocity at the sampling station, description of the substrate, duration of the sampling effort, and habitat area sampled (e.g., length of stream or area of lake). Selected water quality measurements (e.g., conductivity, pH, dissolved oxygen, temperature, etc.) may also be useful. It is becoming routine to collect and analyze water, sediment and fish at common stations to gain a more complete understanding of contaminants in aquatic environments.

11.3 Sample Collection

11.3.1 The following three objectives should guide sample collection:

1. Provide comparable data

2. Utilize sizes and ages of species generally available to the fishery and,

3. Yield data which will screen for problems that might indicate that more intensive studies are needed.

11.3.2 Samples should be obtained at each station from the principal fish categories. Fish species are grouped by feeding strategy into predators, omnivores and bottom feeders. To reduce the number of categories, the

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omnivores may be placed with the bottom feeders. USEPA (1990a) sampled 388 sites nationwide at which 119 different species of fish representing 33 taxonomic families of fish were collected. The most frequently sampled freshwater and marine species in that study are listed in Table 1.

11.3.3 This national study indicates that of the freshwater species, carp and largemouth bass were the most frequently sampled and are the most likely to provide interstate comparability. The other freshwater species listed may be selected in a declining order of priority; however, additional less common species may not be added except in special situations. The diversity of marine species is much greater resulting in a lack of focus on a limited number. Additional effort will be needed to determine which marine species should receive priority on the Atlantic, Pacific and Gulf Coasts in order to provide long term comparative data.

11.3.4 Cunningham et al. (1990) in a census of state fish/shellfish consumption advisory programs found that approximately 60 species of fish and shellfish are used as the basis for consumption advisories nationwide. The leading fish families are the Ictaluridae (catfish), Centrarchidae (sunfish, largemouth and smallmouth bass), Cyprinidae (carp), and Salmonidae (salmon and trout). Among shellfish, crustaceans (e.g., blue crab) and molluscs (e.g., American oyster, soft-shelled clam, and blue mussel) are the most widely used. The criteria most frequently used for collecting fish/shellfish species were: 1) the dominant species harvested for consumption, 2) the most abundant species and 3) the species representing a specific trophic order.

11.3.5 Consistent sampling of common species over long time periods (several years) and large geographic areas will greatly facilitate future trend analyses. Many species are similar in appearance, and taxonomic identification must be reliable to prevent mixing species. Under no circumstance should two or more species be mixed to create a composite sample. Fish for contaminant analyses may be obtained during studies to determine fish community structure. The measurement of multiple parameters (e.g., fish health condition assessment, histopathological examination, bioindicators of stress, etc.) are encouraged on common samples to provide the information needed in ecological risk assessment.

11.3.6 Screening studies should endeavor to collect the largest individuals available. However, more detailed studies should sample the predominant two or three age classes of the same species in a water body to determine the relationship between contaminant burden and fish size (age) to provide information needed for greater risk management flexibility. This information could allow the lifting of an advisory on smaller, more abundant sizes of a contaminated species with lower body burdens if these were important to a sport fishery.

11.3.7 The frequency of sampling should be considered in each study design. Most long-term monitoring programs will be based on an annual frequency due to the costs of analysis. However, special studies may require seasonal sampling. Fish sampled in the fall may tend to have a higher lipid content than those sampled during the spring. Sampling freshwater in the spring may

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TABLE 1. FREQUENCY OF OCCURRENCE FOR FRESHWATER AND MARINE SPECIES IN THE NATIONAL FISH BIOACCUMULATION STUDY (USEPA, 1990a)

FRESHWATER

Bottom Feeder Species	Site Occurrence
Carp	135
White sucker	32
Channel Catfish	30
Redhorse sucker	16
Spotted sucker	10

Game (Predator) Species	Site Occurrence
Largemouth Bass	83
Smallmouth Bass	26
Walleye	22
Brown trout	10
White Bass	10
Northern Pike	8
Flathead Catfish	8
White Crappie	7
Rainbow trout	7

MARINE

Species	Site Occurence
Hardhead catfish	7
Starry flounder	5
Blue fish	5
White perch	4
Winter flounder	4
White sturgeon	4
Red drum	3
Black drum	3
Striped mullet	3
Atlantic croaker	3
Spot	3
Spotted seatrout	3
Weakfish	3
Sheepshead	2
Southern flounder	2
Flathead sole	2
Atlantic salmon	2
Red snapper	2
Gizzard shad	1
Atlantic cod	1
Yellow jack	1
Striped bass	1
American shad	1
Surf smelt	1
Spotted drum	1
Crevalle jack	1
Redstripe rockfish	1
Summer flounder	1
Diamond turbot	1
Hornyhead turbot	1
Bocaccio	1
White surfperch	1
Quillback rockfish	1
Brown rockfish	1
Copper rockfish	1
American eel	1

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find fish more available due to spawning movements exhibited by spring spawning species; however, extensive movement may temporarily dislocate fish from the usual area where they have been exposed to contaminants. The various methods of collecting fillets (skin-on versus skin-off, belly flap included or excluded) must be standardized. A skin-on fillet with belly flap included is recommended. A lipid analysis of each sample is required for trend analysis and model validation, however, lipid content is not recommended for use in normalizing the differences among fillet types because it frequently increases the variance in the data (NOAA, 1989). Even when considering the bioaccumulation of lipophilic compounds all of the compound is typically not stored in the lipid. At any given time additional amounts of the compound will be found in the cell moisture and the non-lipid tissue. Lipid content may also provide insight into seasonal changes within species, as well as identify differences between species used in contaminants monitoring.

11.3.8 Active sampling techniques (electrofishing, trawling, seining, etc.) are preferred over passive capture techniques (gill nets, trammel nets, etc.) however, the latter can be used as long as the gear is checked on a frequent basis to avoid sample deterioration. Species that are difficult to collect may be obtained from a commercial fisherman, but only when the collector accompanies the fisherman to verify the time and place of capture. Following collection, fish should be placed on wet ice in clean coolers prior to processing. Fish should be either processed within 24 hours or frozen within 24 hours for later processing if immediate processing is not possible. If analyses of fish eggs or internal organs are required, a sample size of at least 20 grams is required.

11.3.9 Composite samples of three to ten fish (same species) are recommended for each of the predator and bottom feeder categories based on the variability of contaminant concentration in fish at the site. The number of fish/composite selected should remain constant over time and space for each species monitored. Composites are used to reduce the cost of analysis per fish; however, it must be recognized that statistical manipulation of the data is compromised when individual values are not determined. The smallest size fish in a composite should equal 75% of the total length of the largest fish in a composite, e.g., if the largest is 400 mm, the smallest should not be less than 300 mm. Replicate composite samples may be added as needed to meet statistical requirements; (USEPA, 1989) however, the cost of additional samples will quickly become a factor. The most important sport and/or commercial species in each feeding strategy group should be used for analysis. Composite samples can be collected for either fillet analysis (human health risk assessments) or for whole body analysis (ecological risk assessments and worst case monitoring).

11.3.10 When a study is planned, it is not certain that the quantity of each species indicated for analysis can be obtained especially if the water body has had little or no prior sampling activity. In order to meet both the human health and ecological requirements a sample of a sport fish species and a bottom feeder species is needed. The sport fish species is usually filleted and the data used for human health risk assessment. The whole body analysis of bottom feeder species is used both for initial "worst case" monitoring and for ecological risk assessment.

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11.3.11 If fish are not abundant or detailed comparisons with other parameters are desired, it may be possible to do a reconstructed analysis (Figure 1) on a single species either sport fish or bottom feeder. To do a reconstructed analysis, the fish are filleted and the remainder of the carcass is saved for analysis. The contaminant concentrations in both the fillet and remaining carcass portions can then be added together to estimate the whole body concentration. A lipid analysis must be performed on both the fillet and remaining carcass to allow normalization of the contaminant concentrations in both samples. A reconstructed analysis may be performed on either single fish or composite fish samples, however, the data may be more reliable if single fish are analyzed.

11.3.12 Sediment samples can sometimes indicate a "hot spot" and can be helpful in determining the source(s) of contamination or the zones of deposition. However, sediment samples cannot be used as a substitute for fish collections, but both can provide complimentary data.

11.4. Sample Preparation For Organic Contaminants in Tissue

11.4.1 Collection Precautions

11.4.1.1 In the field, sources of tissue contamination include sampling gear, boats and motors, grease from ship winches or cables, engine exhaust, dust, and ice used for cooling. Efforts should be made to minimize handling and to avoid sources of contamination. For example, to avoid contamination from ice, the whole samples (e.g., molluscs in shell, whole fish) should be wrapped in aluminum foil, placed in watertight plastic bags, and immediately cooled in a covered ice chest. Many sources of contamination can be avoided by resecting (i.e., surgically removing) tissue in a controlled environment (e.g., a laboratory). Organisms should not be frozen prior to resection if analyses will be conducted on only selected tissues (e.g., internal organs) because freezing may cause internal organs to rupture and contaminate other tissue. If organisms are eviscerated in the field, the remaining tissue may be wrapped as described above and frozen. Tissue sample collection and preparation requirements are summarized in Table 2 (Puget Sound Estuary Program, 1989).

11.4.2 Processing

11.4.2.1 To avoid cross-contamination, all equipment used in sample handling should be thoroughly cleaned before each sample is processed. All instruments must be of a material that can be easily cleaned (e.g., stainless steel, anodized aluminum, or borosilicate glass). Before the next sample is processed, instruments should be washed with a detergent solution, rinsed with tap water, rinsed in isopropanol, and finally rinsed with organic free distilled water. Work surfaces should be cleaned with isopropanol, washed with distilled water and allowed to dry completely.

11.4.2.2 The removal of biological tissues should be carried out by or under the supervision of an experienced biologist. Tissue should be removed with clean stainless steel or quartz instruments (except for external surfaces). The specimens should come into contact with precleaned glass surfaces only. Polypropylene and polyethylene (plastic) surfaces and implements are a

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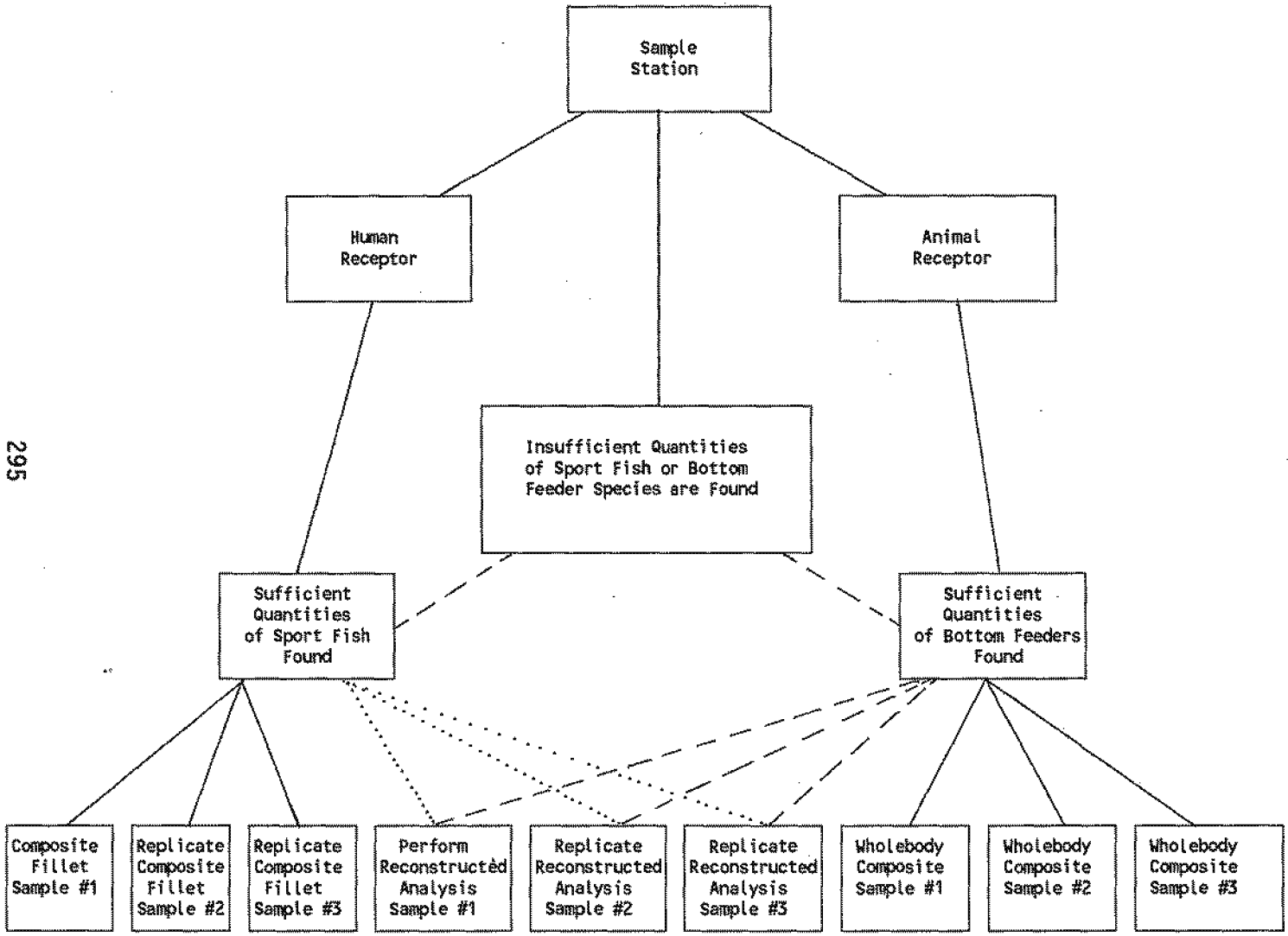

Figure 1. General sampling scheme for bioaccumulative contaminants in fish, multiple age groups will require additional samples.

TABLE 2. SUMMARY OF SAMPLE COLLECTION AND PREPARATION QA/QC REQUIREMENTS FOR FISH TISSUE (MODIFIED FROM PUGET SOUND ESTUARY PROGRAM, 1986, 1989)

Variable	Sample Size (a)	Container (b)	Preservation	Maximum Holding Time (c)	Maximum Extract Holding Time
Organic Compounds					
Wholebody Tissues (after resection)	--	A	Freeze (-18°C)	1 yr	40 days
Semivolatiles	25 g	G,T,A	Freeze (d) (-18°C)	1 yr	40 days
Volatiles	5 g	G,T	Freeze (d) (-18°C)	14 days	--
Trace Metals					
Wholebody Tissues (after resection)	--	W,P,B	Freeze	6 mo	
All Metals	5 g	P,B	Freeze (d)	6 mo	
(except Hg)	0.2 g	P,B	Freeze (d)	28 days	

a. Recommended wet weight sample sizes for one laboratory analysis. If additional laboratory analyses are required (i.e., replicates) the field sample size should be adjusted accordingly. If specific organs are to be analyzed, more tissue may be required.

b. G = glass, A = wrapped in aluminum foil, placed in watertight plastic bags, T = PTFE (Teflon), P = linear polyethylene, B = borosilicate glass, W = watertight plastic bags.

c. This is a suggested holding time. No USEPA criteria exist for the preservation of this variable.

d. Post-dissection

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potential source of contamination and should not be used. To control contamination when resecting tissue, technicians should use separate sets of utensils for removing outer tissue and for resecting tissue for analysis.

11.4.3 Preparation of Composite Fillet Samples

11.4.3.1 For fish samples, special care must be taken to avoid contaminating targeted tissues (especially muscle) with slime and/or adhering sediment from the fish exterior (skin) during resection. The proper handling in the preparation of fish tissue samples to decrease the likelihood of contamination cannot be over emphasized. To reduce variation in sample preparation and handling, samples should be prepared in the laboratory rather than in the field. However, if no laboratory is available, field preparation is acceptable if portable tables are used, dust and exhausts are avoided and proper decontamination procedures are followed. Regardless of where preparation occurs, the following subsections should be followed to insure quality fillet samples:

11.4.3.2 To initiate processing, each fish is measured (total or fork length) to the nearest tenth of a centimeter, weighed (nearest gram) and external condition noted. A few scales should be removed from each fish for age and growth analysis. This presents an excellent opportunity to systematically evaluate each fish using the Fish Health and Condition Assessment Methods (Section 10). Fish are scaled (or skinned: catfish) and filleted carefully, removing bones, to get all of the edible portion flesh.

11.4.3.3 A fillet includes the flesh tissue and skin from head to tail beginning at the mid-dorsal line from the left side of each fish and including the belly flap. The fillet should not be trimmed to remove fatty tissue along the lateral line or belly flap. A comparable fillet can be obtained from the right side of the fish and can be composited with the left fillet, kept separate for duplicate quality assurance analysis, analyzed for different compounds or archived. Each right and left fillet should be weighed individually, recorded and individually wrapped in clean aluminum foil.

11.4.3.4 Care must be exercised not to puncture any of the internal organs. If the body cavity is entered, rinse the fillet with distilled water. Fish sex and condition of internal organs are determined during or after filleting. This skin-on fillet deviates from the skin-off fillets analyzed in the National Fish Bioaccumulation Study (USEPA 1990a), however, skin-on is recommended because it is believed that this is the way most sport anglers prepare their fillets. The issue of skin-on versus skin-off fillets differs greatly among jurisdictions (Hesse, 1990) and is far from settled, however, the above recommendations appear to be the preferred method unless the species specificity is increased in future guidelines.

11.4.3.5 Filleting should be conducted on cutting boards covered with heavy duty aluminum foil, which is changed between composite samples. Knives, fish scalers, measurement boards, scales, etc. should be cleaned with reagent grade isopropanol, followed by a rinse with distilled water between each composite sample.

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11.4.3.6 Because of the low limits of detection for many environmental analyses, clean field and laboratory procedures are especially important. Sample contamination can occur during any stage of collection, handling, storage or analyses. Potential contaminant sources must be known and steps taken to minimize or eliminate them.

11.4.3.7 Large sheets of heavy duty aluminum foil should be used to carefully fold and completely wrap the fillet samples. When filling out I.D. labels use pencil or waterproof marker and place the foil wrapped sample in a secured plastic bag.

11.4.4 Storage

11.4.4.1 Recommended holding times for frozen tissue samples have not been established by USEPA, but a maximum 1 year holding time is suggested. For extended sample storage, precautions should be taken to prevent desiccation. National Institute For Standards and Technology is testing the effects of long-term storage of tissues at temperatures of liquid nitrogen(-120° to -190°C). At a minimum, the samples should be kept frozen at -20°C until extraction. This will slow biological decomposition of the sample and decrease loss of moisture. Liquid associated with the sample when thawed must be maintained as part of the sample because the lipid tends to separate from the tissue. Storage of samples should remain under the control of the sample collector until relinquished to the analytical laboratory.

11.4.4.2 Whole fish may be frozen and stored if no resection of internal organs or fillets will be conducted and the ultimate analysis is whole body. However, if resection of fillets or organs is required, these tissues should be removed prior to freezing and can be stored frozen in appropriate individual containers. The tissues may then be ground and homogenized at a later date and refrozen in sample packets for shipment on dry ice to the analytical laboratory(s).

11.4.4.3 It is frequently necessary to ship whole fish, fillets or homogenized tissue samples over long distances to an analytical laboratory. To avoid sample deterioration, it is recommended that all samples be frozen solid prior to shipment. The frozen and logged samples should be wrapped in newspaper to provide additional insulation for the samples which are shipped in well sealed insulated containers with an appropriate quantity of dry ice. The quantity of dry ice should be sufficient to eliminate any defrosting of the samples during the time of priority transport. However, in the event that a delay occurs in transit, these recommendations will provide some assurance that the samples will arrive in usable condition. Under no circumstances should unfrozen tissue be shipped either with or without dry ice because the quality of the sample cannot be assured.

11.4.5 Tissue Preparation

11.4.5.1 Organic contaminants are not evenly distributed throughout biological tissue, especially in fish. This is also true for fish fillets. Therefore, to obtain a homogenous sample, the whole fish or the whole fillet

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must be ground to a homogeneous consistency. This procedure should be carried out by the sample collector on partially thawed samples.

11.4.5.2 Chop the sample into 2.5 cm cubes unless the sample is small enough to fit in a hand crank meat grinder (300 gm or less) or a food processor (Hobart Model 81810 or equivalent for large fish) (USEPA, 1990b). Then pass the whole sample through a meat grinder. Grinding of biological tissue is easier when the tissue is partially frozen. This is especially true when attempting to grind the skin. Chilling the grinder with a few chips of dry ice will reduce the tendency of the tissue to stick to the grinder. Do not freeze the grinder since hard frozen tissue is difficult to force through the chopper plate.

11.4.5.3 The ground sample is divided into quarters, opposite quarters are mixed by hand with a clean stainless steel spatula and then the two halves are mixed back together. Repeat the mechanical grinding, quartering and hand mixing two more times. No chunks of tissue should be present at this point as they will not be efficiently extracted. Very small fish or small fillets may be homogenized in a high speed blender.

11.4.5.4 When compositing fillets or whole fish each individual fillet or fish should be ground separately following the above described procedure. Then take equal amounts from each fillet or fish sample to be composited to provide a total equal to that required for extraction or the total number of split and archived samples required by the study plan.

11.4.5.5 If the ground fish is to be re-frozen prior to extraction and analysis, weigh out the exact amount for extraction into a small container. Using a top loading balance, tare a 2 oz. glass jar (or a small sheet of aluminum foil that can be formed into a sealed packet) to 0.0 gm and carefully dispense a 20.0 gm portion of homogenized tissue into the container. Tightly seal the container or foil packet. Repeat with additional containers for duplicates, splits, or archived samples. Lipid material tends to migrate during freezing; therefore, storing a weighed portion ensures extraction of a representative portion of the tissue if the foil or container is completely rinsed with solvent by the analytical chemist.

11.4.5.6 Whenever a ground sample is to be split between two or more labs, the ground sample must also be mixed with reagent grade anhydrous sodium sulfate (previously heated to 400°C to drive off any phthalate esters acquired during storage). To ensure the homogeneity of the sample prior to splitting, transfer 100 gm of ground tissue to a 600 mL beaker. Add 250 gm of anhydrous sodium sulfate and mix thoroughly with a stainless steel spoon or a spatula. There should not be any lumps and the mixture should appear homogeneous. Dispense exactly 70.0 gm of mixture to each lab and note on the package that it contains 20 gm of tissue.

11.4.5.7 When preparing the tissue for volatile analysis, grind it in an area free of volatile organic compounds. The meat grinder or food processor must be heated in an oven for 30 minutes at 105°C after solvent rinsing and then allowed to cool at room temperature. Immediately after grinding the tissue,

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weigh duplicate 1 gm portions into culture tubes with screw caps. Analyze immediately or store in a freezer.

11.5 5ample Preparation For Metal Contaminants In Tissue

11.5.1 Collection Precautions

11.5.1.1 The major difficulty in trace metal analyses of tissue samples is controlling contamination of the sample after collection. In the field, sources of contamination include sampling gear, grease from winches or cables, engine exhaust, dust, or ice used for cooling. Care must be taken during handling to avoid these and any other possible sources of contamination. For example, during sampling the ship should be positioned such that the engine exhausts do not fall on deck. To avoid contamination from melting ice, the samples should be placed in watertight plastic bags.

11.5.1.2 Sample resection and any subsampling of the organisms should be carried out in a controlled environment (e.g., dust-free room). In most cases, this requires that the organisms be transported on ice to a laboratory rather than being resected in the field. It is recommended that whole organisms not be frozen prior to resection if analyses will be conducted only on selected tissues, because freezing may cause internal organs to rupture and contaminate other tissue. If organisms are eviscerated in the field, the remaining tissue (e.g., muscle) may be wrapped as described above and frozen (Puget Sound Estuary Program, 1986).

11.5.1.3 Resection is best performed under "clean room" conditions. The "clean room" should have positive pressure and filtered air and also be entirely metal-free and isolated from all samples high in contaminants (e.g., hazardous waste). At a minimum, care should be taken to avoid contamination from dust, instruments, and all materials that may contact the samples. The best equipment to use for trace metal analyses is made of quartz, TFE (tetrafluoroethylene), polypropylene, or polyethylene. Stainless steel that is resistant to corrosion may be used if necessary. Corrosion-resistant stainless steel is not magnetic, and thus can be distinguished from other stainless steels with a magnet. Stainless steel scalpels have been found not to contaminate mussel samples (Stephenson et al., 1979). However, low concentrations of heavy metals in other biological tissues (e.g., fish muscle) may be contaminated significantly by any exposure to stainless steel. Quartz utensils are ideal but expensive. To control contamination when resecting tissue, separate sets of utensils should be used for removing outer tissue and for removing tissue for analysis. For bench liners and bottles, borosilicate glass would be preferred over plastic if trace organic analyses are to be performed on the same sample.

11.5.1.4 Resection should be conducted by or under the supervision of a competent biologist. Special care must be taken to avoid contaminating target tissues (especially muscle) with slime and/or adhering sediment from the fish exterior (skin) during resection. The procedure previously outlined for the preparation of fillet samples should generally be followed. Unless specifically sought as a sample, the dark muscle tissue that may exist in the

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vicinity of the lateral line should not be separated from the light muscle tissue that constitutes the rest of the muscle tissue mass.

11.5.1.5 Prior to use, utensils and bottles should be thoroughly cleaned with a detergent solution, rinsed with tap water, soaked in acid, and then rinsed with metal-free water. For quartz, TFE, or glass containers, use 1+1 HNO_3, 1+1 HCl, or aqua regia (3 parts conc. HCl + 1 part conc HNO_3) for soaking. For plastic material, use 1+1 HNO_3 or 1+1 HCl. Reliable soaking conditions are 24 h at 70°C (APHA, 1989; 1992). Oo not use chromic acid for cleaning any materials. Acids used should be at least reagent grade. For metal parts, clean as stated for glass or plastic, except omit the acid soak step. If trace organic analyses are to be performed on the same samples, final rinsing with methylene chloride is acceptable.

11.5.1.6 Sample size requirements can vary with tissue type (e.g., liver or muscle) and detection limit requirements. In general, a minimum sample size of 6 g (wet weight) is required for the analysis of all priority pollutant metals. To allow for duplicates, spikes, and required reanalysis, a sample size of 50 g (wet weight) is recommended. Samples can be stored in glass, TFE, or high-strength polyethylene jars.

11.5.2 Processing

11.5.2.1 Samples should be frozen after resection and kept at -20°C. Although specific holding times have not been recommended by USEPA, a maximum holding time of 6 months (except for mercury samples, which should be held a maximum of 28 days) would be consistent with that for water samples.

11.5.2.2 When a sample is thawed, the associated liquid should be maintained as a part of the sample. This liquid will contain lipid material. To avoid loss of moisture from the sample, partially thawed samples should be homogenized. Homogenizers used to grind the tissue should have tantalum or titanium parts rather than stainless steel parts. Stainless steel blades used during homogenization have been found to be a source of nickel and chromium contamination. Some trace metal contamination during processing cannot be avoided and it is therefore necessary to determine and control the amount of contamination introduced during processing. Contamination can be monitored by introducing a dry ice blank into the blender and analyzing the chips.

11.5.2.3 To avoid trace metal contamination during processing the preferred method is to proceed to a chemical digestion process which minimizes or eliminates resection, homogenization, or grinding. Chemical digestion is best limited to specific organ tissues from large fish or to smaller sized whole fish.

11.6 Identification of Composite Whole Fish or Fillet Samples

11.6.1 Composite whole fish samples will be made up of three to ten fish with any deviation in number clearly identified. The limitation on the variance between individual fish in each composite will be as previously described. The length and weight of each fish must be recorded. The same field

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information should be provided as described above for both fillet and/or whole body composite samples. The same handling precautions as described above should be followed for either organic or trace metal contaminants. Spines on whole fish should be sheared to minimize puncturing the sample packaging.

11.6.2 The following information should be included on the field/lab form for each sample collected:

11.6.2.1 Project Name

11.6.2.2 Station Code (if applicable)

11.6.2.3 Date

11.6.2.4 Collector's Name

11.6.2.5 Sampling location (river mile and/or other specific information relating to local landmarks)

11.6.2.6 Latitude and Longitude

11.6.2.7 Water body name

11.6.2.8 Sampling technique(s), i.e. 230 vac electrofishing apparatus, hoop nets, etc.

11.6.2.9 Fish species

11.6.2.10 Individual lengths and weights of fish in sample

11.6.2.11 Sample type (Whole or Fillet)

11.6.2.12 Individual fillet weights (whether left or right)

11.6.2.13 Comments or Unusual Conditions, i.e., tumors, sores, fin rot, blind, etc.

11.7 Chain-of-Custody Procedures (USEPA, 1990c; USEPA, 1991) Also See Section 2, Quality Assurance and Quality Control.

11.7.1 All samples should be kept in a secure (locked) area to avoid legal complications in administrative proceedings. Transportation of the samples must be coordinated between the agency responsible for the field collection and the agency responsible for analytical work. When custody of the samples is transferred, the following checks should be implemented:

11.7.1.1 All transfers should be properly relinquished to ensure chain-of-custody. Transfers should be recorded on a form separate from the field data sheet. The chain-of-custody form should include the sample identification number(s). Custody tags must be used and numbered in sequence (if possible).

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11.7.1.2 The field data sheet should stay with the sample until it is logged in by the analytical laboratory.

11.7.1.3 Samples can be shipped and chain-of-custody maintained as long as shipping containers are sealed with custody tape.

11.7.1.4 Samples should remain frozen until they are prepared for analysis. Shipping with dry ice is recommended.

11.7.1.5 The laboratory's receiving agent should initial the field data sheet and affix the date of sample receipt. Depending on administrative need, a copy of this form (with initials and date of sample receipt plainly visible) may be required by the lab agency's central office.

11.8 Conclusion

11.8.1 This protocol only addresses the steps to be considered in field sampling fish and sample preparation for human health fish consumption advisories and ecological risk assessment. Additional protocols must be followed to carry out the appropriate analytical chemistry and the risk assessment/management requirements leading to an action. These additional protocols were beyond the scope of this assignment.

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STANDARD OPERATING PROCEDURES

TERRESTRIAL PLANT COMMUNITY SAMPLING

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SUPERCEDES: SOP #2037; Revision 0.0; 01/24/92; U.S. EPA Contract EP-W-09-031.

1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) describes the method for sampling terrestrial plant communities on hazardous waste sites. Analysis of vegetation will be used, in conjunction with other bioassessment techniques, to assess the impact of site contamination on plant life. Vegetation will be evaluated for shifts in community structure as a function of site contamination. Included below are procedures for obtaining representative measurements and guidance on quality assurance/quality control measures.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

The use of this SOP is dependent on weather and season. Non-woody plants will not endure throughout a winter with freezing temperatures, and thus cannot be evaluated by these methods during this part of the year in such climates.

A survey of site history will be made with all readily available information. Information on site contaminants, site and regional vegetation, and local climatic conditions will be considered. Remote sensing and topographic maps, when available, will be obtained and reviewed. Information on rare and endangered flora that may exist within the study areas should be obtained and reviewed.

Plots and transects are used to collect information representative of vegetative communities of the study site. Choice of appropriate sampling technique (i.e., plots vs. transects) depends upon site characteristics, plant characteristics, and study objectives. Information concerning species identification, enumeration, spatial arrangement, and size/shape attributes of the vegetation will be recorded in logbooks and on field data sheets. Signs of stressed vegetation will be noted. Samples representative of study location flora will be gathered for taxonomic verification. Values for species density, coverage, and frequency will be computed, as necessary.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Samples of vegetation may be required for taxonomic verification. Whole plants or selected parts (i.e., leaves, twigs, or flowers) will be placed in a resealable plastic bag and kept cool (4°C) to slow decay. All materials, with the exception of woody specimens, should be kept from temperature extremes and should be identified as soon as possible. If more than a week will pass before the samples can be identified, the samples will be placed in a plant press. Samples may also be archived by placing them in a plant press after identification.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

There are several potential problems and interferences that may occur when sampling plant communities.

1. Access to study locations must be obtained prior to study commencement.

2. Environmental disturbances, such as drought or fire, may confound data collection and interpretation. In addition, physical disturbances by man, such as the mowing or trampling of site vegetation, will further complicate assessment.

3. Microclimatic differences, such as sun/shade and moisture/drought, will affect plant growth and response.

5.0 EQUIPMENT/APPARATUS

Equipment needed for plant community sampling may include, depending upon the study objectives, the following items:

- Stakes - with sufficient height to be observed and sufficient width to stay in place during the period of study
- Line or rope
- Tape measure and/or plot frames
- Shovels and hand trowels - both of which must have unpainted stainless steel blades
- Pruning shears and/or knives
- Resealable plastic bags
- Cooler with ice
- Regional field guides to native plants
- Compass
- Vernier calipers
- Clinometer (optional) - necessary when measuring tree heights
- Documentation supplies (includes logbook, chain of custody records and custody seals, field data sheets and sample labels)
- Plant press (optional)

6.0 REAGENTS

Reagents are not required for preservation of vegetation samples. Samples should, however, be cooled to 4°C in order to minimize the degree of deterioration. Decontamination of sampling equipment may be required. Decontamination solutions are specified in ERT/SERAS SOP #2006, Sampling Equipment Decontamination.

7.0 PROCEDURES

7.1 Sampling Considerations

7.1.1 General Site Survey

Prior to initiation of vegetation sampling, the appropriate sample collection area(s) should be determined. This may be accomplished with the assistance of remote sensing and/or topographic maps. Field guides to the regional vegetation species and experts

knowledgeable about local conditions should be consulted. The extent of contamination should be established.

Consideration must also be given to the location of specific sampling points so that they provide representative samples (Section 7.1.2). The presence of rare or endangered species should also be determined and care taken not to adversely impact these communities during site activities.

A site sampling plan which details the number and general areas to be assessed will be prepared prior to plant community sampling activities.

7.1.2 Representative Samples

For representative sample collection, seasonal community fluctuations should be determined and climatic patterns analyzed. Topography and soil types should also be considered.

Sampling of vegetation should occur during seasons of the year where the species of interest are present. For example, if a complete vegetation survey were to be performed, plant assessment may be required over several seasons. If the species of concern were annuals, vegetation study should occur during the growing season while these species display characteristics that can be observed. Additionally, depending upon the study objectives, it may be necessary to survey plant communities several times during the growing season or throughout the year.

7.2 Sample Collection

The ecological parameters of density, coverage, and frequency reflect vegetational community structure and are those that are discussed in this SOP. Additional information may be collected for use in studies of plant community structure. Additional parameters useful in determining and comparing plant community structure include diversity and similarity indices. These parameters will not be addressed in the present SOP; however, measurements used to calculate these parameters may be collected at the same time as sampling activities described in this SOP. For a description of these additional parameters, refer to Brower and Zar.[1]

The size, shape, and number of vegetation sample locations ultimately depends upon the vegetation type present (i.e., herb, shrub, tree, vine, etc.) and their distribution pattern. Basically, there are two general approaches to plant community sampling: plots/quadrats and transects.

7.2.1 Sample Plots/Quadrats

A sample plot or quadrat is the specific area within which vegetation analysis will occur. The number, size, shape, and location of sample plots will depend upon the types of vegetation to be sampled and the objectives of the study. For example, smaller plots may be required for a site with dense or rich flora.

Typically, rectangular or circular plots are used. Circular plots are easy to set up. They require only a stake and premeasured line (or measuring tape). Circular plots are often

used in the assessment of woody species. However, rectangular plots have been found, in general, to yield better results for plant surveys.[1] Rectangular plots require at least four stakes and a plot frame of desired size (or measuring tape and a means to make right angles) to be constructed.

The following procedure will be followed when surveying plant communities:

1. Divide vegetational areas of the site to be assessed into a grid. If soil/sediment sampling is also performed, it is most efficient and advantageous to use the same sample location grid for both soil/sediment sampling and plant community assessment. When vegetation is collected for analysis, use of the same grid locations will provide the potential for comparison of contaminant concentrations in the soil/sediment and the vegetation.

2. Select locations for a predetermined number of plots (as described in the site sampling plan) using randomly-selected grid coordinates. (X and Y coordinates can simply be paced out from the appropriate axis.)

3. Establish plots according to study objectives and the following vegetation classifications:

   a. Closely Spaced Herbs - [plants of less than 1 meter (m) in height]use a rectangular plot of 1 m^2 (for example, 1.0 m x 1.0 m)

   b. Bushes/Saplings/Shrubs - [woody plants with height greater than 1 m and main stem diameter of less than 10 centimeters (cm), excluding vines] use a plot area of 10 m^2 (for example, 2.5 m x 4.0 m)

   c. Trees - [any non-climbing woody plants with main stem diameter at breast height (DBH) of greater or equal to 10 cm. (DBH = 1.5 m above ground level)]identify each tree within a 10 meter radius of the selected center point of the sample plot

   d. Woody Vines (Lianas) - (woody climber with DBH of less than 10 cm) identify each vine within a 10 meter radius of the selected center point of the sample plot (usually associated with tree plots)

4. Identify and count species in each plot.

5. Estimate species coverage within plot area. Measure DBH for tree species, when applicable, to calculate basal area form which cover estimates are made.

6. Note visual cues of stress and overall health of plot vegetation (including wilting, browning, stunted growth, chlorosis, etc.).

7. Note habitat characteristics (for example, moisture availability, degree and direction of exposure of slope, tidal location, etc.).

8. Collect vegetative samples from each plot, as necessary, for taxonomic verification. Store samples as described in Section 3.0.

9. Repeat the above procedures for an uncontaminated reference area during the same period of study.

10. Perform appropriate calculations (Section 8.0) and appropriate statistical analyses upon the data.

11. Prepare generalized vegetation map showing plant communities and sampling locations.

7.2.2 Transect Sampling

When the use of plots is impractical, transects may be used. Transects are especially useful in the evaluation of transitional communities. Ecological parameters that are studied utilizing plots can be studied utilizing transects. Additionally, changes in the vegetation in relation to environmental gradients may be observed. The type, size, number, and locations of transects chosen will depend upon study objectives, vegetation type, and site characteristics. Longer transects should be made when plants are widely dispersed.

Types of transects include belt transects and line intercept transects. A belt transect is a line transect with width. It is essentially a long, thin quadrat or can be divided into zones (each of which act as plots). In the line intercept method a known length of rope or tape measure is laid out in a line and information is collected as vegetation intercepts the line. The line intercept method is particularly useful for surveys of shrubs. This method is used for vegetative cover estimates and species composition estimates. With this method, only estimates of linear density can be made, as area is not involved.

The following procedure applies to plant community sampling using transects:

1 Determine which transect method best suits the objective(s) of the study and habitat available.

2 Establish transects according to the study objectives and the appropriate transect method:

a. Belt transect

- establish transect length and width
- locate belt transect(s) randomly in the selected study area(s) or with bias along a specific gradient or feature of interest
- identify and count species
- estimate coverage and measure DBH (on woody species, when required) within plot(s)

b. Line intercept

- · establish transect length
- Short lines (under 50 m) are used for assessment of herb species
- Long lines (greater than 50 m) are used for assessment of some shrub and tree communities
- locate transect line(s) randomly in the selected study area(s) or with bias along a specific gradient or feature of interest
- divide transect line into equal intervals
- record the length of the line intercepted for each plant intercepting the line
- count, measure, and identify plants that either intercept the transect line or are within a small distance from the line, depending upon the density of the vegetation

3. Note visual cues of stress and overall health of plot vegetation (including wilting, browning, stunted growth, chlorosis, etc.).

4. Note habitat characteristics (for example, moisture availability, degree and direction of exposure of slope, tidal location, etc.).

5. Collect vegetative samples from each transect, as necessary, for taxonomic verification. Store samples as described in Section 3.0.

6. Repeat the above procedures for an uncontaminated reference area during the same period of study.

7. Perform appropriate calculations (Section 8.0) and appropriate statistical analyses upon data

8. Prepare a generalized vegetation map showing plant communities and sampling locations.

7.3 Sample Collection Variation

Taxonomic identification to the species level is often required for the vegetation assessment methods described. When no such knowledge is desired and/or available, a generalized physiognomic approach may be utilized. Physiognomy is the study of form, structure, and spatial arrangement of an organism. The resulting data may be sufficiently detailed and organized and can be collected comparatively rapidly.

Physiognomic characteristics that may be observed and documented include:

- Life form - presence, dominance, or absence of specific structural life forms (herbs, trees, vines, etc.)
- Stratification and zonation - layers of vegetation from the ground-layer to the canopy
- Foliage density - amount of shading vs. light penetration
- Coverage - sparse (less than five percent coverage) to dense (greater than 75% coverage)
- Dispersal pattern - arrangement of species (rows, clumps, solitary, etc.)
- uniformity (evenly-spaced vs. irregularly distributed) –

- spacial separation (distant vs. dense)

8.0 CALCULATIONS

8.1 Calculations for Plots and Belt Transects

Density for Species i (D_i)

$$D_i = n_i / A$$

where:

n_i = total individuals for species i
A = total area sampled

Relative Density for Species i (RD_i)

$$RD_i = n_i / \sum n$$

where:

n_i = number of individuals of species i
Σn = total number of individuals of all species in sampled plots

Coverage for Species i (C_i)

$$C_i = a_i / A$$

where:

a_i = total area covered for species i
A = total area sampled

Relative Coverage of Species i (RC_i)

$$RC_i = C_i / \sum C$$

where:

C_i = coverage for species i
ΣC = sum of coverage for all species

Frequency of Species i (f_i)

$$f_i = j_i / k$$

where:

j_i = number of plots containing species i
k = total number of plots

Relative Frequency of Species i (RF_i)

$$RF_i = f / \sum f$$

where:

f_i = frequency of species i
Σf = sum of frequencies of all species

8.2 Calculations for Line Transects

Linear Density Index of Species i (ID_i)

$$ID_i = n/L$$

where:

n_i = number of individual of species i
L = total length of all sampled transects

Relative Density for Species i (RD_i)

$$RD_i = n_i / \sum n$$

where:

n_i = number of individual of species i
Σn = total number individuals of all species in sampled transects

Linear Coverage Index of Species i (IC_i)

$$IC_i = I/L$$

where:

l_i = sum of intercept lengths intercepted by species i
L = total length of all sampled transects

Relative Coverage of Species i (RC_i)

$$RC_i = I_i / \sum I$$

where:

l_i = sum of intercept lengths intercepted by species i
Σl = sum of intercept lengths for all species intercepting transects

Frequency of Species i (f_i)

$$f_i = j_i / k$$

where:

j_i = number of intervals containing species i
k = total number of intervals on transects

Relative Frequency of Species i (RF_i)

$$RF_i = f_i / \sum f$$

where:

f_i = frequency of species i
Σf = sum of frequencies of all species

8.3 Additional Calculation for Tree Species

Basal Area at Breast Height (A), calculated for each tree

$$A = \pi r^2$$

where:

pi = 3.1416
r = radius (in cm)

9.0 QUALITY ASSURANCE/QUALITY CONTROL

The following quality assurance/quality control procedures apply:

1. All data must be documented on field data sheets or within field/site logbooks.
2. All instrumentation must be operated in accordance with the operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.
3. Calculations will be checked by an additional person at a rate of ten percent.
4. A sampling plan, including sample size, will be created prior to sampling.

10.0 DATA VALIDATION

Data generated will be reviewed according to the quality assurance/quality control considerations listed in Section 9.0.

In addition, taxonomic information will be confirmed by a regional biologist familiar with the site's vegetation.

11.0 HEALTH AND SAFETY

When working with potential hazardous materials, follow U.S. EPA, OSHA, and corporate health and safety procedures.

When sampling at a known or suspected contaminated site, precautions must be taken to safeguard the samplers from chemical and physical hazards. In addition, it would benefit the samplers to be familiar with and avoid any contact with plants that present a contact hazard such as poison ivy, poison sumac, and poison oak.

12.0 REFERENCES

[1]Brower, J.E., and J.H. Zar, "Field and laboratory methods for general ecology," William C. Brown Publishers, Dubuque, Iowa, 1984.

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Greig-Smith, P., "Quantitative plant ecology," University of California Press, California, 1983.

Kapustka, L.A. and M. Reporter, preparers, "Evaluating exposure and ecological effects with terrestrial plants: Proceedings of a workshop for the US EPA Exposure Assessment Group," United States Environmental Protection Agency, Region 10, Seattle, Washington, August 28, 1991.

Smith, R.L., "Ecology and field biology," 3rd Edition, Harper and Row, New York, NY, 1980.

United States Army Corp of Engineers, "Wetlands delineation manual," Vicksburg, Mississippi, 1987.

APPENDIX B

SAMPLE CHAIN OF CUSTODY

RMC

Laboratory Services Request Form

I. CLIENT INFORMATION	SEND REQUESTS TO:
Client Name: UNITED PARK CITY MINES	**American West**
Client Address: PO BOX 1450 PARK CITY, UT 84060	**Analytical Laboratories**
	463 W. 3600 South
Client Phone: 435-608-0954	**Salt Lake City, UT**
Client Fax: 435-615-1239	**84115**
II. ACCOUNT INFORMATION	
Account Name:	**Patrick Noteboom**
Sample Questions- Dan Dean RMC- 801-255-2626	**Phone # (801) 750-2585**
	Fax (801)-263-8687

TAT: _____ **P.O. No:**

III. REPORT INSTRUCTIONS

Report Results To: KERRY GEE- UPCM AND DAN DEAN - RMC FAX-255-3266 **INCLUDE EDD**

Report Address: PO BOX 1450 PARK CITY UT 84060 AND DAN DEAN, RMC, 8138 S. STATE ST., STE 2A, MIDVALE UT 84047

Please Forward Results By: US Mail (X) Fed Ex ( ) Fax ( ) Email dan@rmc-ut.com

Services Requested below are required no later than _____ (date)

IV. TYPE OF SERVICE REQUESTED

Please analyze the enclosed environmental samples for:

Lab Use Only Lab No.	Field Sample No./Description	Sampling Date & Time	No. of Cont.	Analysis Requested
notes:	For water samples, Cd detection limits must be <0.0008 ppm and all detection limits should be as low as pratical.			

V. CHAIN OF CUSTODY RECORD

Dispatched by:	Date	Time	Courier Co. Name
Relinquished by:	Date	Time	Airbill #
Received by:	Date	Time	Custody Seal Intact?
Received for lab by:	Date	Time	Yes No

APPENDIX C

FIELD FORMS

EQUIPMENT CALIBRATION FORM

Project: _____

Project Number: _____

Instrument: _____

Model/Serial Number: _____

Weather: _____

Calibration								
Date	Time	Calibration Standard	Standard Expiration Date	Meter Reading	Comments			

Calibration Checks								
Date	Time	Calibration Standard	Standard Expiration Date	Meter Reading	Comments			

Calibration Personnel: _____

GROUNDWATER SAMPLING FORM

Project Name: _____ Total Depth (ft BTOC): _____

Sample Location: _____ Static Water Level (ft BTOC): _____

Sample ID: _____ Water Column (ft): _____

Sample Date: _____ Calculated Purge (gal): _____

Sample Time: _____ Actual Purge (gal): _____

QA/QC Sample (Type and ID): _____ Sample Method: _____

Water Quality Meter: _____ Filter Manufacture/Size: _____

Depth of Pump Intake (ft BTOC): _____ Sample Filtered: (Y/N) Analyte: _____

Sampling Personnel: _____

Time	Vol. (gal)	pH	Temp (°C)	DO (mg/L)	ORP (MV)	Turb (NTU)	Notes and Comments

Recorded By: _____ Approved By: _____

Page _____ of _____

PIEZOMETER DEVELOPMENT LOG

Project: _____

Piezometer Number: _____

Date: _____

Start of Purging: _____

End of Purging: _____

Water Quality Meter: _____

Development Personnel: _____

_____

_____

Location: _____

Initial Total Depth (ft BTOC): _____

Initial Total Depth to Water (ft BTOC): _____

Final Total Depth (ft BTOC): _____

Final Total Depth to Water (ft BTOC): _____

Casing Diameter (in): _____

Saturated Borehole Volume (gal): _____

Method/Equipment: _____

_____

Time	Vol. (gal)	Clarity/ Color	pH	Temp (°C)	Cond (ms/cm)	Turb (NTU)	Notes and Comments

Recorded By: _____

Approved By: _____

Page _____ of _____

SURFACE WATER SAMPLING FORM

Log of:							
US State Plane, Utah Central, NAD 83							
Northing:				Easting:			
Surface Elevation:							
General Information	Project Name:					Page: 1 of 1	
	Sample Location:					Date:	
	Field Investigator:					C of C#:	
	Surface Water Sampling Method:						
Sample Information	Comments:						
	Surface Water Sample ID:	Surface Water					
		Sample Filtered: (Y/N)			QA/QC Sample (Type & ID):	Water Quality Meter:	
		Analyte:					
		Filter Manufacturer:			Sample Date and Time:	Water Color & Clarity	
		Filter Size:					
		pH	Conductivity (mS/cm)	Temp (°C)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Water Level (ft.)
Plan View	N W E S Not to scale						
Recorded By:			Date:		Checked By:		

WATER LEVEL FORM

Site: _____ Personnel: _____

Location Id	Date	Time	Depth to Water (ft BTOC)	Total Depth (ft BTOC)	Comment

Recorded By: _____ Approved: _____

Page _____ of _____

RESOURCE MANAGEMNET CONSULTANTS

CLIENT:	Boring/Monitor Well ID:
PROJECT:	Start Date: / / Completion Date: / /
LOGGED BY:	Location: Grade Elev:
SAMPLE ID:	Top Casing Elevation: Static Depth to Water:

Graphic Log			Geotechnical		Samples		LITHOLOGIC DESCRIPTION/ COMMENTS
Depth FEET	WELL WATER LEVEL	LITHOLOGY	BLOW COUNTS PER 6"	USCS CLASS	% RECOVERY	SAMPLE ID	
0							
5							
10							
15							
20							
25							
30							

Boring

Total Depth:

Boring Diameter:

Drilling Method:

Drilling Co:

Depth to 1st Water:

Abandonment:

NOTES:

Well

Total Well Depth:

Surface Completion:

Casing:

Screen:

Bottom Cap:

Pack Type:

Annular Seal #1:

Annular Seal #2:

UNIFIED SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFIACATION PROCEDURES (Excluding particles larger than 3 inches and basing fraction on estimated weights)					GROUP SYMBOLS	TYPICAL NAMES
Coarse-grained Soils More Than Half Of Material is Larger Than No. 200 Sieve	**Gravels** More Than Half Of Coarse Fraction is Larger Than No. 4 Sieve Size	For Visual Classification, The ¼" Size May Be Used As Equivalent To The No. 4 Sieve Size	**Clean Gravels** (Little To No Fines)	Wide range in grain sizes and substantial amounts of intermediate particles sizes	**GW**	Well-graded gravels or gravels-sand mixtures, little to no fines
				Predominately one size or a range of sizes w/some intermediate sizes missing.	**GP**	Poorly-graded gravel or gravel sand mixtures, little to no fines
			Gravel with Fines (Appreciable Amounts Of Fines)	Non-plastic fines (for identification procedures see ML below)	**GM**	Silty gravels, gravel-sand-silt mixtures
				Plastic fines (for identification procedures see CL below)	**GC**	Clayey gravel, gravelly sand-clay mixtures
	Sands More Than Half Of Coarse Fraction is Smaller Than No. 4 Sieve Size		**Clean Sands** (Little To No Fines)	Wide range in grain size and substantial amounts of intermediate particle sizes	**SW**	Well-graded sand or gravelly sands, little to no fines
				Predominately one size or a range of sizes w/some intermediate sizes missing	**SP**	Poorly-graded sand or gravelly sands, little to no fines
			Sands with Fines (Appreciable Amounts Of Fines)	Non-plastic fines (for identification procedures see ML below)	**SM**	Silty sand, sand-silt mixtures
				Plastic fines (for identification procedures see CL below)	**SC**	Clayey sands, sand-clay mixtures

ID Procedures on Fraction Smaller Than No. 40 Sieve Size						
Fine-grained Soils More Than Half Of Material is Smaller Than No. 200 Sieve Size		**Dry Strength** (Crushing Characteristics)	**Dilatancy** (Reaction of Shacking)	**Toughness** (Consistency Near Plastic Limit)		
	Silts and Clays Liquid Limit Less Than 50	None to low	Rapid to Slow	None	**ML**	Inorganic silts, very fine sands, rock flour; silts or clayey fine sands with sight plasticity
		Medium to high	None to slow	Medium	**CL**	Inorganic clays of low to medium plasticity, gravel clays, sandy clays, silty clays, lean clays
		Low to medium	Slow	Low	**OL**	Organic silts and organic silty clays of low plasticity
	Silts and Clays Liquid Limit Greater Than 50	Low to medium	Slow to none	Low to medium	**MH**	Inorganic silts and organic silty-clays of low plasticity
		High to very high	None	High	**CH**	Organic clays of high plasticity, fat clays
		Medium to high	None to very slow	Low to medium	**OH**	Organic clays of medium to high plasticity, organic silts
Highly Organic Soils		Readily identified by color, odor, spongy feel and frequently by fibrous texture			**PT**	Peat and other highly organic soils

USCS Check List

1-Group Name	
2-Group symbol	
3-Color (in moist condition)	
4-Percentage of cobbles or boulders, or both (by volume)	
5-Percentage of gravel, sand, fines or all three (by dry weight)	
6-Particle-size Gravel (fine, coarse) Sand (fine medium, coarse)	
7-Particle angularity: angular, subangular, subrounded, rounded	
8-Particle shape (if appropriate) flat, elongated, flat and elongated	
9-Maximum particle size or dimension	
10-Hardness of coarse sand and larger particles	
11-Plasticity of fines: nonplastic, low, medium, high	
12-Dry strength: none, low, medium, high, very high	
13-Dilatancy: none, slow, rapid	
14-Toughness: low, medium, high	
15-Odor: (mention only if organic or unusual)	
16-Moisture: dry, moist, wet	
17-Reaction with HCl: none, weak, strong	
For Intact Samples	18-Consistency: (fine grain soil only) very soft, soft, medium stiff, stiff, very stiff, hard
	19-Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
	20-Cementation: weak, moderate, strong
	21-Local name
	22-Geologic interpretation
	23-Additional comments: presence of roots or root holes, presents of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavation, etc.
Silty Sand with Gravel (SM), brown, about 60% predominantly fine sand; about 25% silt fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15% fine, hard, subrounded gravel, a few gravel-sized particles fractured with hammer blows, maximum size, 25 mm; no reaction with HCl.		

Clay Consistency	THUMB PENETRATION	SPT, N Blows/ ft	Underdrained Shear Strength c (PSF)	Unconfined Compressive Strength q_u (PSF)
			TOVANE	POCKET PENETROMETER
Very Soft	Easily penetrated several inches by thumb. Exudes between thumb and fingers when squeezed in hand	<2	250	500
Soft	Easily penetrated one inch by thumb. Molded by light finger pressure.	2-4	250-500	500-1000
Medium Stiff	Can be penetrated over ¼ inch by thumb with moderate effort. Molded by strong finger pressure	4-8	500-1000	1000-2000
Stiff	Indented about ¼ inch by thumb but penetrated only with great effort	8-15	1000-2000	2000-4000
Very Stiff	Readily indented by thumbnail.	15-30	2000-4000	4000-8000
Hard	Indented with difficulty by thumbnail.	>30	>4000	>8000

Soil Type	SPT, N Blows /ft	Relative Density %	Field Test
Very Loose Sand	4	0-15	Easily penetrated with ½" rod pushed by hand.
Loose Sand	4-10	15-35	Easily penetrated with ½" rod pushed by hand.
Medium Dense Sand	10-30	35-65	Penetrated a foot with a ½" rod driven with 5-lb hammer.
Dense Sand	30-50	65-85	Penetrated a foot with a ½" rod driven with 5-lb hammer.
Very Dense Sand	50	85-100	Penetrated only a few inches with ½" rod driven with a 5-lb hammer.

Criteria for Describing Reaction with HCl	
Description	**Criteria**
None	No visible reaction.
Weak	Some reaction, with bubbles forming slowly.
Strong	Violent reaction, with bubbles forming immediately.

Criteria for Describing Dilatancy	
Description	**Criteria**
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

Criteria for Describing Angularity of Coarse-grain particles	
Description	**Criteria**
Angular	Particles have sharp edges and relatively planes sides with unpolished surfaces.
Subangular	Particles are similar to angular description but having rounded edges.
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

Criteria for Describing Toughness	
Description	**Criteria**
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium thickness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

Criteria for Describing Cementation	
Description	**Criteria**
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

Criteria for Describing Moisture Content	
Description	**Criteria**
Dry	Absence of moisture, dusty, dry to tough.
Moist	Damp, but no visible water.
Wet	Visible free water, usually soil is below water table.

Criteria for Describing Dry Strength	
Description	**Criteria**
None	The dry specimen crumbles into powder with mere pressure on handling.
Low	The dry specimen crumbles into powder with some finger pressure.
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure.
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and hard surface.
Very High	The dry specimen cannot be broken between the thumb and a hard surface.

Unified Soil Classification System			
	Millimeters	Inches	Sieve Sizes
Boulders	> 300	> 11.8	--
Cobbles	75 - 300	2.9 - 11.8	--
Gravel			
Coarse	75 - 19	2.9 - 0.75	--
Fine	19 - 4.8	0.75 - 0.19	¾" - No. 4
Sand			
Coarse	4.8 - 2.0	0.19 - 0.08	No. 4 - No. 10
Medium	2.0 - 0.43	0.08 - 0.02	No. 10 - No. 40
Fine	0.43 - 0.08	0.02 - 0.003	No. 40 - No. 200
Fines			
Silts	<0.08	<0.003	< No. 200
Clays	<0.08	<0.003	< No. 200

Conversion Factors		
To Convert from	**To**	**Multiply By**
in	m	0.025 400
ft	m	0.304 800
mi	ft	5 280
mi	km	1.609 3
in^2	mm^2	645.160 00
ft^2	m^2	0.092 903
acre	ft^2	43 560.174
arce	mi^2	1.562 5 E-3
ft^3	m^3	28.316 847 E-3
ft^3	gallon	7.480 519
quart	liter	0.946 353
gallon	m^3	3.785 412 E-3
lb (mass)	kg (mass)	0.453 592
ton	lb	2000
atm	bar	1.013 3
kg/m^2	N/m^2 (pascal)	9.806 650
kg/cm^2	kN/m^2 (kPa)	98.066 500
lb/in^2 (psi)	kN/m^2 (kPa)	6.894 757
lb/in^2 (psi)	atm	0.068 046
lb/in^2 (psi)	ft of H_2O	2.309
$T°F = 9/5T°C+32$		
Formulas		
π	3.14 159	
Cone	$V=(\pi/3)*r^2*h$	
Cylinder	$V= \pi*r^2*h$	
Right Triangle	$A=(b*h)/2$	
Circle	$A=\pi*r^2$	
	$C=2\pi*r$	
Percentage Terminology		
Trace	< 5%	
Few	5-10%	
Little	15-25%	
Some	30-45%	
Mostly	50-100%	

Criteria for Describing Plasticity	
Description	**Criteria**
Nonplastic	A 1/8" thread cannot be rolled at any water content.
Low	The tread can be barely rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Criteria for Describing Structures	
Description	**Criteria**
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fractures with little resistance to fracturing
Slickensided	Fractures planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

Water Level (level after completion)

Water Level (level where first encountered)

Depth & Length of Coring Run with Core Barrel

Shelby Tube (3" outer diameter)

Bulk/Grab Sample

Standard Penetration Split Spoon Sampler (1.4" inside diamter)

California Modified Sampler (2" inside diamter)

Depth of Sampling Attempted w/ No Recovery

APPENDIX D

READINESS REVIEW CHECKLIST

Readiness Review Checklist

Project:

Sampling Event:

Date:

Laboratory	Yes	No	NA	Comments/Remarks
Has laboratory been notified?				
Have sample containers been ordered?				
Has an analyte and method list been prepared?				
Have detection limits been determined?				
Are Chain of Custody forms available?				

Field Equipment	Yes	No	NA	Comments/Remarks
Is there ample disposable equipment (e.g. gloves, bags)?				
Is field equipment precleaned and calibrated?				
Have batteries been checked in field equipment?				
Have field personnel been trained in use of field equipment?				
Is a copy of the SAP/HASP onsite?				

Field Personnel	Yes	No	NA	Comments/Remarks
Have field personnel reviewed the SAP/QAPP?				
Have the sampling objectives been reviewed/discussed?				
Do field personnel have appropriate safety training?				
Have field personnel reviewed the Site Health and Safety Plan?				

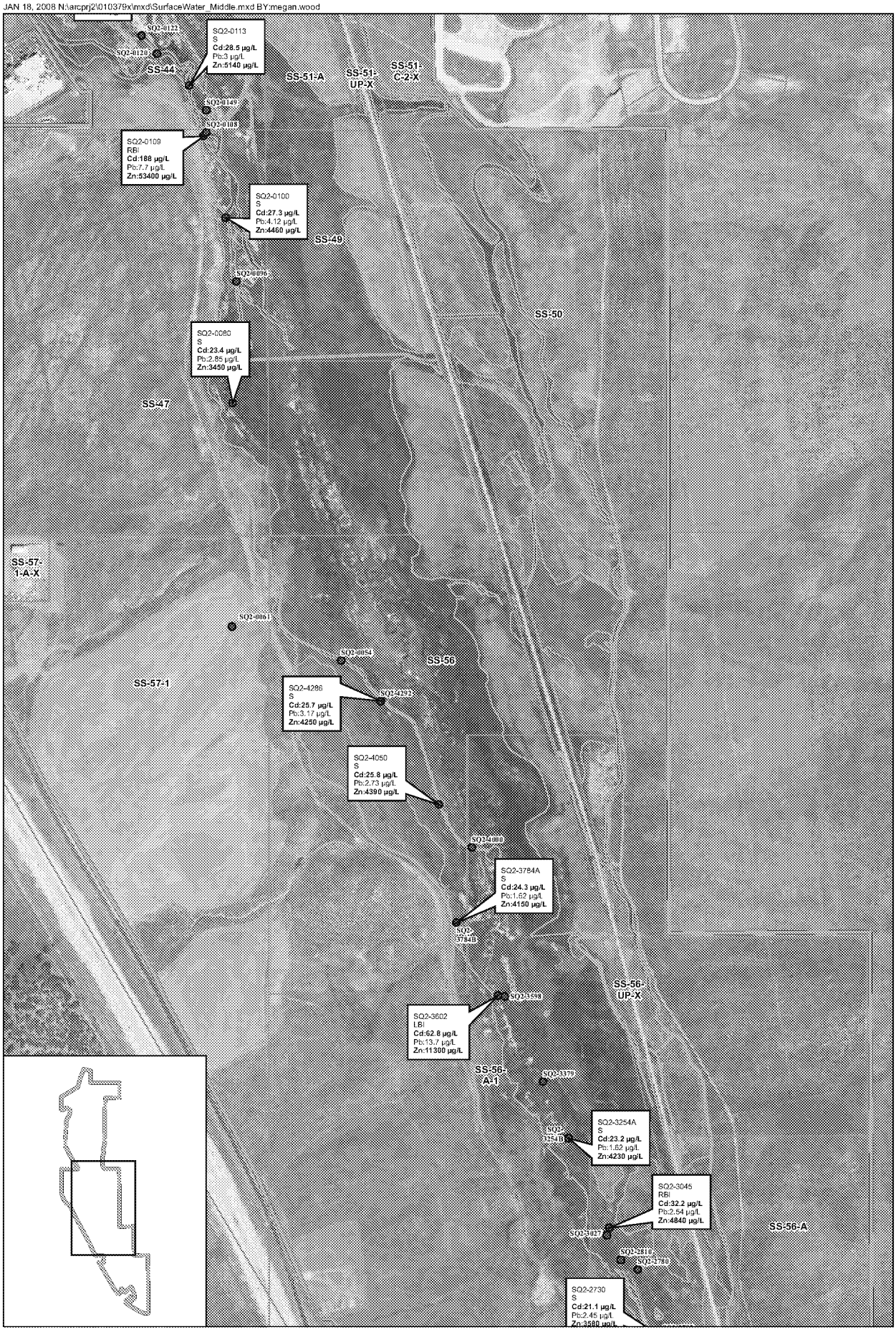
Quality Assurance/Quality Control	Yes	No	NA	Comments/Remarks
Is there a plan to collect QA/QC samples?				
Have the QA/QC objectives been reviewed/discussed?				
Has the QA/QC officer approved of the QA/QC objectives?				
Have sampling locations been pre-determined?				
Is a sampling location map available?				
Has a plan for field-fit sample locations been developed/discussed?				

Corporate	Yes	No	NA	Comments/Remarks
Is landowner permission required?				
Have landowners been contacted?				
Has the client been notified?				
Have regulatory agencies been notified?				

APPENDIX E

TETRA TECH AND USGS SURFACE WATER SAMPLING FIGURES

JAN 18, 2008 N:\arcprj2\010379x\mxd\SurfaceWater_Middle.mxd BY:megan.wood



Note: 1) Data presented in figure represents dissolved metals concentrations. Data obtained from the April, 2004 USGS Report: Pricipal Locations of Metal Loading from Foodplain Tailings, Lower Silver Creek, Utah.
2) Bold values represent values above the Zinc and Cadmium chronic water quality standard targets (adjusted for a hardness of 400mg/L) defined by the report: Silver Creek Total Maximum Daily Load for Dissolved Zinc and Cadmium, by the Utah Department of Environmental Quality, Division of Water Quality, approved by the EPA August 4, 2004.

JAN 18, 2008

FIGURE 4B

Legend

- Surface Water Samples
- Study Boundary
- Parcel Boundaries
- Wetlands Delineation

S = Stream
RBI = Right Bank Inflow
LBI = Left Bank Inflow

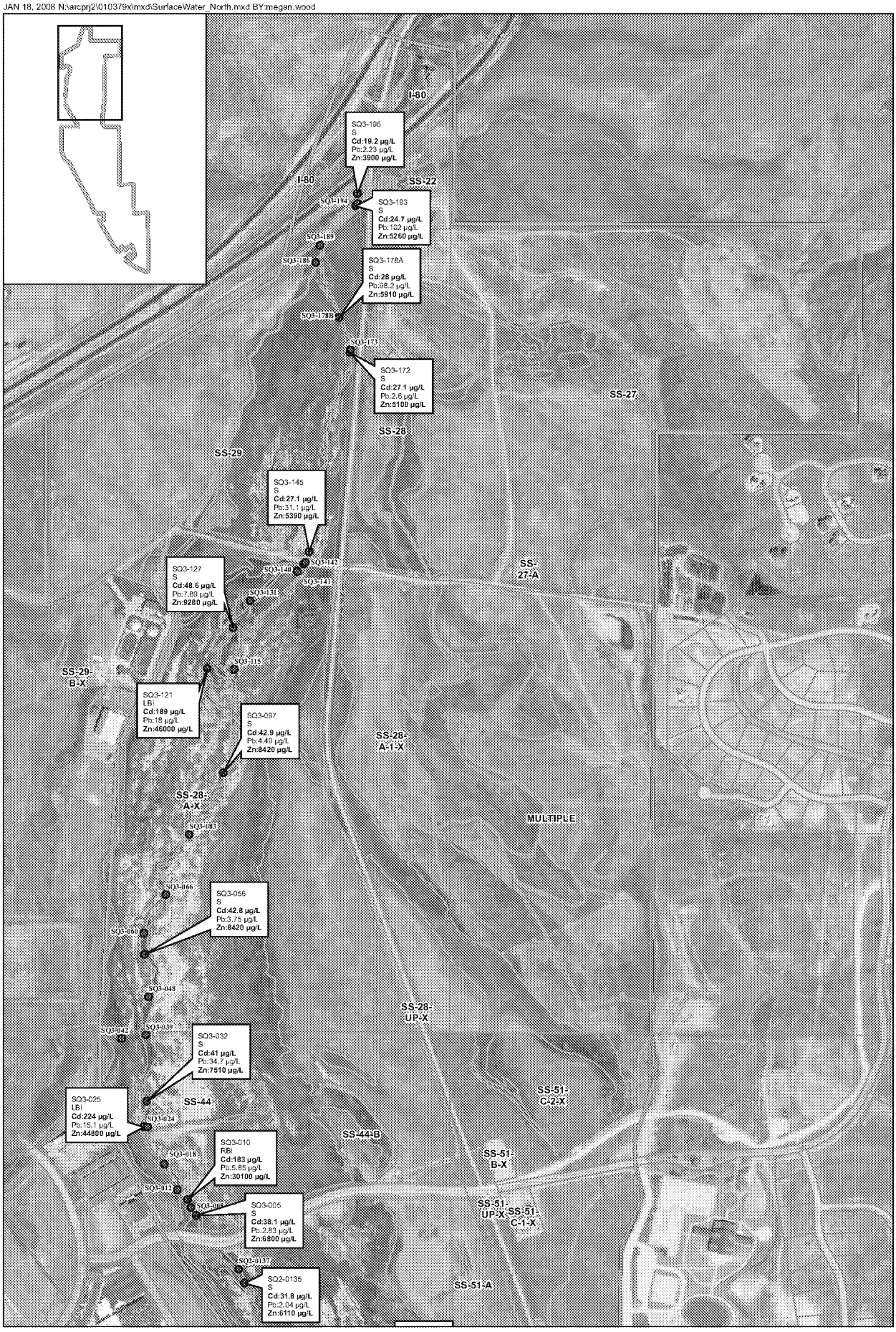
N

SCALE IN FEET
0 1,000

SURFACE WATER SAMPLING RESULTS

SILVER CREEK 010379X

JAN 18, 2008 N:\arcprj2\010379x\mxd\SurfaceWater_North.mxd BY:megan.wood



Note: 1) Data presented in figure represents dissolved metals concentrations. Data obtained from the April, 2004 USGS Report: Pricipal Locations of Metal Loading from Foodplain Tailings, Lower Silver Creek, Utah.
2) Bold values represent values above the Zinc and Cadmium chronic water quality standard targets (adjusted for a hardness of 400mg/L) defined by the report: Silver Creek Total Maximum Daily Load for Dissolved Zinc and Cadmium, by the Utah Department of Environmental Quality, Division of Water Quality, approved by the EPA August 4, 2004.

JAN 18, 2008

FIGURE 4A

Legend

- Surface Water Samples
- Study Boundary
- Parcel Boundaries
- Wetlands Delineation

S = Stream
RBI = Right Bank Inflow
LBI = Left Bank Inflow

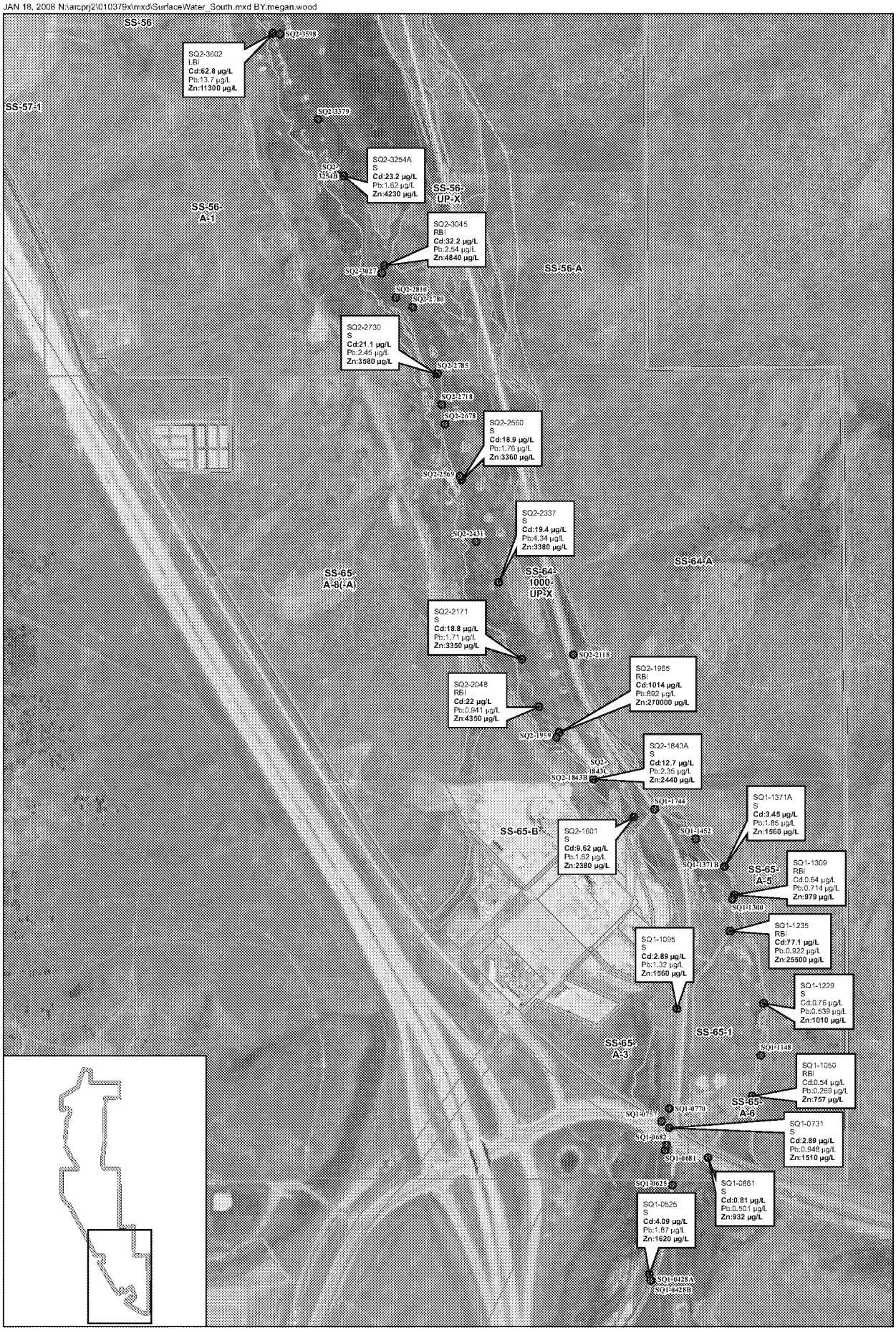
N

SCALE IN FEET
0 1,000

SURFACE WATER SAMPLING RESULTS

SILVER CREEK 010379X

JAN 18, 2008 N:\arcprj2\010379x\mxd\SurfaceWater_South.mxd BY:megan.wood



Note: 1) Data presented in figure represents dissolved metals concentrations. Data obtained from the April, 2004 USGS Report: Pricipal Locations of Metal Loading from Foodplain Tailings, Lower Silver Creek, Utah.
2) Bold values represent values above the Zinc and Cadmium chronic water quality standard targets (adjusted for a hardness of 400mg/L) defined by the report: Silver Creek Total Maximum Daily Load for Dissolved Zinc and Cadmium, by the Utah Department of Environmental Quality, Division of Water Quality, approved by the EPA August 4, 2004.

JAN 18, 2008

FIGURE 4C

Legend

- Surface Water Samples
- Study Boundary
- Parcel Boundaries
- Wetlands Delineation

S = Stream
RBI = Right Bank Inflow
LBI = Left Bank Inflow

N

SCALE IN FEET
0 1,000

SURFACE WATER SAMPLING RESULTS

SILVER CREEK 010379X

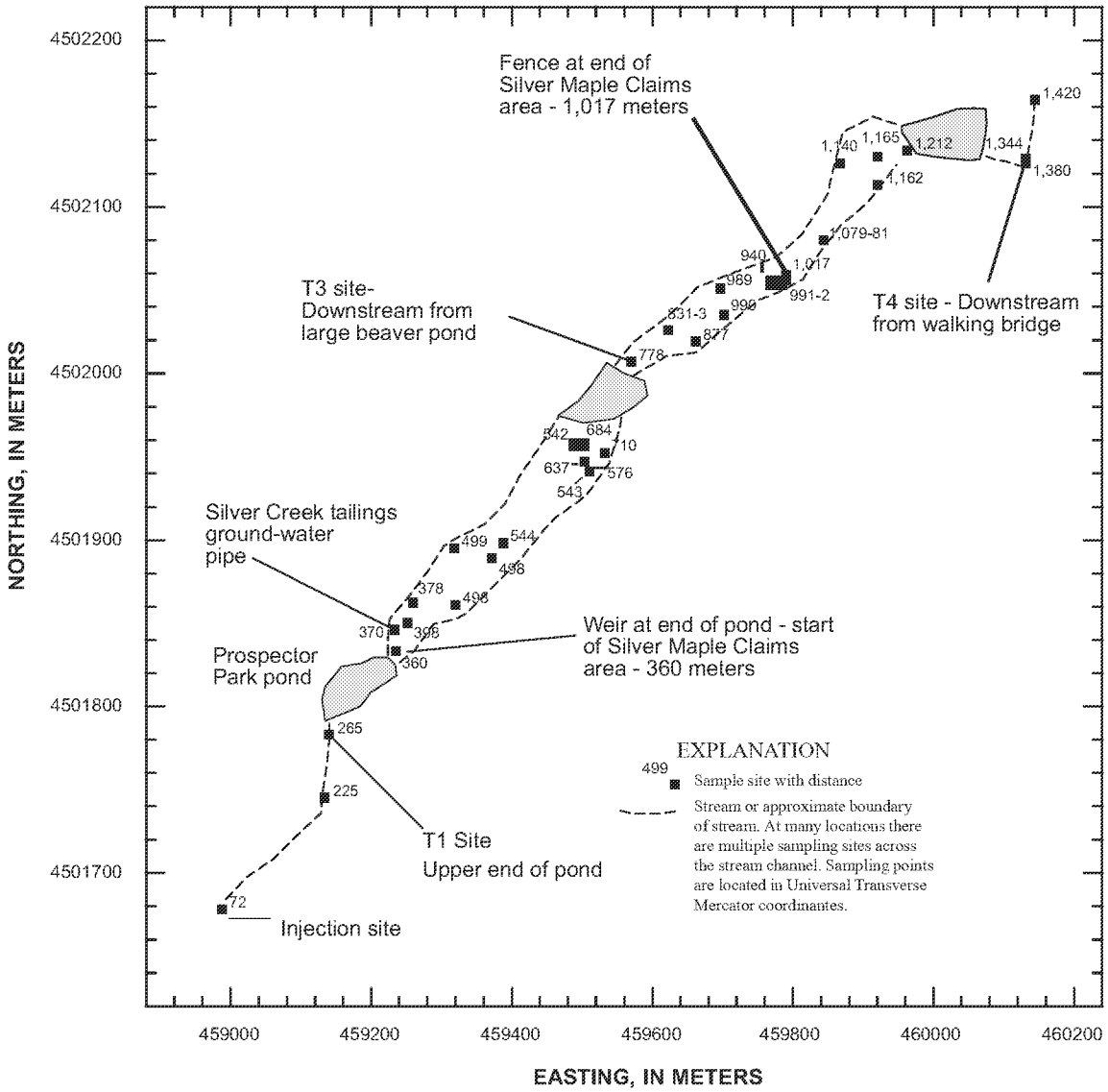


Figure 2. Schematic map of injection reach, Silver Creek, Utah.

Principal Locations of Metal Loading from Flood-Plain Tailings, Lower Silver Creek, Utah, April 2004

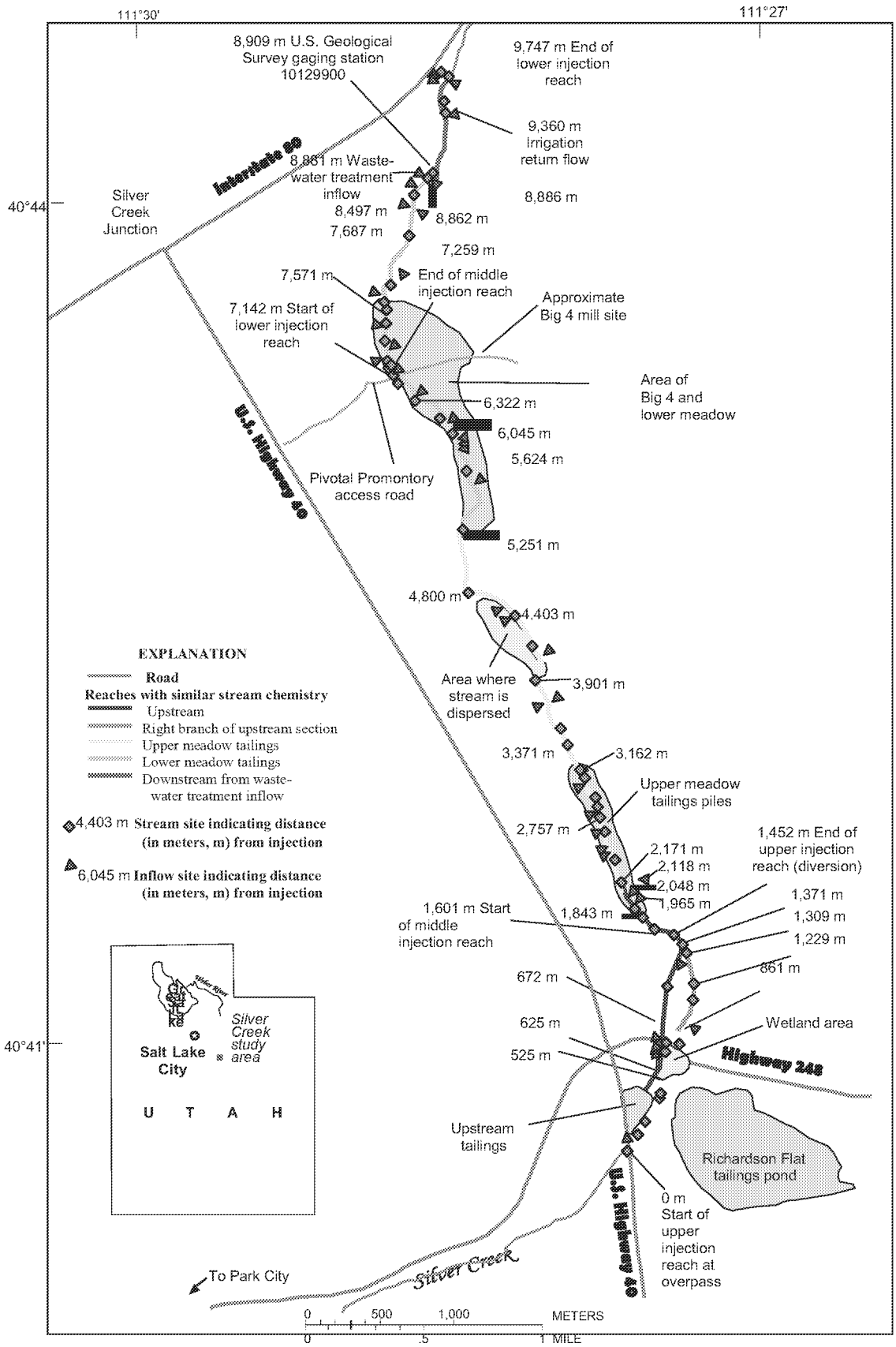


Figure 1. Location of the study reach indicating upper, middle, and lower injection reaches, location of changes in stream-water chemistry (colors indicate classification by cluster analysis), and principal locations of tailings, Silver Creek, Utah, April 2004.

QUALITY ASSURANCE PROJECT PLAN

Richardson Flat Tailings Site
Operable Units 2 and 3

Park City, Utah

Site ID Number: UT980952840

Revision 0

September 5th, 2014

A PROJECT MANAGEMENT
A1 Title Sheet

Prepared for:

United Park City Mines Company
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Prepared by:

Resource Environmental Management Consultants, Inc. d.b.a. RMC
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Fax: (801) 255-3266

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LIST OF ACRONYMS AND ABBREVIATIONS

COC	chain-of-custody
DQO	data quality objective
EE/CA	Engineering Evaluation/Cost Analysis
EPA	United States Environmental Protection Agency
FM	Field Manager
FSP	Field Sampling Plan
GPS	global positioning system
HASP	Health and Safety Plan
ID	identification
LCS	laboratory control sample
MCL	maximum contaminant level
MDL	method detection limits
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MS	matrix spike
MSD	matrix spike duplicate
NRDR	Natural Resource Damages and Restoration
OU1	Richardson Flat Tailings Site Operational Unit 1
OU2	Richardson Flat Tailings Site Operational Unit 2
OU3	Richardson Flat Tailings Site Operational Unit 3
PARCC	precision, accuracy, representativeness, completeness, and comparability
PM	Project Manager
QA	quality assurance
QM	Quality Manual
QAO	Quality Assurance Official
QAPP	Quality Assurance Project Plan
QC	quality control
RL	reporting limit
RMC	Resource Environmental Management Consultants, Inc.
RPD	relative percent difference
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
Settlement Agreement	Administrative Settlement Agreement and Order on Consent for EE/CA Investigation and Removal Action
SOPs	standard operating procedures
UDERR	Utah Department of Environmental Response and Remediation
United Park	United Park City Mines Company
USFWS	United States Fish and Wildlife Service
%R	percent recovery
µg/L	micrograms per liter
XRF	field-portable X-ray fluorescence meter

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A3 Distribution List

This QAPP and subsequent revisions will be distributed to the following organizations and individuals:

Kathryn Hernandez, U.S. Environmental Protection Agency Region VIII, Remedial Project Manager

Andrea Madigan, U.S. Environmental Protection Agency Region VIII
Mo Slam, Utah Department of Environmental Quality (UDEQ), UDEQ Project Manager

Sandra K Allen, Utah Department of Environmental Quality, Assistant Attorney General

Heather B. Shilton, Utah Division of Parks and Recreation, Assistant Attorney General

Brad T Johnson, State Natural Resource Trustee, State Natural Resource Lead Trustee

Kent Sorenson, State Natural Resource Trustee, State Trustee Technical Advisor

Casey S. Padgett, Branch of Environmental Compliance and Response, Office of the Solicitor, Department of Interior

Dana Jacobson, Office of the Solicitor, Department of Interior

Trent Duncan, Bureau of Land Management, Utah State Office

Jim Fricke, RMC Project Manager

A4 Project/Task Organization

The management team consists of United Park City Mines Company (United Park) personnel with assistance from Resource and Environmental Management Consultants (RMC) and other environmental consulting firms as needed. Figure 1 shows the chain-of-command for the project managers, engineers, and quality assurance officials responsible for managing field activities.

A4.1 United Park Project Manager

United Park is responsible for implementing this project. United Park's Project Manager (PM) is Kerry Gee, who will be responsible for all project management and communication with the regulatory agencies. The United Park PM has the authority to halt work conducted pursuant to the Settlement Agreement in the event that significant problems are identified which could potentially affect data quality. Mr. Gee, as Project Manager, is responsible for the overall management and coordination of the following activities:

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- Coordination with EPA/UDERR/Trustees regarding the status of the project;
- Providing oversight of the subcontractors;
- Reviewing monthly status reports;
- Supervising production and review of deliverables;
- Tracking work progress against planned budgets and schedules;
- Informing EPA/UDERR/Trustees of changes in the Work Plans, SAP, HASP and/or other project documents;
- Notifying EPA/UDERR/Trustees immediately of significant problems affecting the quality of data or the ability to meet project objectives;
- Communication with property owners including site access considerations;
- Procuring subcontractors to provide sampling and analytical support;
- Providing oversight of report preparation; and
- Organizing and conducting a field planning meeting.

Some of the above listed responsibilities may be performed by others at the direction of the United Park PM if required. Oversight activities including sampling to be conducted by EPA/USFWS/UDERR will be coordinated between the EPA Remedial Project Manager and United Park Project Manager.

A4.2 EPA Remedial Project Manager

EPA is the lead agency for this project. The EPA Remedial Project Manager (RPM) is Kathryn Hernandez, Region VIII, Denver, Colorado. The EPA RPM will provide oversight of activities conducted pursuant to the Settlement Agreement. While the EPA RPM does not have an active role in directing daily work at OU2 and OU3, the EPA RPM has ultimate approval authority of the work completed. The EPA RPM also has the authority to halt work at OU2 and OU3 in case significant problems that affect the quality of data generated are identified or corrective actions are not implemented as planned

A4.3 RMC Project Manager

The RMC PM will be responsible for overall project management, including planning, coordination of data acquisition/field activities, and implementing the RMC and project-specific QA Programs. The RMC PM is Jim Fricke. Mr. Fricke is responsible for the following:

- Coordinating with the laboratory regarding the analytical, data validation, and Quality Assurance/Quality Control (QA/QC) issues related to sample analysis;
- Reviewing analytical results and deliverables from subcontractors;
- Incorporating changes in the Work Plan, SAP, HASP, and/or other project documents;
- Scheduling personnel and material resources;
- Implementing field aspects of the investigation, including this SAP and other project

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documents;
- Implementing the QC measures specified in this QAPP and other project documents;
- Implementing corrective actions resulting from staff observations, QA/QC surveillance, and/or QA audits;
- Providing oversight of data management;
- Coordinating and overseeing the efforts of the subcontractors providing sampling and analytical support;
- Scheduling and conducting field work;
- Notifying the subcontract analytical laboratory of scheduled sample shipments and coordinating work activities;
- Gathering sampling equipment and field logbooks, and confirming required sample containers and preservatives;
- Maintaining proper chain-of-custody forms and shipping of samples to the analytical laboratory during sampling events;
- Ensuring that sampling is conducted in accordance with procedures detailed in this SAP and that the quantity and location of all samples meet the requirements of the SAP;
- Identifying problems at the field team level; resolving difficulties in consultation with the QA/QC staff;
- Implementing and documenting corrective action procedures at the field team level; and
- Providing communication between the field team and United Park management.

Some of the above listed responsibilities may be performed by others at the direction of the RMC PM if required.

A4.4 RMC Quality Assurance Official

The RMC Quality Assurance Official (QAO) is Tess Byler, who is responsible for the quality assurance/quality control of the data that are generated during implementation of the SAP. Ms. Byler will report any QA/QC problems to the RMC PM. As the QAO, she will be responsible for the following:

- Reviewing and approving project specific plans;
- Directing the overall project QA/QC program;
- Maintaining QA/QC oversight of the project;
- Reviewing QA/QC sections in project reports, as applicable;
- Reviewing QA/QC procedures applicable to this SAP;
- Auditing selected activities of this project performed by RMC and subcontractors, as necessary;
- Initiating, reviewing, and following up on response actions to address QA/QC problems, as necessary, including problems with subcontractors;
- Consulting with the Field Manager and/or Project Manager, as needed, on appropriate QA/QC measures and corrective actions;
- Arranging performance audits of measurement activities, as necessary;
- Distributing the most current copy of the approved QA project plan to personnel;

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- Providing written reports on QA/QC activity to the United Park PM and RMC PM; and
- Insuring all training/certifications of personal are satisfied.

A4.5 RMC Field Manager

The RMC Field Manager (FM) is Dan Dean, who will be responsible for all field activities related to this SAP. Specific responsibilities of the RMC FM are as follows:

- Implement the project FSP according to guidance of the QAPP and Health and Safety Plan (HASP);
- Ensure that Standard Operating Procedures (SOPs) are available and in use for activities that affect product quality and that assigned staff have been trained in their implementation;
- Inspect and accept supplies and consumables;
- Monitor sample collection, preservation, handling, transport and custody throughout the project;
- Ensure that the proper number and type of environmental and control samples are collected, identified, tracked, and sent to the laboratory for analysis;
- Coordinate and schedule sample shipment/delivery to analytical laboratories to meet holding times and analytical procedure specifications;
- Ensure that appropriate sampling, field testing and analysis, and surveying procedures are followed and recorded and that correct QC checks are implemented;
- Ensure that field documentation and logbooks are completed during field activities. The RMC FM inspects the field team logbooks and field documentation daily for completeness;
- Assists the RMC PM to monitor subcontractors for compliance with both project and data quality requirements, record cost and progress of the work, and replan and reschedule work tasks, as appropriate.
- Coordinate the appropriate disposal of investigation-derived waste;
- Verify data quality, test results, equipment calibrations, and QC documentation;
- Review and approve calculations to ensure that data reduction is performed in a manner that produces quality products;
- Provide full assistance during the conduct of QA audits and take corrective action that may be required by audit findings;
- Ensure that procedures are modified to reflect the corrective actions implemented and that they are distributed to all field personnel, including subcontractors;
- Report QA problems to the United Park PM and RMC PM; and

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- Lead the preparation of the final Site Characterization Report.

A4.6 RMC and United Park Field Staff

Under the direction of the United Park PM, RMC PM and RMC FM, the RMC and United Park Field Staff are responsible for the planning, coordination, performance, and reporting of specific technical tasks. RMC and United Park Field Staff have the responsibility of applying the QAPP and project-specific FSP to their assigned activities. Their specific responsibilities are as follows:

- Accurately develop and maintain technical activity files, including detailed logbooks and field forms; and
- Execute field work preparation and field work per the project specific SAP and HASP.

A4.7 Subcontractors

RMC may delegate to others, by subcontract, the responsibility of establishing and executing certain portions of the project, but shall retain responsibility for their conformance of the results to project requirements. When organizations other than RMC are involved in the execution of activities covered by the requirements of the SAP or Work Plan, the activities will be monitored by the RMC PM, RMC FM, and RMC Field Staff, as appropriate. Activities shall be monitored against technical requirements specified in the Scope of Work, which is prepared and provided to the subcontractor during the procurement process. When non-conformances are identified, the United Park PM, RMC PM and RMC QAO will be notified as necessary to determine if the project DQOs have been affected. Resolution of non-conformances will be made and, if necessary, corrective actions will be implemented. In the case of subcontracted laboratories, performance will be measured through the data review and validation process.

A4.8 Laboratory Analytical Services

Laboratory information is presented in the following table:

Laboratory	Analysis	Laboratory Director	Laboratory Reporting Coordinator	Laboratory Certification
American West Analytical Laboratories	Environmental laboratory conducting the following analyses: General Chemistry, total, dissolved surface and groundwater, sediment and soil metals analysis.	Kyle Gross	Melanie Humphrey	State of Utah

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A5 Problem Definition/Background

A5.1 Background

Site background information including Operable Unit descriptions, site history, and environmental setting is presented in the Field Sampling Plan.

A5.2 Problem Definition

The work addressed by this QAPP is being conducted to complete an Engineering Evaluation / Cost Analysis (EE/CA) as required by the Administrative Settlement Agreement and Order on Consent for EE/CA Investigation and Removal Action for the Richardson Flat Tailings Site, Operable Units 2 and 3, in Park City, Utah, effective as of March 6, 2014 [Settlement Agreement, (EPA et al., 2014)].

A5.3 Regulatory Information

This Quality Assurance Project Plan (QAPP) is one of two plans that make up the Sampling and Analysis Plan (SAP) for Operable Units 2 and 3 (OU2 and OU3) of the Site[1]. The companion plan to the QAPP is the Field Sampling Plan (FSP), which is also included in the SAP. The SAP is based on the approved OU2 and OU3 Engineering Evaluation / Cost Analysis Work Plan (EE/CA Work Plan), which details OU2 and OU3 strategy and defines the overall approach for work anticipated to be performed at OU2 and OU3. The OU2 and OU3 EE/CA Work Plan is included as Appendix C of the Settlement Agreement (EPA et al., 2014). This QAPP governs all data collection activities conducted pursuant to completing the OU2 and OU3 EE/CA.

United Park is performing this work under the Settlement Agreement, (EPA et al., 2014) with the United States Environmental Protection Agency (EPA) as the lead oversight agency. The EPA is joined in oversight by Trustees for Natural Resource Damages and Restoration (NRDR); the United States Bureau of Land Management, the United States Fish and Wildlife Service, the Utah Department of Environmental Quality, the Utah Division of Parks and Recreation, and the State of Utah Natural Resource Trustee.

---

1 Capitalized terms used, but not defined, herein are defined in the Administrative Settlement Agreement and Order on Consent for EE/CA Investigation and Removal Action for the Richardson Flat Tailings Site, Operable Units 2 and 3, in Park City, Utah, effective as of March 6, 2014 [Settlement Agreement, (EPA et al., 2014)].

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A6 Project/Task Description

This QAPP will be used for all phases of sampling and analysis activities for the OU2 and OU3 EE/CA. The goal of sampling efforts to be conducted under the SAP is to define the nature and extent of contamination and to collect data needed for the evaluation of risk posed to human and ecological receptors by metals in surface water, shallow groundwater, soils, sediments, tailings materials and biota in the vicinity of OU2 and OU3. The primary objective for the EE/CA is to determine if there is risk and if so where, since the presence or absence of risk will determine the need for and scope of a response action. Table 1 presents the project specific analytes that will be analyzed for as part of activities conducted under this SAP. Results from these sampling efforts, coupled with results from previous studies, will be used to conduct the EE/CA for OU2 and OU3.

The objectives of sampling activities governed by this QAPP are:

- Determine the nature and extent of contamination;
- Collect data of sufficient quantity and quality to complete the EE/CA. Data will be collected to fill in data gaps from previous studies. Data collected will build upon and supplement the existing dataset;
- Collect data to perform ecological and human health risk assessments;
- Collect data to determine removal alternatives;

Draft human health and ecological conceptual site models, and a preliminary identification of potential receptor groups, candidate species, assessment endpoints and measurement endpoints are presented in Section 2 of the FSP. The type, quantity, purpose, and intended uses of data to be collected are defined in the FSP.

A6.1 Work Schedule

Sampling and analysis activities for the OU2 and OU3 EE/CA are anticipated to begin in late summer or fall 2014 and continue through 2015. Sample analysis will be conducted with standard laboratory turnaround times. The site is generally accessible from early spring through late fall of each year. Snowfall can limit site access during the winter season.

A6.2 Laboratory Testing

The following analytical laboratory is being used for this project:

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Laboratory	Analysis
American West Analytical Laboratories (AWAL)	Environmental laboratory conducting the following analyses: General Chemistry, total, dissolved surface and groundwater, sediment and soil metals analysis. Analysis of organism tissue samples will be performed by AWAL subcontract laboratories certified to analyze biological samples.

The AWAL Quality Manual (QM) is included in Appendix A.

A7 Data Quality Objectives and Criteria

The QA objectives for measurements established for this project are listed below.

- Implement standard operating procedures for field sampling, sample custody, equipment operation and calibration, laboratory sample analysis, data reduction, and data reporting that are designed to ensure the consistency and thoroughness of data generation.
- Assess the quality of data generated to ensure that all data are scientifically valid, of known and documented quality and legally defensible, where appropriate. This will be evaluated by precision, accuracy, representativeness, completeness, and comparability (PARCC), and by testing generated data against acceptance criteria established for these parameters.
- Achieve an acceptable level of confidence in the decisions that are made from data by controlling the degree of total error permitted in the data using QC procedures. Data that do not satisfy the established QC criteria will be evaluated for usability in meeting project objectives during validation of the data.
- Ensure that the QAPP and associated project plans are properly implemented by conducting compliance inspections and audits if necessary. In addition, verify that corrective action is executed for any nonconformance identified through QA reports to management.

The methods and procedures used to implement and accomplish the above-described objectives are described throughout this QAPP.

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A7.1 DQO Process

The DQO process consists of the seven steps listed in Table 2 below with site-specific conditions.

Table 2: General Data Quality Objectives for Richardson Flat OU2-OU3

Step 1: State the Problem
The purpose of the Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) is to outline the general requirements to complete an investigation to support preparation of an Engineering Evaluation/Cost Analysis (EE/CA). The FSP and QAPP will be implemented by United Park City Mines Company to investigate the presence of hazardous substances and the risk posed thereby within the Richardson Flat Tailings Site Operable Units 2 and 3 (OU2 and OU3). The potential pollutants of interest in OU2 and OU3 are heavy metals present in the Silver Creek watershed. Tailings are primarily present in the floodplain of Silver Creek in OU2 and OU3. Limited areas of contaminated soils are also known to exist in upland areas of OU2 and OU3 as a result of historic water diversions and irrigation activity. Known and potentially contaminated media include soil, sediment, groundwater and surface water. In regards to surface water, the Silver Creek watershed from the confluence with the Weber River to its headwaters has been included on Utah's 303(d) lists as impaired since 1998, and a total maximum daily load for dissolved zinc and cadmium was completed in in 2004. Potential contaminant fate and transport pathways, and possible human and ecological exposure routes are presented in the draft human health and ecological conceptual site models presented in the FSP. Previous investigations and known data gaps are discussed in the FSP. In order to complete the EE/CA, there is a need for additional investigation of OU2 and OU3. This includes analysis of pollutants, assessment of source and/or pollutant reduction options, and assessment of risk to humans and the environment from OU2 and OU3.
Step 2: Identify the Goals of the Study
This project is being undertaken to characterize the current levels of contaminants present in surface water, shallow groundwater, surface and subsurface soils, sediments and biota in OU2 and OU3. Sampling activities are designed to fill data gaps from previous investigations and adequately address data needs for conducting the EE/CA and a Streamlined Risk Assessment. The specific goals of the study include: • Determine the nature and extent of contamination; • Collect data of sufficient quantity and quality to complete the EE/CA. Data collected will build upon and supplement the existing dataset; • Collect data to perform ecological and human health risk assessments; • Collect data to determine potential removal action alternatives; These goals will be accomplished through:

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- Soil sampling as described in the FSP;
- Sediment sampling as described in the FSP;
- Surface water sampling as described in the FSP;
- Groundwater sampling as described in the FSP;
- Biota sampling as described in the FSP; and
- Additional sampling as required to accomplish the goals of the study.

For the OU2 and OU3 EE/CA, the following DQO has been proposed:

- Perform necessary investigations to prepare all the components of an EE/CA, including a Streamlined Risk Assessment.

Additional focused DQOs and specific decision statements are presented in the FSP.

Step 3: Identify Information Inputs

The specific environmental media to be sampled are surface water in Silver Creek and selected tributaries, shallow groundwater in the Silver Creek alluvial aquifer, surface and subsurface soils in upland and wetland areas, tailings, sediments in wetland areas, and biota in OU2 and OU3. Soil and surface water data will be used for both determining the nature and extent of contamination and for risk assessment purposes. Groundwater data will be used for determining the nature and extent of contamination. Sediment and organism tissue data will be used for risk assessment purposes.

Secondary data sources – Secondary data sources that may be utilized during the site characterization and development of the EE/CA are discussed in the FSP. Secondary data sources of sufficient quality to be used quantitatively may be limited to data collected by Tetra Tech (for EPA) and the USGS. Remaining secondary data sources may be used qualitatively. Secondary data sources will be evaluated for usability per the data quality assessment procedures specified in the QAPP. A complete listing of the secondary data sources available for the Site is presented in the Summary of Previous Investigations Report prepared by RMC (RMC, 2014).

Primary data – The data collection described in the FSP will be the primary data.

The primary and secondary data may be used to perform pollutant loading analysis, prepare removal volume estimates, and conduct risk assessments. Screening values have been selected *a priori* and are presented in Table 3 of the QAPP. The screening values presented in QAPP Table 3 were provided by EPA for use at OU2 and OU3.

Step 4: Define the Boundaries of the Study

Spatial Boundaries

The study area encompasses the boundaries of OU2 and OU3. Operable Unit boundaries are defined in the Settlement Agreement and generally described below.

OU2 extends approximately 4.5 miles along Silver Creek from U. S. Highway 40 on the southern end to Interstate 80 on its northern end, ranging in width from approximately 2,100 feet at the southern boundary to approximately 3,800 feet near Pivotal Promontory Road. Areas within OU2 that are now

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categorized as OU3 are excluded from evaluation as OU2.

OU3 is comprised of five separate areas as shown on Figure 1-1 of the FSP and QAPP:

- Middle Reach – The first area is commonly known as the Middle Reach of Silver Creek. This area encompasses the Silver Maple Claims from its upstream end at Prospector Park downstream to U.S. Highway 40;
- Floodplain Tailings Reach (FPT Reach) – The second area extends from U.S. Highway 40 northward to State Route 248. A portion of this area is referred to as the "Floodplain Tailings" in the OU1 RI/FS (RMC, 2004); This area was initially included as part of OU2;
- State Route 248 North Reach – The third area extends from State Route 248 northward approximately 9,000 feet through the southerly one-third of the Lower Silver Creek floodplain. This area was initially included as part of OU2;
- P. C. West – The fourth area is located in the northern part of OU3 and is adjacent to the Snyderville Basin Water Reclamation Facility (sewage treatment facility) to the west. This area was initially included as part of OU2; and
- P. C. East – The fifth area is located in the northern part of OU3 to the north of Promontory Road and is adjacent to a residential development, Pivotal Promontory, LLC, which has constructed a private club and second-home community on the eastern OU3 boundary. This area was initially included as part of OU2.

Temporal Boundaries

Data collection for the OU2 and OU3 EE/CA is expected to occur from approximately fall 2014 to fall 2015. Surface water and groundwater will be sampled quarterly for one year starting in approximately fall 2014. Groundwater static water levels will be measured monthly for one year starting in approximately fall 2014. Soil sampling is expected to begin in fall 2014 and be completed in late summer or early fall 2015 (with a hiatus during the 2014/2015 winter season and possibly spring 2015 season). Sediment and organism tissue sampling is expected to occur in July or August 2015.

Step 5: Develop the Strategy for Information Synthesis – Develop an Analytic Approach

The quality of new and existing data to be used for the OU2 and OU3 EE/CA will be evaluated for usability. New data will be evaluated according to the EPA guidance *Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review* (EPA, 2010). Nature and extent determination may consist of an evaluation of spatial trends that terminate at background or possibly risk-based values.

Risk Assessment Decision Rule

The decision rules that will be used to guide final risk management decisions regarding the need for remediation of surface water, soil and/or sediment are described below. The decision rules are based on a consideration of the level of risk posed to humans and ecological receptors by site-related contaminants.

For humans, the decision rule is based on the estimated level of cancer and non-cancer risk to an individual with reasonable maximum exposure (RME). If the estimated cancer risk to the RME receptor is below the specified level (e.g., 1E-04), and if the estimated non-cancer risk is below a hazard Index of

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1.0, it is likely that these site media will be considered acceptable for human exposure. If either the cancer or non-cancer risks exceed the maximum acceptable value, then some response action will be considered appropriate.

For ecological receptors, risk characterization will, to the extent that data allow, be based on calculation of hazard quotient (HQ) values based on measured concentration values and available toxicity reference values (TRVs). If HQs indicate a likelihood of adverse effects to site receptors compared to what would be expected in the absence of site-related contamination, then a response action will be appropriate.

Step 6: Specify Performance or Acceptance Criteria

This has been documented in the field sampling SOPs attached to the FSP and Sections B-D of the QAPP for laboratory methods. Data that meets the performance criteria can be used as intended to meet the DQOs.

Step 7: Develop the Plan for Obtaining Data

The data requirements of this SAP encompass aspects of historical record searches and data evaluation, primary data collection, field data and laboratory results and database management to reduce sources of errors and uncertainty in the use of the data.

Directed sampling will be employed at the locations shown in the FSP. These locations are distributed throughout OU2 and OU3. Sampling locations and total number of samples for each OU may be modified from that presented in the FSP based on observed site conditions and to maximize the potential for adequate characterization. Optimization of the sampling design may result in an iterative process based on site-specific field observations, intermediate data interpretation, and apparent conditions. Specific sampling protocols are presented in the FSP. Analytical data will be downloaded and manipulated electronically to reduce manual data entry whenever possible.

Uncertainty in the data due to sampling and measurement errors or errors introduced during data manipulation could result in identifying a hazard when one does not actually exist or in not identifying a hazard when one does exist. Reducing data uncertainty is of the highest priority.

It is important to reduce uncertainty because these data will be used to develop project recommendations that are feasible, cost effective, and environmentally acceptable. Data will also be used by Federal and State regulatory agencies to fulfill their review and oversight requirements as specified in pertinent laws, regulations and policies.

Two types of decision errors are possible when making risk management decisions:

- A false negative decision error occurs when it is decided that risk is acceptable when the true risk is actually above the level of concern.
- A false positive decision error occurs when it is decided that risk is not acceptable when the true risk is actually below the level of concern.

Of these two types of errors, EPA is primarily concerned with avoiding false negative errors, since an error of this type can leave human or ecological receptors exposed to unacceptable levels of contamination and risk.

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A false positive decision error does not leave humans or ecological receptors at risk, but is also of concern to EPA because this type of error may result in the expenditure of resources (time, money) that might be better invested elsewhere. There is no Agency-wide standard for the acceptable probability of a false positive decision error.

A7.2 Precision, Accuracy, Representativeness, Completeness, and Comparability Criteria

Analytical data generated for the project will be assessed for the PARCC parameters. These objectives are expressed as quantitative and qualitative statements concerning the type of data needed to support a decision, based on a specified level of uncertainty. Further discussion of each parameter and rationale for its use is presented below. PARCC criteria are detailed in Table 7.

Two categories of data are used for analytical analyses: screening and definitive. Screening data are generated by rapid methods of analysis with less rigorous sample preparation, calibration, and QC requirements than are necessary to produce definitive data. Physical test methods such as meter readings for water quality parameters and XRF analysis of metals in soil and sediment are considered screening methods. Screening data will be documented on field forms and/or in field logs, as appropriate, and will be reviewed as discussed in Section B2.1, and will not be assessed for the PARCC parameters.

Definitive data are generated using rigorous EPA-approved analytical methods which have standardized QC and documentation requirements. For this project, all analytical data are definitive data and will be independently validated.

Precision

The precision of a measurement is an expression of mutual agreement among individual measurements of the same property taken under prescribed similar conditions. Precision is quantitative and will be expressed in terms of relative percent difference (RPD). RPD is defined as follows:

$$\text{RPD (percent, \%)} = 100 \times \frac{|S-D|}{(S+D)/2}$$

Where: S = concentration of an analyte in a sample
D = concentration of an analyte in a duplicate sample

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Precision of reported results is a function of inherent field-related variability plus laboratory analytical variability. The closer the numerical values of the measurements are to each other, the more precise the measurement. Various measures of precision exist, depending upon "prescribed similar conditions." Field duplicate samples (one sample in twenty or one per day of sampling, whichever is greater) will be collected to provide a measure of the contribution to overall variability of field-related sources. Contribution of laboratory-related sources to overall variability is measured through various laboratory QC samples (laboratory duplicates, matrix spike/matrix spike duplicates, and laboratory control sample/laboratory control sample duplicates).

The acceptable RPD limits for field duplicates are less than 35% for soil, water and sediments where both results are greater than 5 times the reporting limit (RL). If one or both results are less than 5 times the RL, then the acceptable RPD limit is an absolute difference of less than 2 times the greater RL (the RL is used for nondetect results). Due to the heterogeneous nature of soil and sediments, the 35% is a goal for these matrixes, results may be accepted with RPD limits >35%. Chemical analytical data will be validated for precision using field duplicates, laboratory duplicates, matrix spike/matrix spike duplicates (MS/MSDs), and laboratory control sample/laboratory control sample duplicates (LCS/LCSDs), as applicable.

Accuracy

Accuracy is the degree of agreement of a measurement with an accepted reference or true value, and is a measure of the bias in a system. Accuracy is quantitative and usually expressed as the percent recovery (%R) of a matrix spike (MS) analyte or of a standard reference sample, and is defined as follows:

$$\%R = \frac{A-B}{C} \times 100$$

Where: A = measured concentration of analyte in a spiked sample
B = concentration of analyte in an unspiked sample
C = known concentration of spike added

Ideally, it is desirable that the reported concentration equals the actual concentration present in the sample. Acceptable QC limits for %R are 75% to 125% for LCS/LCSDs, and laboratory-defined for MS/MSDs. Accuracy of spiked sample analyses will be determined for no less than one sample in twenty.

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Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent (a) a characteristic of a population, (b) parameter variations at a sampling point, and/or (c) an environmental condition. Representativeness is a qualitative parameter that is most concerned with the proper design of the sampling plan and the absence of cross-contamination. Good representativeness will be achieved through: (a) careful, informed selection of sampling locations, (b) selection of testing parameters and methods that adequately define and characterize the extent of possible contamination and meet the required parameter reporting limits, (c) proper gathering and handling of samples to avoid interference and prevent contamination and loss, and (d) collection of a sufficient number of samples to allow characterization.

Representativeness is a consideration that will be employed during all sample location and collection efforts and will be assessed qualitatively by reviewing field procedures and reviewing actual sampling locations versus planned locations.

Completeness

Completeness is a measure of the amount of usable data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. Evaluating the PARCC parameters will assess usability. Those data that are validated and need no qualification, or are qualified as estimated data, are considered usable. Rejected data are not considered usable. Completeness will be calculated following data evaluation as follows:

$$\text{Completeness (\%)} = \frac{V}{P} \times 100$$

Where: V = number of valid measurements
P = number of planned measurements

The overall completeness goal is 90 percent for each sampling event. If this goal is not met, additional sampling may be necessary to adequately achieve project objectives.

Comparability

Consistency in the acquisition, handling, and analysis of samples is necessary for comparing results. Where appropriate, the results of analyses obtained will be compared with the results obtained in previous studies. Standard EPA analytical methods and QC will be used to ensure

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comparability of results with other analyses performed in a similar manner. Comparability is a qualitative parameter and cannot be assessed using QC samples.

A7.3 Field Measurements

Field measurements will be conducted during sample collection activities. All procedures recommended by the manufacturer will be followed in calibrating and operating the instruments. Field measurements will include soil screening, water quality and flow rates as described in Section B2.3.

A7.4 Sensitivity

To evaluate the utility of the data for comparison to numeric standards or screening levels (e.g., federally mandated criteria such as maximum contaminant levels [MCLs], etc.), it is important that the sensitivity of the methods utilized is acceptable. This QAPP specifies the use of routine and commercially available EPA-approved analytical methods. In general, these methods provide the necessary level of sensitivity. It is important to note that the laboratory method detection limits (MDLs) must be at least two to three times less than the RLs listed. Table 3 presents screening values for surface water, soil and sediment provided by EPA for use at OU2 and OU3.

A7.5 Bias

Assessment of field sampling precision and bias will be accomplished through collecting field duplicate samples and equipment blank samples for laboratory analysis. Sampling design error can lead to systematic error (bias) in estimates of population parameters. This is reflected in the sampling design by: 1) appropriate selection of sampling locations and analytes, and 2) identification of appropriate sample collection methods.

A8 Special Training Requirements/Certification

A8.1 Field Personnel

The RMC FM and all RMC and United Park Field Staff, including subcontractors, that will be performing work at OU2 and OU3 shall have completed Hazardous Waste Operations and Emergency Response training that meets the requirements in 29 Code of Federal Regulations 1910.120. All RMC and United Park personnel will receive training and a project-specific review based on anticipated responsibilities. No other certifications or special training are required for the completion of this project. Daily safety reviews will be conducted for all field personnel.

Analytical laboratories performing analyses will be certified by the State of Utah Department of

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Health Services Environmental Laboratory Accreditation Program and the National Environmental Laboratory Accreditation Program.

A8.2 Training Records

RMC's Health and Safety Manager is responsible for maintaining the OSHA Health and Safety Training Records for RMC's field personnel. All field personnel will carry a copy of their current OSHA HAZWOPER certifications. OSHA Health and Safety Records are kept in RMC's human resources personnel training files located in our Salt Lake City, Utah office. The Health and Safety Manager is required to maintain readily accessible OSHA Health and Safety Training Records for their onsite field personnel.

A9 Documentation and Records

Documentation and record-keeping for field tasks, laboratory analytical tasks, and reporting tasks are discussed below. RMC will archive and store all data, field forms and field notebooks for a minimum of five years after completion of the project.

Field Operation Records

Documentation of field activities will be conducted in accordance with RMC SOP 5 (Sample Handling and Documentation). As detailed in the FSP, the field sampling team will maintain a comprehensive field logbook and field forms, as appropriate, that include notes regarding instruments used, site and weather conditions, GPS coordinates, vegetative community observations, sample time, sampler's name, analytical parameters, sample handling and chain of custody, and all interaction with subcontractors and visitors. Representative photographs will also be taken of field activities and sample locations, and a description will be recorded in the logbook. Photographs will be taken at all sampling locations (water, soil, sediment, macroinvertebrates, fish and plants) to document habitat type and conditions. Habitat type & conditions should also be recorded on field data forms for these samples.

The field activities will be recorded in bound, waterproof notebooks and/or field forms printed on water-resistant paper. All entries will be made in permanent ink and will be clear, objective, and legible. If data or information is entered incorrectly, the erroneous data or information will be corrected via a single line strike out labeled with the correcting personnel's initials, the date, and the rationale for the correction, if possible. At minimum, if space is a limitation, the correction will be labeled with the correcting personnel's initials and the date of correction. The RMC FM is responsible for maintenance and document control of the field logbooks and field forms. Example field forms are included in Appendix C of the FSP.

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Laboratory Data Reporting Package Format and Documentation Control

All hard copy laboratory data deliverables shall meet the Level 2 QA/QC requirements defined in the laboratory's QM. All electronic laboratory data deliverables (EDDs) shall be submitted in Microsoft Excel format.

Each submission shall include sufficient data to unequivocally identify each sample delivery group and the impact of quality control on each sample result. Any result that may be deemed questionable by the laboratory in the process of any internal review prior to submission to United Park shall be fully explained with a description of all corrective actions taken so that assurances of data quality are maintained. Nonconformance corrective action documentation shall include but is not limited to:

- Where the out-of-control incident occurred;
- When the incident occurred and was corrected;
- Who discovered the out-of-control incident;
- Who verified the incident;
- Who corrected the problem; and
- What corrective action was taken.

Laboratory Data Package Archiving and Retrieval

Unless prior written agreement is obtained from United Park, the laboratory will be required to hold all unused sample volumes for 180 days before disposal. Sample volumes will be stored according to the appropriate method preservation requirements (e.g., 4 degrees Celsius).

The laboratory shall be required to maintain all analytical data for a minimum of five years for each analytical sample delivery group. The laboratory data package will include copies of the chain-of-custody (COC) forms. The laboratory will note on the COC any discrepancies between the sample labels and COC document.

When samples are in the custody of the laboratory, sample integrity will be maintained through the use of locked storage areas. Removal of samples for analysis will be documented on the sample log-in sheet or computer system.

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B DATA GENERATION AND ACQUISITION

B1 Sampling Process Design

Sampling design, sampling schedule, sampling methods, and procedures for locating and selecting environmental samples are presented in the FSP.

Critical measurements directly support the primary project objectives. The sample requirements are listed in Table 8.

B2 Sampling Methods

Custody and documentation for field and laboratory work are described below, followed by a discussion of corrections to documentation.

B2.1 Field Sampling Equipment and Procedures

The following Standard Operating Procedures (SOPs) are included as Appendix A of the FSP:

- RMC SOP 1: Standard Procedures for Collection of Surface Water Samples and General Water Sampling
- RMC SOP 2: Standard Procedures for Collection of Surface and Near Surface Soil Samples;
- RMC SOP 2B: Hand Auger Soil Sampling;
- RMC SOP 2C: Geoprobe Sampling;
- RMC SOP 3A: Hollowstem Auger Drilling, Soil Sampling and Monitoring Well Instillation
- RMC SOP 3B: Standard Procedures for Monitoring Well Development
- RMC SOP 3C: Standard Procedures for Groundwater Sampling
- RMC SOP 4: Standard Procedures for Collection of Wetland and Stream Sediment Samples;
- RMC SOP 5: Standard Procedures for Sample Handling, Documentation and Shipping;
- RMC SOP 6: Standard Procedures for Sampling Equipment Decontamination; and
- RMC SOP 8: Standard Procedures for XRF Field Screening.
- RMC SOP 9: Standard Procedures for Filed Water Quality Meter Calibration and Field Water Quality Measurements
- UDEQ SOP: Standard Operating Procedures for the Collection of Macroinvertebrates in Wetlands
- EPA-600-R-92-111, *Fish Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters*

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- SERAS SOP: Standard Operating Procedures for Terrestrial Plant Community Sampling

B2.2 Field Sample Handling and Analysis

All samples will be collected and preserved in accordance with Table 8 which specifies the following:

- Matrix;
- Analytes;
- Sample holding times;
- Preservation; and
- Sample containers.

Samples will be submitted to the following laboratory:

American West Analytical Laboratories
463 West 3600 South
Salt Lake City, Utah 84115
(801) 263-8686

All sample handling will be conducted in accordance with RMC's Standard Operating Procedures (SOPs) presented in Appendix A of the FSP.

B2.3 In-situ Monitoring

Field equipment to be used during sampling activities include, but are not limited to, field-portable X-ray fluorescence meter (XRF), multiparameter water quality field meters, flow meters, peristaltic pumps, GPS devices and disposable sampling materials (spoons, baggies, tubing, filters).

B3 Sample Handling and Custody

Custody and documentation for field and laboratory work are described below, followed by a discussion of corrections to documentation.

B3.1 Field Sample Custody and Documentation

Samples analyzed through laboratories coordinated by RMC will be labeled using procedures established in the FSP. Sample labels will include the sample identification number and required

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analyses. Additional sample collection information including the date and time of sample collection, and sampler's initials will be recorded on the labels in permanent black ink markers or pens at the time of sample collection

B3.2 Chain-of-Custody Requirements

A chain-of-custody record will be completed at the time of sample collection. Field personnel will record the sample identification number, sampling date and time, sample matrix, sampler's initials, and analytical requirements. Completed chain-of-custody records will be reviewed for completeness by the RMC FM prior to sample submittal or shipment. Samples will be relinquished under the Chain-of-Custody Procedures identified in RMC SOP 5 (Sample Handling and Documentation).

B3.3 Sample Packaging and Shipping

Samples will be hand delivered to the laboratory or shipped via appropriate courier if necessary.

If samples are shipped the following procedure will be used for packaging:

- Inert cushioning material will be placed in the bottom of the cooler if shipping glass sample containers.
- A temperature blank will be included with each cooler in order to record the cooler temperature upon receipt by the laboratory.
- The cooler will be lined with two large garbage bags (an outer bag and inner bag).
- Sample containers will be placed upright in the inner bag which will then be securely twisted and taped closed.
- Ice will be placed between the inner and outer plastic bags, and the outer bag will then be securely twisted and taped closed.
- If required to adequately secure the sample containers, additional packaging materials will be placed around the containers as cushioning material.
- The COC form and any other pertinent paperwork will be double-bagged within resealable plastic bags and taped to the inside lid of the cooler.
- The cooler will be sealed with packaging tape.
- A shipping label will be affixed to the outside of the cooler.

Signed custody seals will be attached to the cooler in two places and covered with clear tape in such a way that the custody seal must be broken to open the cooler

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B3.4 Laboratory Custody Procedures and Documentation

Laboratory custody procedures are provided in each laboratory's QM. Upon receipt at the laboratory, each sample cooler will be inspected to assess the condition of the cooler and the individual samples. This inspection will include measuring the temperature of the cooler (if cooling is required) to document that the temperature of the samples is within the acceptable criteria and verifying sample integrity. The enclosed chain-of-custody records will be cross-referenced with all of the samples in the shipment. Laboratory personnel will then sign these chain-of-custody records. The sample custodian will continue the chain-of-custody record process by assigning a unique laboratory number to each sample on receipt. This number, if assigned, will identify the sample through all further handling. It is the laboratory's responsibility to maintain samples in a secure location, maintain internal logbooks and records throughout sample preparation, analysis, data reporting and disposal.

B4 Analytical Methods Requirements

All chemical analysis of analytical samples will be completed using EPA-approved methods. Table 8 summarizes the chemical analyses that will be completed during this investigation. For all analytical methods used during this investigation, method performance requirements are specified in the methods, and no additional performance requirements will be implemented. An electronic Level 2 QA/QC data package is required, along with an electronic data deliverable (EDD) submitted in Microsoft Excel format.

Any out-of-control occurrence must be reported to United Park and RMC as soon as possible so that the out-of-control event can be assessed and an appropriate course of action be determined based on the overall project objectives, critical nature of the data, and project schedule. At a minimum, the laboratory will report the types of out-of-control occurrences, how these occurrences are documented, and who is responsible for correction and documentation. Generally, corrective action will be required for out-of-control events such as poor analysis replication, poor recovery, instrument calibration problems, and blank contamination.

Corrective action will be taken at any time during the analytical process when deemed necessary based on analytical judgment or when QC data indicate a need for action. Corrective actions may include, but are not limited to:

- Re-analysis
- Calculation checks
- Instrument recalibration
- Preparation of new standards/blanks
- Re-extraction/digestion

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- Dilution
- Application of another analysis method
- Additional training of analysts

The items listed below must be documented for out-of-control incidents. Out-of-control incidents do not include routine laboratory corrective action performed within method holding times. Documentation is only be required if data are potentially compromised in the final report issued by the laboratory. These items will constitute a corrective action report, and will be signed by the laboratory director and the laboratory QA contact:

- Where the out-of-control incident occurred
- When the incident occurred and was corrected
- Who discovered the out-of-control incident
- Who verified the incident and what the problem was
- What the corrective action was and who corrected the problem

B5 Quality Control

B5.1 Analytical Sample Quality Control

Sections B5.1.1 through B5.1.3 describe the type and frequency of QC samples that will be collected and analyzed. QC samples will be employed to assess various data quality parameters such as representativeness of the environmental samples, the precision of sample collection and handling procedures, the thoroughness of the field equipment decontamination procedures, and the accuracy of laboratory analysis.

In addition to the control samples identified below, the analytical laboratory will use a series of QC samples as identified in the laboratory QM and specified in the standard analytical methods. The types of samples are method blank, laboratory control standard, matrix spike, and laboratory duplicate or matrix spike duplicate. Analyses of QC samples will be performed for samples of similar matrix type and concentration and for each sample batch.

The quantities and types of field and laboratory control samples (LCSs) to be used for each data collection activity are presented in Table 9 and further described below. Tables 4 through 6 provide the acceptance criteria for LCSs, MS/MSD samples, laboratory duplicates, and field duplicates. Data will be evaluated as specified in Section D2.

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B5.1.1 Equipment Blanks

If non-disposable sampling equipment is used, equipment rinsate blanks will be collected and analyzed for metals to assess potential contamination from sampling equipment. Equipment rinsate samples will be collected at a frequency of one rinsate for every 20 environmental samples, or one per day, whichever is greater. Equipment rinsate water will be collected immediately after following the final decontamination of the non-disposable sampling equipment is completed. The equipment blanks will be handled and analyzed in the same manner as all environmental samples. Equipment rinsate blanks will be prepared from laboratory-grade deionized water.

Due to the nature of the contaminants at OU2 and OU3, ambient and trip blanks will not be collected.

B5.1.2 Field Duplicates

Field duplicates will be collected at a rate of five percent of the sample load (one for every 20 environmental samples) or one per day, whichever is greater, for each sample type. Field duplicates will be submitted "blind" to the sample laboratory, i.e., they will be given a unique sample ID from the parent sample and not identified as duplicates on the chain-of-custody form. Field duplicates will be run for the same analytical suite as the parent samples. All field duplicates will be collected simultaneously with collection of the parent sample.

B5.1.3 Matrix Spike / Matrix Spike Duplicates

Samples for preparation of matrix spikes and laboratory duplicates will be selected at random by the laboratory. Separate samples do not need to be collected in the field. The laboratory will perform and report all analyses under QA/QC procedures that include the results of method blanks, laboratory control samples, matrix spikes, and laboratory duplicates. Additional method-specific quality control procedures such as interference check samples, serial dilution, and internal standards will be used as specified for each analytical method. Field personnel will be responsible for completely filling laboratory provided sample containers to ensure that the laboratory receives sufficient sample volume to perform the required laboratory QC analyses.

B5.2 Field Quality Control

RMC sampling personnel ensures the production of quality field data through the use of overall quality assurance systems that are supported by documented quality control checks. These checks include instrument calibration standards and equipment blanks.

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B5.3 Split Samples Collected by EPA

EPA requires 10% agency splits to be collected and analyzed by a secondary laboratory. At the direction of EPA, the field team will collect and bottle these samples concurrently with or immediately after collection of the primary sample and in exactly the same manner as all primary samples in accordance with the appropriate SOP(s). For water samples, the unfiltered sample split will be collected after the unfiltered primary sample, and the filtered split sample will be collected after the filtered primary sample. The samples will be collected under the observation of the EPA (or assigned agency representative), who will take the agency split samples into custody for completion of a chain-of-custody and delivery to the secondary laboratory for the exact analysis (preparation and analysis methods) as the primary samples.

B6 Instrument/Equipment Testing, Inspection, and Maintenance

RMC field personnel will be responsible for equipment testing, inspection and maintenance. All instruments and equipment will be regularly tested, inspected, and maintained according to manufacturer's instructions and prior to field mobilization. Field equipment will be tested and inspected daily before use by the RMC Field Manager or the most senior member of the sampling crew. Any equipment found to be not functioning properly will be repaired in accordance with manufacturer guidelines or replaced. Repaired or replaced equipment will be tested and recalibrated. Spare parts such as batteries will be mobilized to the Site for each sampling event, or obtained from equipment manufacturers as needed. Laboratory equipment will be tested, inspected and maintained in accordance with the laboratory QA/QC manual and manufacturers' recommendations.

B7 Instrument/Equipment Calibration & Frequency

B7.1 Field Instruments

Field equipment to be used during sampling activities include, but are not limited to, field-portable X-ray fluorescence meter (XRF), multiparameter water quality field meters, flow meters, peristaltic pumps, GPS devices and disposable sampling materials (spoons, baggies, tubing, filters). All instruments and equipment will be regularly tested, inspected, and maintained according to manufacturers' instructions. Field equipment will be tested and inspected daily before use. Any equipment found to be not functioning properly will be repaired or replaced. RMC will follow the manufacturer's specifications to calibrate any field equipment prior to each use. These specifications are included in the manufactures manual for each instrument. A record of the calibration will be kept in the field logbook.

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B7.2 Laboratory Equipment

Procedures and schedules for the maintenance and calibration of laboratory equipment are described in the appropriate SW-846 and EPA methods, and in the laboratory's Quality Assurance Plan. These procedures and schedules will be followed for all laboratory work.

B8 Inspection/Acceptance for Supplies and Consumables

Prior to acceptance and use, all supplies and consumables will be inspected to ensure that they are in satisfactory condition and free of defects. RMC field personnel will be responsible for procurement and tracking of supplies and consumables.

B9 Non-Direct Measurements

Non-direct measurement data includes information from site reconnaissance, interviews and resources such as literature searches. The acceptance criteria for such data will include a review by someone other than the data generator. Any measurement data included in information obtained from the above-referenced sources will determine further action at the site only to the extent that those data can be verified.

B10 Data Management

B10.1 Data Flow and Document Control

All data generated during this field investigation will be maintained in the central project files, which will be maintained in the RMC office. All field-generated data such as field forms and logbooks will be reviewed for completeness and legibility prior to incorporation in the central files. If corrections are needed, the document will be returned to the originator for correction. Corrections will be made via a single line strike out labeled with the correcting personnel's initials, the date, and the rationale for the correction, if possible. At minimum, if space is a limitation, the correction will be labeled with the correcting personnel's initials and the date of correction. Information obtained from outside sources will be maintained in the central files only if the information is not publicly available. For instance, documents used as guidance (i.e., EPA QA/R-5) will not be maintained in the central files. Historical information specific to OU2 and OU3 will be maintained in the central files.

Electronic data and electronically generated reports and data interpretations will be stored in the project files on the office network. The network is backed up daily to two onsite locations and weekly to an offsite location to avoid data loss. Sensitive or final electronic documents may be protected to prevent inadvertent changes. Electronic laboratory data will be copied to the office

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network prior to incorporation into any databases in order to maintain an original copy. Pertinent electronic project correspondence will be printed and a hardcopy will be maintained in the central files or saved in the project directory.

Document control includes storage on both onsite computers and offsite backup hard drives. All electronic storage media are kept in secured facilities without public access. RMC's Project Manager will be responsible for data management. RMC will archive and store data for a minimum of five years after completion of the project.

B10.2 Data Reduction

This section outlines the methodology for assuring the correctness of the data reduction process. The procedures describe steps for verifying the accuracy of data reduction. Data will be reduced either manually on calculation sheets or by computer on formatted printouts. The following responsibilities will be delegated in the data reduction process:

- Technical personnel will document and review their own work and are accountable for its correctness. The RMC FM will review field notes, forms, sample containers, COCs and shipping labels on a daily basis as an additional QA check.
- Periodic checks of field and lab data will be made by the QAO, and the QAO will review final submittals.
- Major calculations will receive both a method and an arithmetic check by an independent checker, and will be documented. The checker will be accountable for the correctness of the checking process.
- Detail-checks scheduled by the RMC PM and RMC QAO will be conducted and documented to ensure completeness and correctness of information and data use.
- The RMC PM and RMC QAO will be responsible for assuring that data reduction is performed in a manner that produces quality data through review and approval of calculations.
- As data are reduced, care must be taken so that critical data are not lost.

B10.2.1 Hand Calculations

All hand calculations will be recorded on calculation sheets and will be legible and in logical progression with sufficient descriptions. Major calculations will be checked and documented by an engineer or scientist of professional level equal to or higher than that of the originator. After ensuring mistakes have been corrected, the checker will sign and date the calculation sheet immediately below the originator. Both the originator and checker are responsible for the

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correctness of calculations. The following information will be recorded for each calculation or a series of calculations, as applicable:

- Project title and brief description of the task
- Task number, date performed, and signature of person who performed the calculation
- Basis for calculation
- Assumptions made or inherent in the calculation
- Complete reference for each source of input data
- Methods used for calculations
- Results of calculations, clearly annotated
- Problem statement
- Input data needs to be clearly identified
- Variables must be listed

B10.2.2 Computer Analysis

Computer analyses may include the use of models and programs. Both systematic and random error analyses will be investigated and appropriate corrective action measures taken. The RMC PM will evaluate, determine applicability, and document the use of automated data reduction techniques if needed on the project.

For in-house developed models and programs, documentation will be reviewed by the RMC PM prior to use. This documentation will be prepared in accordance with computer program verification procedures and will contain at a minimum:

- Description of methodology, engineering basis, and major mathematical operations.
- Flow chart presenting the organization of the model (or program).
- Test case(s), sufficiently comprehensive to test all model (or program) operations.

QC procedures for checking models (or programs) will involve reviewing the documentation, running the test case, manually checking selected mathematical operations, and documenting the computer program QC check. Each computer run will have a unique number, date, and time associated with it appearing on the printout.

B10.2.3 Project Database

Analytical data will be incorporated into the project database for ease of reporting, sorting, and analyzing. An unchanged copy of the electronic data deliverable received from the laboratory will be maintained. After incorporation into the database, the data will be verified for accuracy.

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A 5% transcription check will be made of the EDD compared to the final laboratory analytical report. Corrections will be made to both the electronic database and laboratory analytical report and documented on the laboratory report as needed. Reports and analyses of the data results will be completed from the information in the database as necessary.

C ASSESSMENT AND OVERSIGHT

C1 Assessments and Response Actions

Audits may be conducted as a principal means to determine compliance with this QAPP. This approach will be used to review the actual performance of the project during its course and throughout all operations and levels of management. Specifically, audits may be conducted for both field and laboratory operations to assess the accuracy of the measurement systems and to determine the effectiveness of QC procedures. Several factors will be taken into consideration for determining the scope and frequency for audits as follows:

- Complexity of the project
- Duration and scope of project or task
- Degree of QC specified
- Criteria to achieve DQOs
- Requirements for deliverables
- Participation of subcontractors
- Criticality of data collection
- Potential for or frequency of nonconformances

The RMC QAO will have primary responsibility for performing audits, and the authority to delegate certain audit functions, as necessary. The RMC QAO or designee will be familiar with the technical and procedural requirements of both the field and laboratory operations, and the associated QA plans. Whenever possible, auditors will not be directly involved with the actual tasks themselves, so as not to introduce bias in the auditing process.

The auditing process includes identifying an auditor, audit notification, audit report, identification of nonconformances, establishing corrective actions, and audit completion notification. In circumstances where corrective actions have not been completed as planned or scheduled, the auditing process provides for management intervention to resolve problems and for issuance of stop work orders, if necessary.

An adequate level of auditing should be performed on individual projects. The various types of audits that may be conducted during the project are described in the following sections.

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C1.1 Performance Audit

A performance audit may be used by the RMC QAO to determine the status and effectiveness of both field and laboratory measurement systems if the RMC QAO has reason to suspect that the effectiveness of field and/or laboratory measurement systems is deficient. An independent check is made to obtain a quantitative measure of the quality of data generated. For laboratories, this involves the use of standard reference samples or performance evaluation samples. These samples have known concentrations of constituents that are analyzed as unknowns in the laboratory. Results of the laboratory analysis are calculated for accuracy against the known concentrations and evaluated in relation to the DQOs. Field performance is evaluated using equipment blanks and field duplicate samples as described in Section B5.1. For both laboratory and field performance, the number of and type of control samples are presented in Table 9. In both instances, the performance audit is conducted following laboratory analysis of the control samples.

C1.2 Data Quality Audit

A data quality audit is conducted to assess the effectiveness and documentation of the data collection and generation processes. This includes checking sample containers, chain-of-custodies, field notes, shipping labels and custody labels by the RMC FM or designee. Data quality audits will be conducted following laboratory analysis of the appropriate control samples described in Section B5.1. Data quality audits may be completed as stand-alone project documentation or as subsections of larger reports.

C1.3 Technical Systems Audit

A technical systems audit is used to confirm the adequacy of the data collection (field operation) and data generation (laboratory operation) systems. This is an on-site audit that is conducted to determine whether the QA plans are properly implemented. A technical systems audit may consist of:

- A systems audit of field procedures assesses and documents, at a minimum, sampling methods (including sample collection, containers and preservation), equipment decontamination, chain of custody, sample tracking and shipment documentation, sample labeling, methodology, pre-field activities, equipment maintenance and calibration, post-field activities, sampling documentation and other field activity logs, field team debriefing, and equipment check-in and re-calibration).
- A systems audit of laboratory procedures assesses and documents, at a minimum, methods for: data qualification, analytical data generation, COC documentation and protocol, instrument calibration, data reporting, and QC methods.

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Technical systems audits will be performed on an as-needed basis as determined by the RMC QAO.

C1.4 Management Systems Audit

A management systems audit is used to evaluate the ability of the project management team to meet specified data collection and DQOs. This type of audit will not be scheduled for this project. However, if substantial nonconformances are identified by the RMC QAO from the other scheduled audits, or if programmatic concern exists for the quality of data and related documentation, then this form of auditing will be employed.

C1.5 Corrective Action

Provisions for establishing and maintaining QA reporting to the appropriate management authority will be instituted to ensure that early and effective corrective action can be taken when data quality falls outside of established DQOs (acceptance criteria). In this context, corrective action involves the following steps:

- Discovery of a nonconformance
- Identification of the root cause
- Plan and schedule of corrective action
- Review of the corrective action taken
- Confirm that the desired results were produced

It is the intent of the QA process to minimize corrective actions through the development and implementation of effective internal controls. To accomplish this, procedures will be implemented as described in this section to activate a corrective action for each measurement system when QA/QC or FSP procedures are not followed and DQOs may not be achieved. In addition, reviews and audits will be conducted on a periodic basis to check this. Results of QA reviews and audits typically identify the requirement for corrective action. When this occurs, a corrective action plan will be prepared to include identification of the corrective action, organizational level responsible for the action taken, steps to be taken for correction, and approval for the corrective action.

Activities subject to QA/QC will be evaluated for compliance with applicable procedures. This includes both field and laboratory operations as described in the QAPP. A lack of compliance with these procedures will constitute a nonconformance. The RMC QAO or any project member who discovers or suspects a nonconformance is responsible for initiating a nonconformance

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report. The RMC PM will ensure that no additional work, which is dependent on the nonconforming activity, is performed until a confirmed nonconformance is corrected.

The RMC QAO will be responsible for reviewing all audit and nonconformance reports to determine areas of poor quality or failure to adhere to established procedures. Nonconformances will be reported by the RMC QAO to the RMC PM. The RMC PM will be responsible for evaluating all reported nonconformances, conferring with the RMC QAO on the steps to be taken for correction, and executing the corrective action as developed and scheduled. Corrective action measures will be selected to prevent or reduce the likelihood of future nonconformances and address the causes to the extent identifiable. Selected measures will be appropriate to the seriousness of the nonconformance and realistic in terms of the resources required for implementation.

Upon completion of the corrective action, the RMC QAO will evaluate the adequacy and completeness of the action taken. If the action is found inadequate, the RMC QAO and RMC PM will confer to resolve the problem and determine any further actions. Implementation of any further action will be scheduled by the RMC PM. The RMC QAO will issue a stop work notice in cases where significant problems continue or corrective action was not completed as planned. The United Park PM, EPA RPM, and RMC PM will be notified in a timely manner prior to project completion. If the corrective action is found to be adequate, the RMC PM will notify the United Park PM of the satisfactory corrective action and the completion of the audit. Audit files will remain open until compliance is demonstrated.

A report format for documenting a nonconformance and scheduling a corresponding corrective action are described below. This procedure follows the established guidelines for corrective actions.

C1.6 Field Changes

The RMC PM is responsible for all OU2 and OU2 EE/CA sampling activities. In this role, the RMC PM at times is required to adjust the field program to accommodate site-specific needs. When it becomes necessary to modify a program, the RMC FM notifies the RMC PM of the anticipated change, and documents and implements the necessary changes. The United Park PM and EPA RPM will be notified in advance of implementation if the change is determined to be a significant one. Significant field changes may include deleting a sampling location or using different sampling devices.

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C1.7 Laboratory Data

The laboratory will report the types of out-of-control occurrences, how these occurrences are documented, and who is responsible for correction and documentation. Generally, corrective action will be required in response to out-of-control events such as poor analysis replication, poor recovery, instrument calibration problems, blank contamination, etc. Corrective action will be taken at any time during the analytical process when deemed necessary based on analytical judgment or when QC data indicate a need for action. Corrective actions may include, but are not limited to:

- Re-analysis
- Calculation checks
- Instrument recalibration
- Preparation of new standards/blanks
- Re-extraction/digestion
- Dilution
- Application of another analysis method
- Additional training of analysts

The items listed below must be documented for out-of-control incidents. Out-of-control incidents do not include routine laboratory corrective action performed within method holding times. Documentation is only be required if data are potentially compromised in the final report issued by the laboratory. These items will constitute a corrective action report, and will be signed by the laboratory director and the laboratory QA contact:

- Where the out-of-control incident occurred
- When the incident occurred and was corrected
- Who discovered the out-of-control incident
- Who verified the incident
- What the problem was
- What the corrective action was
- Who corrected the problem

C2 Reports to Management

As required, internal QA assessments will be completed as stand-alone project documentation or as subsections of larger reports. The QA assessments will describe the status and results of the QA process. The types of QA assessments that will be prepared are as follows:

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An assessment of data quality will document the overall quality of data in terms of the established DQOs and the effectiveness of the data collection and generation processes. The data assessment parameters calculated from the results of the laboratory analyses will be reviewed to ensure that all data used in evaluations are scientifically valid, of known and documented quality, and legally defensible, where appropriate.

- Audit and corrective action reports will be prepared as applicable and will summarize the findings or observations resulting from audits and describe how recurrence of any nonconformances will be prevented. The report will discuss the problems identified, solutions implemented, and any trends discovered. A summary of all audits conducted, nonconformances identified, and corrective actions taken will also be presented.
- A report of laboratory data will present a summary of the laboratory results and performance based on the data validation process.
- QA/QC reviews on project deliverables will provide QA during the various phases of report generation. During the course of the project, coordinated reviews of subcontractor deliverables, detail-checks of RMC generated materials, and calculation checks will be conducted, as appropriate.

The occurrence and resolution of major QA issues identified during QA assessments will be documented in memorandum to appropriate United Park, EPA, RMC, UDERR and USFWS Project Managers. Routine evaluations of data quality described throughout this QAPP will be documented and filed in the project files.

C3 Reports to EPA

Reports required to be submitted to EPA are described in the Settlement Agreement. An analytical data validation report will be included with each data submission.

D DATA VALIDATION AND USABILITY

D1 Data Review, Verification, and Validation

Data validation is defined as the evaluation of the technical usability of the data. Data verification is defined as the determination of adherence to SOPs, the SAP, and the laboratory QMs. Data review and validation will be performed as presented below. Verification is accomplished through laboratory audits and review of QC data. Data validation and verification requirements are further defined in Table 10.

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D1.1 Laboratory Data Review and Verification

Data verification takes place on two levels. The first level of review occurs "at the bench." Analysts are charged with the responsibility of monitoring all laboratory QA/QC activities, and verifying that systems are in control. Data verification also occurs on a sample-by-sample basis. The initial review is performed by the instrument operator or analyst who is responsible for assessing the following:

- Cross-checking all sample identification numbers on work sheets, extract vials/digestate bottles, and instrument outputs.
- Verification that QA acceptance criteria are met.
- Verification that all calibration, tuning, linearity, and retention time drift checks are within QA acceptance criteria.
- Determination that peak chromatography and other instrument performance characteristics are acceptable.
- Confirmation that chain-of-custody is intact based on accompanying paperwork.
- Verification of all preparative and analytical procedures was conducted within method suggested holding times.

The area supervisor and/or technical supervisor perform the second level of validation and review. The analyst, technical reviewer, and the laboratory Project Manager are responsible for the QC and data review of analyses and reports. The QC review of QC analyses and applicable calibrations is completed and includes the following:

- Confirmation that all quality control blanks meet QA requirements for contamination, and that associated sample data are appropriately qualified when necessary.
- Calculation of matrix spike recoveries and duplicate RPDs, and confirmation that accuracy and precision QA criteria are met.
- Comparison of all injections of a sample and comparison of matrix spikes with the original unspiked sample for acceptable replication.

After QC review, the data are sent to report preparation. The final report review includes both data review and a review of report accuracy. The data review includes confirmation of all assessments previously made by the operator/analyst, and includes an evaluation of the following:

- Qualitative identification of all target analytes using specific SOP interpretation criteria.
- Confirmation of matrix spike recoveries and duplicate RPDs, and confirmation that accuracy and precision QC criterion are met.
- Comparison of all injections of a sample and comparison of matrix spikes with the original unspiked sample for acceptable replication.

Data generated by the analyst is reviewed by a technical reviewer for data completeness and accuracy. The laboratory Project Manager generates a final report and reviews as summarized below.

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The final report review will assess the complete data report for completeness, accuracy of reported hits, comparison to target analyte lists, and comparison with project QC requirements. Before the report is sent to United Park and RMC, it is reviewed by the laboratory Project Manager. This additional assessment includes the following:

- Making a comparative evaluation of data from individual fractions of a sample, and of samples from the same sample location, project, or case, for consistency of analytical results and resolution of discrepancies.
- Checking data report for completeness.
- Verifying QAPP specific requests have been met.

D1.2 Field Data Review and Verification

After technical field staff verifies their documentation for accuracy and completeness, field data is reviewed by the RMC PM. The RMC PM or designee will additionally check for completeness, representativeness and any transcription errors. If any errors are detected, the sampling personnel will be contacted and corrective action will be initiated. Protocols for correcting manual records are described in Section C1.5. Electronic transcription error corrections will be documented in memoranda to the RMC PM and RMC QAO.

D1.3 RMC Data Review and Verification

All data will be reviewed based on procedures described in *Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review* (EPA, 2010). Data validation procedures will use the method-specific QC acceptance limits specified in the USEPA SW-846 methods and SOPs.

The specific requirements which will be checked during data validation are:

1. Holding times
2. Method blank data
3. Laboratory control sample data
4. Matrix spike data
5. Duplicate analyses data
6. Overall data assessment

Upon completing the validation procedures, a data quality assurance review report will be compiled and submitted.

D2 Verification and Validation Methods

Data validation methods to be used are based on the document *Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review* (EPA, 2010).

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A brief overview of procedures for evaluating and reviewing the data are included below:

Holding Times: Compare the time and date the sample was collected (on the chain-of-custody) to the date analyzed in the laboratory data package. Verify the dates are within the SW-846 recommended holding times for the particular method. Holding times for project-specific analytes are presented in Table 8.

Method Blank Data: Verify through the method blank sample data results that no significant laboratory contamination issues exist.

Laboratory Control Sample Data: Verify the percent recovery of the spiked compounds is within acceptable laboratory criteria.

Matrix Spike Data: Verify the percent recovery of the spiked compounds is within acceptable laboratory criteria.

Duplicate Analysis Data: Calculate the relative percent difference for all detections of target compounds above the laboratory detection limits, and compare them to the acceptance criteria.

Overall Data Assessment: Examine the data package as a whole and compare it to (1) the chain-of-custody to verify completeness, (2) the historical data to verify representativeness (3) the other OU2 and OU3 data to verify comparability is being achieved.

Qualification of the data may result if the evaluation criteria for data validation are not met. All data qualification will be presented on the tabulated form of the data, and in the QA review sections of all OU2 and OU3 reports.

D3 Reconciliation with User Requirements

The data quality assessment process will involve multiple steps depending on the results of the data validation process. Data that has been qualified (by the laboratory or by the RMC QAO) will be assessed for the particular circumstances surrounding the sample. For example, if multiple compounds are detected in a method blank or rinsate blank sample and in the associated samples at comparable levels, the data result will likely be treated as a false positive; however, if the sample location is critical (i.e., compliance boundary), the data may be treated as non-false positive or rejected and resampled. This also applies to qualifications based on failure to meet matrix spike/matrix spike duplicate criteria if the sample or contaminant affected is critical to the project decision-making, in which case corrective actions may result. Corrective actions may include resampling and/or reanalysis of the sample. Detection limits may be elevated above appropriate criteria due to dilutions or matrix interferences. In this case, the necessity of the data will be evaluated as with the previous examples and potential corrective actions may include (a)

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reporting the data result as equal to the method detection limits and using the qualified data, or (b) resampling of critical samples.

Additional factors that may be considered when evaluating the data include:

- Data time-series or historical trends.
- Spatial distributions of results such as similar and dissimilar results from adjacent sample locations.
- Outlier analysis (when statistical sampling protocols are used).
- Statistical interpretation of large data sets (sample sizes) when statistical sampling protocols are used.
- The relationship of detected results to known site history information.
- The relationship of detected results to site conditions such as geologic stratigraphy, historic site development, and proximity to neighboring contamination sources.
- The relationship of detected results to other transient site conditions.

The results will be compared to the project quality assurance objectives (Tables 4 through 6) and DQOs (QAPP Table 2, FSP Tables 2-2 and 2-3).

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Table 1
Project-Specific Analytes and Methods
Richardson Flat OU2 and OU3
Quality Assurance Project Plan

Media	Analysis	Analytical Method/SOP
SURFACE WATER	Field Parameters:	RMC SOP 9
	pH	
	Conductivity	
	Temperature	
	Dissolved Oxygen	
	Oxidation-Reduction Potential	
	Metals (Total and Dissolved):	SW846 6020 or 200.8
	Aluminum	
	Antimony	
	Arsenic	
	Barium	
	Berylilium	
	Cadmium	
	Chromium	
	Cobalt	
	Copper	
	Iron	
	Lead	
	Manganese	
	Nickel	
	Selenium	
	Silver	
	Thallium	
	Vanadium	
	Zinc	
	Mercury	SW846 7470A
	Calcium	SW846 6020
	Magnesium	
	Potassium	
	Sodium	
	Hardness	2340B[2] (calculation)
	Phosphorus	E365.4
	Total Suspended Solids	SM2540D
	Nitrate	E300.0
	Chloride	
	Sulfate	
	Alkalinity	SM2420B
	Total Dissolved Solids	SM2540C
GROUNDWATER	Field Parameters:	RMC SOP 9
	pH	
	Conductivity	
	Temperature	
	Dissolved Oxygen	
	Oxidation-Reduction Potential	
	Metals (Total and Dissolved):	SW846 6020 or 200.8
	Aluminum	
	Antimony	
	Arsenic	
	Barium	
	Berylilium	
	Cadmium	
	Chromium	
	Cobalt	
	Copper	
	Iron	
	Lead	
	Manganese	
	Nickel	
	Selenium	

Table 1
Project-Specific Analytes and Methods
Richardson Flat OU2 and OU3
Quality Assurance Project Plan

	Silver	
	Thallium	
	Vanadium	
	Zinc	
	Mercury	SW846 7470A
	Calcium	SW846 6020
	Magnesium	
	Potassium	
	Sodium	
	Hardness	2340B[2] (calculation)
	Phosphorus	E365.4
	Total Suspended Solids	SM2540D
	Nitrate	E300.0
	Chloride	
	Sulfate	
	Alkalinity	SM2420B
	Total Dissolved Solids	SM2540C
SOIL	Metals (Laboratory):	SW846 6020
	Aluminum	
	Antimony	
	Arsenic	
	Barium	
	Berylilium	
	Cadmium	
	Calcium	
	Chromium	
	Cobalt	
	Copper	
	Iron	
	Lead	
	Magnesium	
	Manganese	
	Nickel	
	Potassium	
	Selenium	
	Silver	
	Sodium	
	Thallium	
	Vanadium	
	Zinc	
	Mercury	SW846 7470A
	Phosphorus	SW846 6010B
	Metals (XRF):	XRF - EPA 6200
	Arsenic	
	Chromium	
	Cobalt	
	Copper	
	Iron	
	Lead	
	Manganese	
	Mercury	
	Nickel	
	Selenium	
	Zinc	
	Metals (Laboratory):	
	Aluminum	
	Antimony	
	Arsenic	
	Barium	
	Berylilium	
	Cadmium	
	Calcium	

Table 1
Project-Specific Analytes and Methods
Richardson Flat OU2 and OU3
Quality Assurance Project Plan

SEDIMENT	Chromium	SW846 6020
	Cobalt	
	Copper	
	Iron	
	Lead	
	Magnesium	
	Manganese	
	Nickel	
	Potassium	
	Selenium	
	Silver	
	Sodium	
	Thallium	
	Vanadium	
	Zinc	
	Mercury	SW846 7470A
	Methylmercury	EPA 1630
	Phosphorus	SW846 6010B
	Metals (XRF):	XRF - EPA 6200
	Arsenic	
	Cobalt	
	Copper	
	Iron	
	Lead	
	Manganese	
	Mercury	
	Nickel	
	Selenium	
	Zinc	
PLANT, MACROINVERTEBRATE, AND FISH TISSUE	Plants - Metals Per Soil or Sediment Lists Above Depending on Collection Location (upland or wetland, respectively) Fish and Macroinvetebrates - Metals Per Sediment List Above	Per Soil and Sediment Lists Above
	Moisture Content	EPA 160.3

Table 3
Screening Values for Heavy Metals Provided by EPA
Richardson Flat OU2 and OU3
Quality Assurance Project Plan

Analyte	Soil Toxicity Benchmarks for Terrestrial Receptors (Plants & Soil Organisms) mg/kg	Bulk Sediment Toxicity Benchmarks for Benthic Macroinvertebrates mg/kg	Surface Water Toxicity Benchmarks for Aquatic Receptors µg/L
Silver	2	1	0.1
Aluminum	50	25519	87
Arsenic	31	9.8	150
Barium	NV	NV	5000
Beryllium	NV	NV	0.66
Calcium	NV	NV	NV
Cadmium	28	1	*
Cobalt	32	NV	23
Chromium	0.4	43	*
Copper	54	32	NV
Iron	200	188400	1,000
Mercury	NV	0.18	*
Methylmercury	NV	NV	NV
Potassium	NV	NV	53000
Magnesium	NV	NV	82000
Manganese	152	631	120
Sodium	NV	NV	680000
Nickel	48	23	*
Lead	210	36	*
Antimony	5	2	30
Selenium	NV	NV	5
Thallium	NV	NV	12
Vanadium	NV	NV	20
Zinc	130	121	*

Notes:

NV — No value provided by EPA

mg/kg — milligrams per kilogram

µg/L — micrograms per liter

* — Hardness dependent citeria. Values will be calculated based on measured site-specific hardness values up to a maximum hardness of 400 mg/L

Table 4
Quality Assurance Objectives for Analytical Soil and Sediment Samples
Richardson Flat OU2 and OU3
Quality Assurance Project Plan

Analysis	Sample Matrix	Reference Methods	Reporting Limits and Units	Precision Objectives		Accuracy Objectives		Completeness
				Field Duplicate Analysis (RPD)	MS/MSD Duplicate Analysis (RPD)	Matrix Spike Analyses (%R)	Laboratory Control Sample Analyses (%R)	
Metals per Table 1-1	Soil and Sediment	SW846 6020	Laboratory RLs[a]	If both results are >5x RL, then, RPD ≤ 35%. If one or both results are <5x RL, then absolute difference ≤ ± 2x greater RL		75% - 125%		90%
Mercury		SW846 7470A						
Methylmercury	Sediment	EPA 1630						
Phosphorus	Soil and Sediment	SW846 6010B						

[a] RLs must be below lowest screening values in Table 3-2.

LCS	laboratory control sample
mg/kg	milligrams per kilogram
MS	matrix spike
MSD	matrix spike duplicate
R	recovery
RL	reporting limit
RPD	relative percent difference
%	percent
<	less than
>	greater than
±	plus or minus
≤	less than or equal to

Table 5
Quality Assurance Objectives for Analytical Water Samples
Richardson Flat OU2 and OU3
Quality Assurance Project Plan

Analysis	Sample Matrix	Reference Methods	Reporting Limits and Units	Precision Objectives		Accuracy Objectives		Completeness
				Field Duplicate Analysis (RPD)	MS/MSD Duplicate Analysis (RPD)	Matrix Spike Analyses (%R)	Laboratory Control Sample Analyses (%R)	
Metals per Table 1-1	Water	SW846 6020 or 200.8	Lowest Method Specific RL Achievable [a]	If both results are >5x RL, then, RPD ≤ 35%. If one or both results are <5x RL, then absolute difference ≤ ± 2x greater RL		75% - 125%		90%
Mercury	Water	SW846 7470A	Lowest Method Specific RL Achievable [a]					90%
Calcium	Water	SW846 6020 or 200.8	Lowest Method Specific RL Achievable [a]					90%
Magnesium								90%
Potassium								90%
Sodium								90%
Hardness	Water	E130.2	10 mg/L	If both results are >5x RL, then, RPD ≤ 35%. If one or both results are <5x RL, then absolute difference ≤ ± 2x greater RL	NA	NA	NA	90%
Total Suspended Solids	Water	SM2540D	5 mg/L		NA	NA	80 - 120%	90%
Phosphorus	Water	E365.4	0.4 mg/L		20%	80 - 120%	80 - 120%	90%
Nitrates	Water	E300.0	0.1 mg/L		20%	80 - 120%	80 - 120%	90%
Chloride								90%
Sulfate								90%
Alkalinity	Water	SM2420B	2 mg/L		20%	80 - 120%	80 - 120%	90%
Total Dissolved Solids	Water	SM2420C	20 mg/L		NA	NA	80 - 120%	90%

[a] RLs must be below the lowest screening values in Table 3-2, specifically cadmium at 0.25 ug/L.

ICP	inductively coupled plasma
LCS	laboratory control sample
mg/kg	milligrams per kilogram
MS	matrix spike
MSD	matrix spike duplicate
NA	not applicable
R	recovery
RL	reporting limit
RPD	relative percent difference
µg/L	micrograms per liter
%	percent
<	less than
>	greater than
±	plus or minus
≤	less than or equal to

Table 6
Quality Assurance Objectives for Analytical Plant, Macroinvertebrate and Fish Tissue Samples
Richardson Flat OU2 and OU3
Quality Assurance Project Plan

Analysis	Sample Matrix	Reference Methods	Reporting Limits and Units	Precision Objectives		Accuracy Objectives		Completeness
				Field Duplicate Analysis (RPD)	MS/MSD Duplicate Analysis (RPD)	Matrix Spike Analyses (%R)	Laboratory Control Sample Analyses (%R)	
Metals per Table 1-1	Biota	SW846 6020	Laboratory RLs	If both results are >5x RL, then, RPD ≤ 35%. If one or both results are <5x RL, then absolute difference ≤ ± 2x greater RL		75% - 125%		90%
Mercury		SW846 7470A						
Methylmercury		EPA 1630						
Moisture Content		EPA 160.3						

LCS	laboratory control sample
mg/kg	milligrams per kilogram
MS	matrix spike
MSD	matrix spike duplicate
R	recovery
RL	reporting limit
RPD	relative percent difference
%	percent
<	less than
>	greater than
±	plus or minus
≤	less than or equal to

TABLE 7
Precison, Accuracy, Representativeness, Comparability and Completeness (PARCC) Criteria
Richardson Flat OU2 and OU3
Quality Assurance Project Plan

Parameter	QC Program	Evaluation Criteria	Acceptance Criteria	Recommended Corrective Actions
Precision	Field Duplicate	Relative Percent Difference (RPD)	RPDs: If both results are >5x RL, then, RPD ≤ 35%. If one or both results are <5x RL, then absolute difference≤ ± 2x greater RL	Verify the RPD calculation. If correct, determine if matrix interference or heterogeneous samples are factors in poor RPD. If matrix effects or heterogeneous samples are not observed, reanalyze the associated investigative samples and MS/MSD. If appropriate, reextract or redigest and reanalyze the associated investigative samples and MS/MSD.
	Matrix Spike/Matrix Spike Duplicate (MS/MSD)	Relative Percent Difference (RPD)	See method-specific control limits[1]	Verify the RPD calculation. If this is correct, determine if matrix interference or heterogeneous samples are factors in poor RPD. If matrix effects or heterogeneous samples are not observed, reanalyze the method duplicate and associated investigative samples.
Accuracy	Matrix Spike (MS)	Percent Recovery	See method-specific control limits[1]	Verify the matrix spike percent recovery calculations and evaluate the LCS percent recovies. If the calculations are correct and the LCS recoveries are acceptable, determine if matrix interference is a factor in the poor recoveries. If matrix effects not observed, reanalyze the MS and associated samples. If appropriate, reextract or redigest and reanalyze the MS and associated investigative samples.
	Matrix Spike Duplicate (MSD)	Percent Recovery	See method-specific control limits[1]	Same as above.
	Laboratory Control Samples (LCS)	Percent Recovery	See method-specific control limits[1]	Verify the percent recovery calculations. Evaluate the standard to determine if it is faulty. If it is, prepare a new standard and reanalyze the LCS and associated investigative samples. If necessary, recalibrate the instrument. Do not continue analysis until problem solved.
Representativeness	Holding Times	Representative of Environmental Conditions	Holding Times Met 100 Percent	Evaluate whether data is critical to decision making. If so, resample and reanalyze for parameter exceeding holding time.
	Method Blanks	Qualitative Degree of Confidence	See method specific requirements[1]	Evaluate instrument, locate source of contamination, perform system blanks to confirm that system blanks meet performance criteria. Re-analyze method blank and associated samples. If method blank still above acceptance criteria, reextract or redigest the method blank and all associated samples.
	Equipment/Rinsate Blanks	Qualitative Degree of Confidence	Target analytes <1 X LRL; 5-10 X LRL for laboratory-inducted contaminants.	Suggests field sampling-induced contamination may have occurred. Evaluate all associated QC samples. If all other QC samples are within prescribed acceptance limits, but equipment blank is not (e.g., positive identification of target analytes observed), contact USEPA immediately to determine if resampling and/or reanalysis required.
	Field Duplicates	Qualitative Degree of Confidence	90 Percent of Field Duplicates Meet RPD Goals	If acceptance criteria not met, evaluate reasons for not meeting criteria (I.e., matrix interferences or heterogeneous samples) and make recommendations on whether resampling and/or reanalysis is necessary to improve degree of confidence.
Comparability	Standard Units of Measure	Qualitative Degree of Confidence	Laboratory Methods Followed	Revise analytical reports with correct units.
	Standard Analytical Methods		SOPs Followed	If SOPs not followed, evaluate whether reanalysis is necessary to obtain reliable data.
Competeness	Complete Sampling	100 Percent Valid[2] Samples	90 Percent Valid[2] Data	If not enough samples were collected for project needs, collect and analyze additional samples for parameters needed for key decisions.

[1] Laboratory Control limits are specific to individual analytical/digestion methods and any deviation outside control limits are reported (see method-specific SOPs in Attachment A).
[2] Valid means that samples meet all evaluation criteria (i.e., are not rejected for any reason).

Precision is a measure of how repeatable data are and is often measured by sample duplicates.
Accuracy is a measure of how close the data are to the actual, or real value, measured by certified reference materials and matrix spikes.
Representativeness is a measure of how representative a sample is of the sample population and is achieved by accurate sampling procedures and appropriate sample homogenization.
Comparability looks at ongoing projects and how variable one set of data is relative to another. Comparability helps to measure the scientific consistency of the system to past work.
Completeness is a measure of how many data points collected are usable; 90% usable data is considered to be an acceptable value for completeness.

Table 8
Analytical Method, Holding Times, Preservation and Turnaround Times
Richardson Flat OU2 and OU3
Quality Assurance Project Plan

Analysis	Reference Methods	Container	Preservative	Holding Time	Turnaround Time
Soil Samples					
Metals per Table 1-1	SW846 6020	Glass Jar (4 oz.)	None	180 days	10 business days
Phosphorus					
Mercury	SW846 7470A			28 days	
Sediment Samples					
Metals per Table 1-1	SW846 6020	Glass Jar (4 oz.)	None	180 days	10 business days
Phosphorus					
Mercury	SW846 7470A			28 days	
Methylmercury	EPA 1630				
Surface Water and Groundwater					
Metals per Table 1-1	SW846 6020 or 200.8	Bottle 1,2	HNO_3	180 days	10 business days
Calcium Magnesium Potassium Sodium	SW846 6020			180 days	
Mercury	SW846 7470A			28 days	
Hardness	2340B3 (calculation)	N/A	N/A	N/A	
Phosphorous	E365.4	Bottle 3	HNO_3	28 days	
Total Suspended Solids	SM2540D	Bottle 4	None	7 days	
Nitrates	E300.0	Bottle 4	None	2 days	
Chloride Sulfate				28 days	
Alkalinity	SM2420B			14 days	
Total Dissolved Solids	SM2540C			7 days	
Field Parameters					
Conductivity	RMC SOP 9	Instream, Flow cell or Polyethylene Bottle	None	1 day	Analyze Immediately
pH					
Temperature					
Dissolved Oxygen					
Oxidation Reduction Potential					
Plant, Macroinvertebrate and Fish Tissue Samples					
Metals per Table 1-1	SW846 6020	Glass Jar (4 oz.) or Polyethylene bag (Ziploc® or equivalent)	None	180 days	TBD
Mercury	SW846 7470A			28 days	
Methylmercury	EPA 1630				
Moisture Content	EPA 160.3				

Bottle 1 - 500 ml bottle filtered to 0.45µm and preserved with HNO3
Bottle 2 - 500 ml bottle unfiltered and preserved with HNO3
Bottle 3 - 250 ml bottle unfiltered and preserved with HNO3
Bottle 4 - 1000 ml bottle unfiltered and unpreserved

Table 9
Quality Control Sample Quantities
Richardson Flat OU2 and OU3
Quality Assurance Project Plan

Analysis	Laboratory QA/QC			Field QA/QC [a]	
	Method Blank	LCS	MS/MSD or Lab Duplicate or LCSD	Field Duplicates	Equipment Blanks [b]
Metals per Table 1-1	1 per analytical batch, minimum of 1 per 20 samples	1 per analytical batch, minimum of 1 per 20 samples	1 per analytical batch, minimum of 1 per 20 samples	1 per 20 samples collected	1 per 20 samples collected with non-disposable equipment
Mercury	1 per analytical batch, minimum of 1 per 20 samples	1 per analytical batch, minimum of 1 per 20 samples	1 per analytical batch, minimum of 1 per 20 samples	1 per 20 samples collected	1 per 20 samples collected with non-disposable equipment
Methylmercury	1 per analytical batch, minimum of 1 per 20 samples	1 per analytical batch, minimum of 1 per 20 samples	1 per analytical batch, minimum of 1 per 20 samples	1 per 20 samples collected	1 per 20 samples collected with non-disposable equipment
Hardness	1 per analytical batch, minimum of 1 per 20 samples	NA	NA	1 per 20 samples collected	1 per 20 samples collected with non-disposable equipment
Total Suspended Solids	1 per analytical batch, minimum of 1 per 20 samples	1 per analytical batch, minimum of 1 per 20 samples	1 per analytical batch, minimum of 1 per 20 samples	1 per 20 samples collected	1 per 20 samples collected with non-disposable equipment
Phosphorous, Nitrates, Chloride, Sulfate	1 per analytical batch, minimum of 1 per 20 samples	1 per analytical batch, minimum of 1 per 20 samples	1 per analytical batch, minimum of 1 per 20 samples	1 per 20 samples collected	1 per 20 samples collected with non-disposable equipment
Alkalinity	1 per analytical batch, minimum of 1 per 20 samples	1 per analytical batch, minimum of 1 per 20 samples	1 per analytical batch, minimum of 1 per 20 samples	1 per 20 samples collected	1 per 20 samples collected with non-disposable equipment
Total Dissolved Solids	1 per analytical batch, minimum of 1 per 20 samples	1 per analytical batch, minimum of 1 per 20 samples	1 per analytical batch, minimum of 1 per 20 samples	1 per 20 samples collected	1 per 20 samples collected with non-disposable equipment

[a] Collect at frequency shown, or one per day, whichever is greater.

[b] Not required if dedicated equipment is used.

LCS	laboratory control sample
LCSD	laboratory control sample duplicate
MS	matrix spike
MSD	matrix spike duplicate
NA	not applicable
QA/QC	quality assurance/quality control

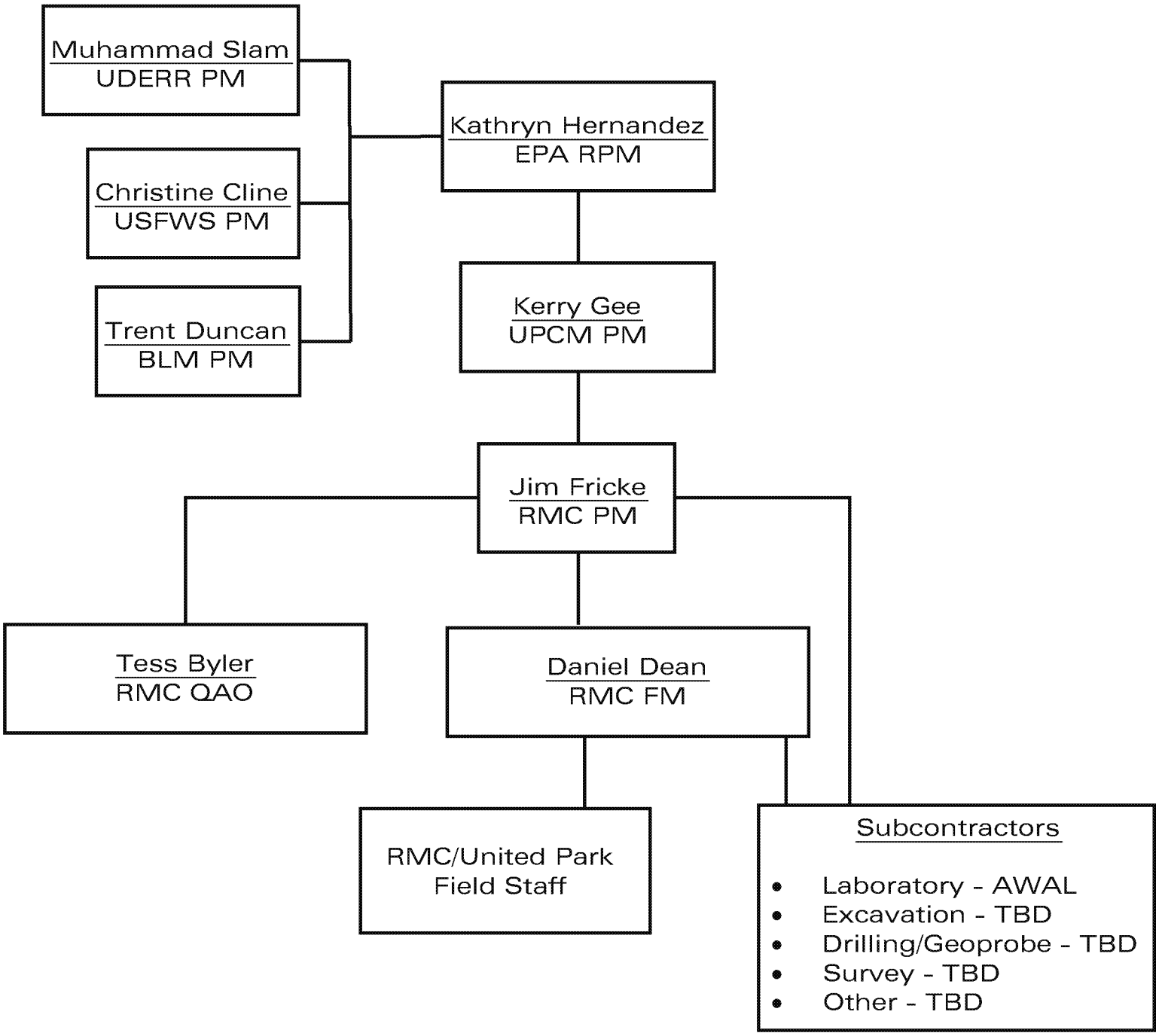
TABLE 10
Data Validation and Verification Requirements
Richardson Flat OU2 and OU3
Quality Assurance Project Plan

Data Validation and Verification Steps		Data Validation and Verification Methods
Samples were collected according to established locations and frequencies.	→	Comparison with Sampling Plan
Sample collection and handling followed established procedures.	→	Review of field notes, field procedures and COCs
Appropriate analytical methods were used; internal laboratory calibration checks were performed according to the method-specified protocol.	→	Review of analytical methods and case narratives provided with laboratory reports. Documentation of any communications with laboratory concerning problems or corrective actions.
Required holding times and laboratory reporting limits were met.	→	Comparison with established holding times and LRLs.
Field Duplicates for QA/AC	→	Field duplicates met acceptance criteria tabulation of RPDs and comparison with PARCC parameters
Acceptance criteria (see Table 8.0) for field and laboratory QC samples (field blanks, field dups, equipment/rinsate blanks, method blanks, LCS) were met.	→	Tabulation of RPDs and spike recoveries, and direct comparison with method-specific acceptance criteria (see SOPs in Appendix A). Comparison with PARCC parameters.
Appropriate steps were taken to ensure the accuracy of data reduction, including reducing data transfer errors in the preparation of summary data tables and maps.	→	Maintain permanent file for laboratory hardcopies of analysis reports. Minimize retyping of data and error check data entered into database, tables, maps, etc.

RPD = Relative Percent Difference
LRL = Laboratory Reporting Limit

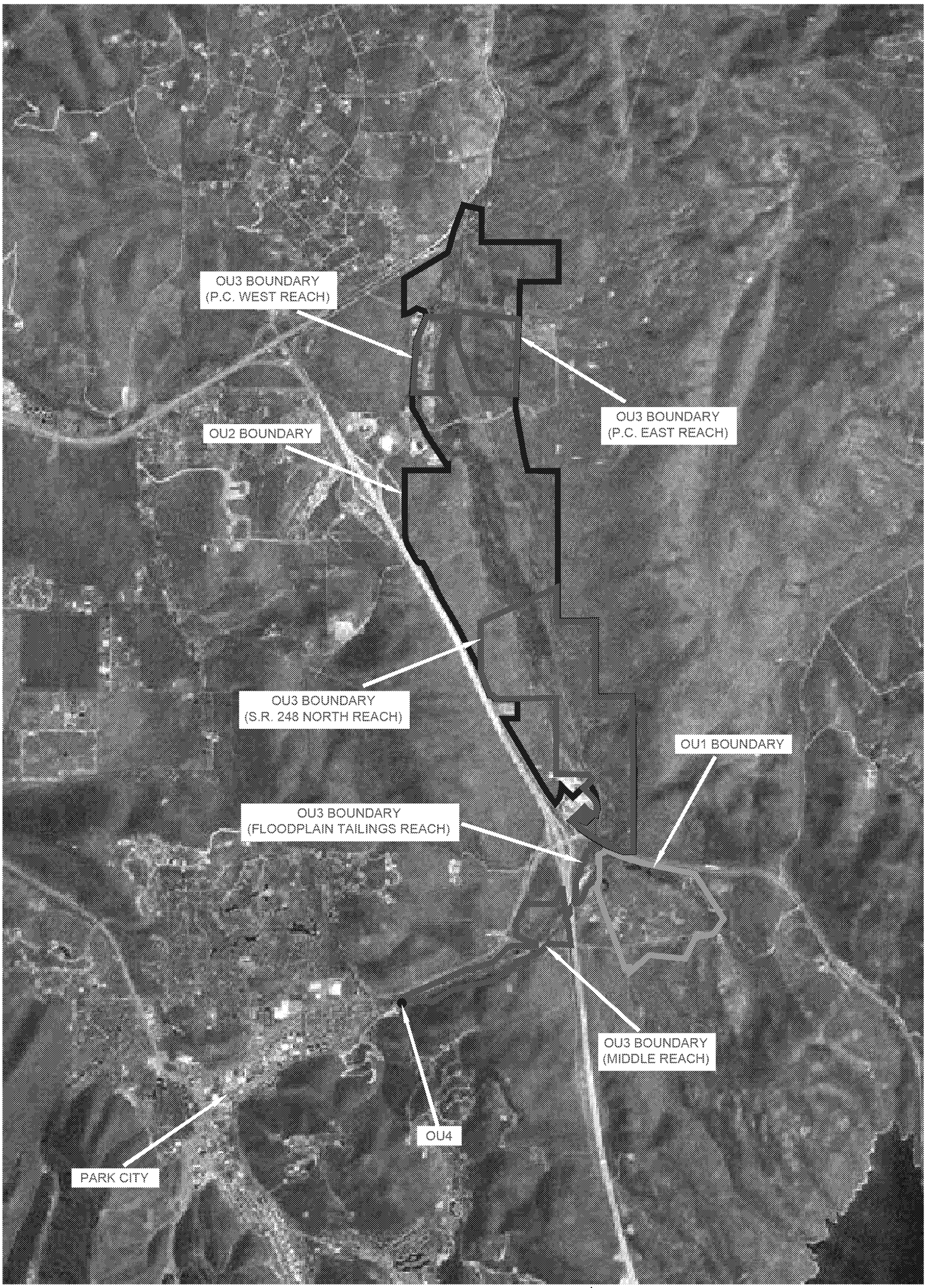
Figure 1

Project Personnel and Organization



Notes

AWAL - American West Analytical Laboratories
BLM - United States Bureau of Land Management
EPA - United States Environmental Protection Agency
FM - Field Manager
PM - Project Manager
QAO - Quality Assurance Official
RPM - Remedial Project Manager
TBD - To Be Determined
UDERR - Utah Department of Environmental Quality, Division of Environmental Response and Remediation
USFWS - United States Fish and Wildlife Service



SCALE
0 0.5 1.0
MILES

N

NOTES:
BOUNDARIES APPROXIMATE, NOT SURVEYED.
IMAGE SOURCE – ESRI MAP SERVER.

UNITED PARK CITY MINES

FIGURE 2
SITE MAP

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2825

MARCH 2014

site map.dwg

APPENDIX A

LABORATORY QUALITY MANUAL

QUALITY MANUAL

American West Analytical Laboratories

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1.0 Presentation Page

1.1 The presentation Page is in page 1 of this Manual.

2.0 Signature Page

2.1 The Signature Page is in page 2 of this Manual.

3.0 Introduction and Scope

3.1 Scope of Testing.

The laboratory scope of analytical testing services includes those listed in table 6.3.5 Technical Methods/SOPs.

3.2 Table of Contents, References and Appendices.

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3.3 Glossary of Acronyms and Terms Used

ACS	American Chemical Society
A.J.	Amber Jar
A2LA	American Association for Laboratory Accreditation.
APHA	American Public Health Association (APHA) Standard Methods.
AIHA	American Industrial Hygiene Association.
Accuracy	The degree of agreement between an observed value and an accepted reference value and is determined by evaluating a sample with a known value.
Analytical Uncertainty	A subset of Measurement Uncertainty that includes all laboratory activities performed as part of the analysis.
AOX	Absorbable Organic Halides.
ASE	Accelerated Solvent Extractor.
ASTM	American Society for Testing and Materials or ASTM International.
AWAL	American West Analytical Laboratories.
Assessment	The physical process of inspecting, testing and documenting results from a laboratory for purposes of certification.
Batch	A group of analytical samples of the same matrix processed together including preparation, with the same method and personnel, using the same lots of reagents. A batch is composed of a MB, LCS, MS, MSD and no more than 20 samples. If the batch needs a preparation step, extraction, digestion or distillation, a sample may be added to an existing batch until midnight of that day.
Bias	The systematic or persistent distortion of a measurement process, which causes errors in one direction (i.e., the expected sample measurement is different from the sample's true value.
Blind audits	A series of proficiency testing samples submitted to an applicant or certified laboratory in a manner that the laboratory is unaware that analyses is being performed on a proficiency testing challenge.
BOD	Biochemical Oxygen Demand.
Calibration Standard	A solution prepared from the primary dilution standard solution or stock standard solutions and the internal standards and surrogate analytes.
CAR	Corrective Action Report. A procedure that is used to correct an out of control operation or process.
CBOD	Carbonaceous Biochemical Oxygen Demand.
CCB	Continuing Calibration Blank. QC sample that contains deionized water and is prepared the same way as the customer's samples.
CCV	Continuing Calibration Verification. A standard prepared from the same stock solution used to prepare the calibration standards. Is also known as an instrument performance check solution (IPC).
CDOC	Continuing Demonstration of Capability. The continuing procedure used to establish the ability of the employee to generate acceptable accuracy and precision. Four passed LCSs, Blind QC samples, PT samples, and/or MDLs are used for this process.
CFR	Code of Federal Regulations
CHP	Chemical Hygiene Plan.
COC	Chain of custody. An unbroken trail of accountability that ensures the physical security of samples, data, and records.
COD	Chemical Oxygen Demand.
C of A	Certificate of Analysis. An independent document verifying the quality and content of a chemical or standard purchased from a vendor.

Compromised Samples	Samples which were improperly sampled, received with insufficient documentation, improperly preserved, received in the wrong containers, and/or received beyond the holding time.
Contamination	The effect caused by the introduction of the target analyte from an outside source into the test system and is determined by evaluating a blank.
CWM	Clear Wide Mouth container.
DDI	Double deionized water. Laboratory feedwater that is re-circulated through the DI system more than once.
Density	Concentration of matter, measured by the mass per unit volume.
DI	Deionized water. Laboratory feedwater that is passed through an ion exchange system, consisting of a carbon bed, cation bed, anion bed, and filters.
DO	Dissolved oxygen.
DoD	Department of Defense.
DUP	Duplicate. A replicate analysis for QC purposes.
Emulsion	Two or more substances in the same phase that cannot be uniformly mixed.
EB	Equipment Blank. A sample of analyte-free media which has been used to rinse common sampling equipment to check effectiveness of decontamination procedures.
ELAP	Environmental Laboratory Accreditation Program.
Extract	Material that has undergone the extraction procedure and is ready for analysis.
ELPAT	Environmental Lead Proficiency Analytical Testing.
FB	Field Blank. A clean representative of sample matrix, carried to the sampling site, exposed to sampling conditions, and returned to the laboratory and treated as an environmental sample. Field blanks are used to check for analytical artifacts or background introduced by sampling and analytical procedures.
Filtrate	Material that is filtered through a 0.7µm glass filter.
FIMS	Flow Injection Mercury System.
Flash point	The lowest temperature at which a sample's vapor is ignited.
Fluid Transfer Device	A device comprised of a glass bottle and a transfer hose that is capable of transferring a known amount of extraction fluid into the ZHE extraction vessel without changing the nature of the extraction fluid.
GC	Gas Chromatography Detector.
GC-FID	Gas Chromatography – Flame Ionization Detector.
GC/MS	Gas Chromatography/Mass Spectrophotometer Detector.
GC-PID	Gas Chromatography – Photo Ionization Detector.
GPC	Gel Permeation Cleanup.
HDPE	High Density Polyethylene. The type of plastic container used as required for certain analyses.
Headspace	The presence of air bubbles or gas in VOA vials or ZHE extraction vessels.
Holding time	The maximum time that a sample is held prior to analysis and is still considered valid.
Hydrolysis	A chemical reaction, where water reacts with another substance to form two or more new substances.
Hygroscopic	The ability of an ion to pull moisture from the surrounding atmosphere.
ICB	Initial Calibration Blank. Same as the CCB except analyzed immediately after the initial calibration to confirm that the zero point is within limits.
ICP	Inductively Coupled Plasma
ICP/MS	Inductively Coupled Plasma / Mass Spectrometry

ICSA	Interference Check Solution A. A solution that contains potentially interfering elements and zero concentration of potentially affected elements. This solution is used in a QC sample to ensure that the instrument is correcting for interferences properly.
ICSAB	Interference Check Solution AB. A solution that contains potentially interfering elements and known concentrations of potentially affected elements. This solution is used in a QC sample to ensure that the instrument is correcting for interferences properly.
ICV	Initial Calibration Verification. An independent check standard analyzed at the beginning of an analysis which is prepared from a separate source than that of the calibration standards.
IDL	Instrument Detection Limit. The IDL is calculated from a repeated analysis (7 minimum) of the calibration blank.
IDOC	Initial Demonstration of Capability. The initial procedure used to establish the ability of the employee to generate acceptable accuracy and precision. Four passed LCSs, Blind QC samples, PT samples, and/or MDLs are used for this process.
Ignitable	A substance with a flash point below 140°F (60°C).
Initial demonstration of analytical capability	The procedure used to establish the initial ability to generate acceptable accuracy and precision which are included in many analytical methods.
Instrument Blank	A clean sample that is known to not contain the determinative analyte, processed through the instrumental steps of the measurement process used to determine the absence of instrument contamination for the determinative method.
Interference	The effect on the final results caused by the sample matrix and is determined by evaluating a matrix spike sample.
IPC	Instrument Performance Check solution. A solution of one or more method analytes used to test the performance of the instrument system. This solution is made from the same source as the calibration standards.
IS	Internal Standard. A known amount of a standard added to a sample as a reference point for evaluating and controlling the precision and bias of the analytical method.
Laboratory Director	The individual responsible for the overall operation of the environmental laboratory.
LCR	Linear Calibration Range. The concentration range over which the instrument response is linear.
LCS	Laboratory Control Sample. An uncontaminated sample matrix spiked with known amounts of analytes from a source independent of the calibration standards. It is generally used to establish intra - laboratory or technical employee specific precision and bias or to assess the performance of all or a portion of the measurement system.
LD	Laboratory Duplicate (#1 and #2). It is the same as the CCV, except analyzed immediately after the initial calibration to confirm that the zero point is within limits.
LDR	Linear Dynamic Range. Upper concentration limit for reporting a particular element. Calculated by increasing the concentration of an element until the reported value is <90% of the true value and using the highest concentration that is >/=90% of the true value as the upper report limit.
Leachate	An aqueous solution generated from the tumble extraction.
LIMS	Laboratory Information Management System.
LL	Low Level. For volatiles, 25mL of water sample are purged.
LLCCV	Low-Level Continuing Calibration Verification. A standard prepared using the same source as the initial calibration standards, at the established lower limit of quantitation.

LLICV	Low-Level Initial Calibration Verification. A standard prepared using the same source as the calibration standards, at a concentration expected to be the lower limit of quantitation.
LLOQ	Lower Limit of Quantitation. A solution containing elements at concentrations equal to the laboratory PQL. This standard is used to both establish and confirm the lowest quantitation.
LOD	Limit Of Detection. An estimated value a process/instrument/laboratory is reliably detected.
LOQ	Limit Of Quantitation. The minimum value that is reported for a process/instrument/laboratory with confidence.
MB/LRB	Method Blank/Laboratory Reagent Blank. A clean sample processed simultaneously with and under the same conditions as samples containing an analyte of interest through all steps of the analytical and any preparation and/or extraction procedures.
MDL	Method Detection Limit. The minimum concentration of a substance that is measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte as described in 40 CFR Part 136 Appendix B, 1 July 1995 edition.
MRB	Method Reagent Blank. A sample consisting of a reagent, without the target analyte or sample matrix, introduced into the analytical procedure at the beginning and carried throughout all subsequent steps to determine the contribution of the reagents and of the involved analytical steps.
MS/MSD	Matrix Spike/Matrix Spike Duplicate. A sample prepared by adding a known amount of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available. The MSD is a second aliquot of the analytical sample spiked just like the MS. Matrix spikes are used to determine the effect of the matrix on a method's recovery efficiency.
MSDS	Material Safety Data Sheet.
NIST	National Institute of Standards and Technology. An organization that provides guidelines for the traceability of standards used in environmental analysis.
NLLAP	National Lead Laboratory Accreditation Program.
NPOX	Non- Purgeable Organic Halides.
Oxidize	A process in which oxygen acid forming element or a radical is increased in proportion in the compound.
PDS	Post Digestion Spike. A sample spiked with elements of known concentration after the digestion process. This is a second QC check. There is one PDS for each batch of 20 samples or fewer.
POD	A cluster of six tanks of gas connected to each other that function off one regulator.
POX	Purgeable Organic Halides.
PQL	Practical Quantitation Limit. Also known as the Reporting Limit (RL) or Detection Limit (DL). The minimum value that is reported for a process/instrument/laboratory with confidence.
Precision	The degree to which a set of observations or measurements of the same property, usually obtained under similar conditions, conform to themselves and are determined by evaluating the results of duplicate analyses. Precision is expressed as standard deviation, variance or range, in either absolute or relative terms.
Preservation	The temperature control or the addition of reagents to maintain the chemical or biological integrity of the sample.
PT/ Proficiency Testing program	The aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of the results in comparison to peer laboratories, and the collective demographics and results summary of all participating laboratories.

Proficiency testing sample	A sample, the composition of which is unknown to the technical employee, which is provided to test whether the technical employee and laboratory produces analytical results within specified performance limits.
PTFE	Polytetrafluoroethylene.
QA	Quality Assurance. An integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence.
QAO	Quality Assurance Officer. The individual responsible for the supervision of all aspects of sample handling, testing, report collation and distribution with the overall purpose of the production of high quality results.
QM	Quality Manual. A written description of the laboratory's quality assurance activities.
QC	Quality Control. The overall system of technical activities whose purpose is to measure and control the quality of a product or service so that it meets the needs of users.
QCS/QCSD	Quality Control Sample/ Quality Control Sample Duplicate. A QC sample prepared in the same manner as an LCS.
RPD	Relative Percent Difference. A calculation used for QC purposes between an MS/MSD, LCS/LCSD, or Sample/Duplicate. It may be used for a usable measure or sample homogeneity and/or precision.
SD	Serial Dilution. A sample diluted, usually 1:5, after the digestion process. This is a second QC check. There is one SD for each batch of 20 samples or fewer.
SVOC	Semivolatiles organic analysis or analytes.
Sensitivity	The minimum significant difference between the control and test concentrations.
SM	APHA Standard Methods.
SOP	Standard Operating Procedure. A written document which details the method of an operation, analysis or action whose techniques and procedures are thoroughly prescribed and is accepted as the method for performing certain routine or repetitive tasks.
SPE	Solid Phase Extraction.
Specific Gravity	The ratio of the mass of a body to the mass of an equal volume of water at 4°C or other specified temperature.
SPLP	Synthetic Precipitation Leaching Procedure. EPA method 1312 is a prep method in which percent pass is a preliminary test required for its procedure.
SRO / SCO	Sample Receiving Officer / Sample Custody Officer
SRM	Standard Reference Material.
Surrogate	A substance with properties that mimic the analyte of interest. It is unlikely to be found in the environment and is added to the samples for quality control purposes.
SW-846	A document produced by the US EPA titled "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods." The acronym can also be shortened to SW when referring to methods.
TB	Trip Blank. A clean sample of a matrix carried to the sampling site and transported to the laboratory for analysis without having been exposed to sampling procedures.
TC	Total Carbon.
TCLP	Toxicity Characteristic Leaching Procedure.
TKN	Total Kjeldahl Nitrogen. It is the sum of free-ammonia and organic nitrogen compounds which are converted to ammonium sulfate $(NH_4)_2SO_4$, through digestion and analysis as stated in this method.
TNI	The NELAC Institute.
TOX	Total Organic Halides.
TPH	Total Petroleum Hydrocarbon.

Ultrasonic	Sound waves that have frequencies above the upper limit of the normal range of human hearing.
USEPA	United States Environmental Protection Agency. The acronym is shortened to EPA or E when referring to methods.
UST	Underground Storage Tank.
VOA	Volatile Organic Analysis.
VOC	Volatile Organic Compound.
ZHE	Zero Headspace Extraction. The volatile extraction in which the sample is tumbled in a pressurized extraction vessel with zero headspace.

3.3.1 Refer to DoD QSM Volume 1, Module 2 Section 3.0 and 2009 TNI Standard, Volume 1 Module 2 Section 3.0 for additional Terms and Definitions.

4.0 Organizational Roles and Responsibilities

4.1 Laboratory Organizational Structure

4.1.1 AWAL is organized along clear lines of authority to provide its customers with service that is efficient and reliable (Refer to Exhibit 4.1). The AWAL organization facilitates efficient communication between our customers, laboratory administrative personnel, and laboratory analytical personnel.

4.1.2 AWAL is organized so that there is confidence in its independence of judgment and integrity at all times. This is achieved by providing supervisors who are familiar with calibration procedures, test methods, and the assessment of results. Additionally, the ratio of supervisors to technical staff is maintained to ensure adequate supervision to achieve adherence to laboratory procedures and accepted techniques. The customer support and sample log-in personnel (SROs, Laboratory Director, Marketing Manager, and Data Deliverables) work closely with customers to determine project specific analytical needs. This information is then communicated to laboratory analytical personnel through the LIMS. It is also communicated in person, via email, through the area supervisors, and through the Laboratory Director as a supplement to the LIMS. Likewise, special sampling requirements or analytical problems are communicated to the customers through the laboratory administrative personnel.

4.1.3 To ensure communication between the departments, key personnel meet several times a week to discuss and coordinate the activities in the laboratory. In addition, laboratory management personnel are very involved with the day-to-day problem solving and decision making in the laboratory.

4.1.4 No less than once a year, AWAL's management meets to talk about the following objectives:

4.1.4.1 The suitability of AWAL policies and procedures.

4.1.4.2 Reports from managerial and supervisory personnel.

4.1.4.3 The outcome of recent internal audits.

4.1.4.4 Corrective and Preventive Actions.

4.1.4.5 Assessments by external bodies.

4.1.4.6 The results of interlaboratory comparisons or proficiency tests.

4.1.4.7 Changes in volume and type of the work.

4.1.4.8 Customer feedback and call backs.

4.1.4.9 Customer complaints, suggestions, and praise.

4.1.4.10 Laboratory capacity and capabilities.

4.1.4.11 Employee training, cross training, and redundancy.

4.1.5 This information will be recorded by the AWAL QAO. The QAO is responsible to track agreed to time tables and review the status of open items at the weekly senior staff meeting. This information will be recorded in the Managers Meeting Logbook for tracking and archiving. This can be a hardcopy and/or an electronic file.

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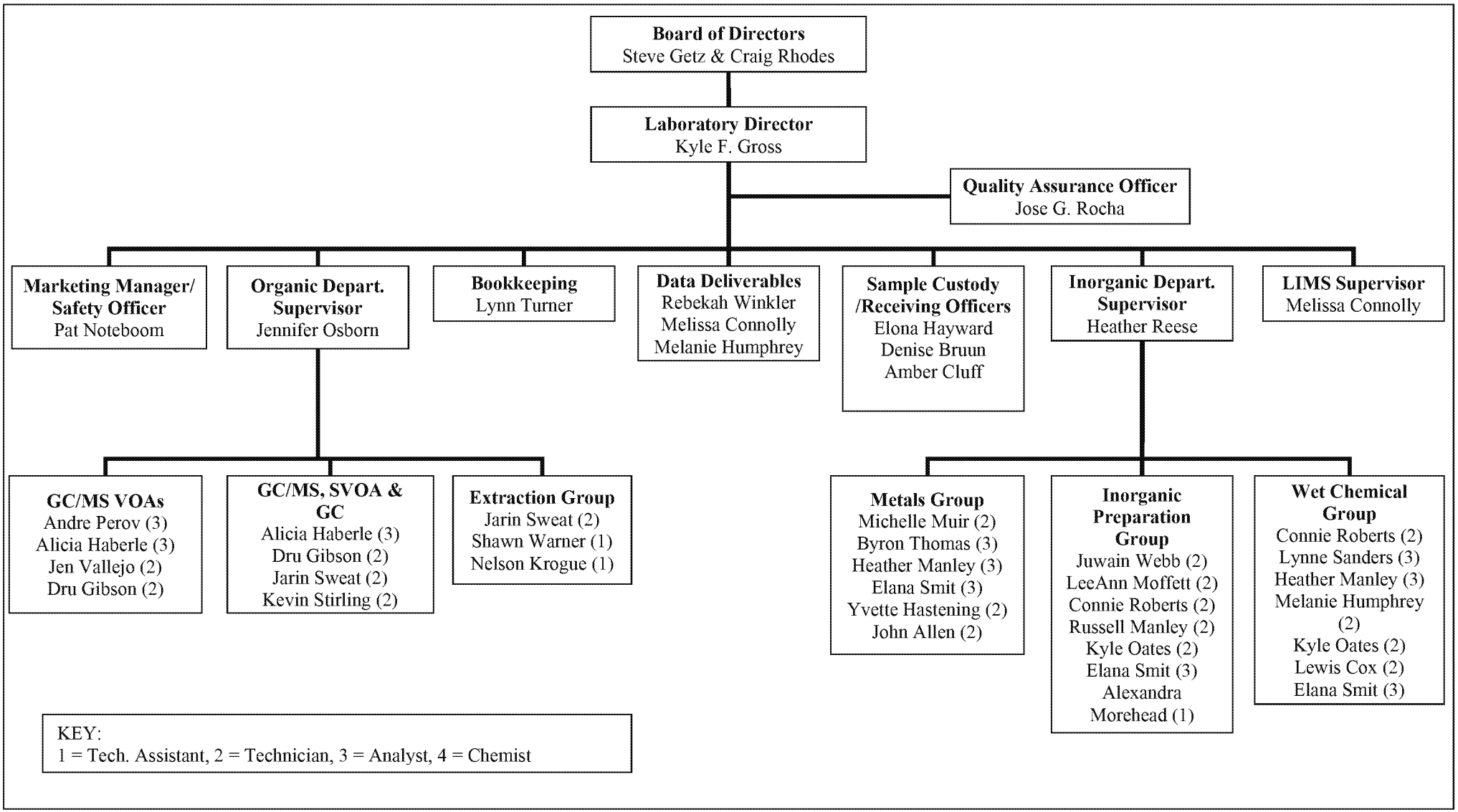
Exhibit 4.1 American West Analytical Laboratories' Organization Chart



4.2 Responsibility and Authority

Specific personnel bearing responsibilities for the production of quality data and the execution of laboratory projects include the Laboratory Director, Department Supervisors, Quality Assurance Officer (QAO), and Marketing Manager.

The Laboratory Director, Department Supervisors, and QAO are ultimately responsible for the quality of all analytical data produced in the laboratory. The Department Supervisors and QAO monitor the QA/QC practices of the laboratory. The Laboratory Director, Department Supervisors, and QAO determine regulatory policy and requirements, develop and initiate internal quality policy and procedures, and ensure that these procedures are properly performed. They review current and future projects to ensure the availability of adequate facilities, materials, and equipment. They also certify that analytical and administrative personnel have the appropriate training, education, and/or experience to perform their designated functions. The safety of all personnel and content of the Chemical Hygiene Plan are the responsibility of the Laboratory Director and the Safety Officer.

5.0 Quality Systems

5.1 Quality Policy

5.1.1 AWAL is committed to comply with the 2009 TNI Standards.

5.1.2 AWAL is committed to comply with ISO 17025 and to continually improve the effectiveness of the management system as well as the quality system through the use of the quality policy, quality objectives, audit results, analysis of data, corrective and preventive actions, and management review.

5.1.3 AWAL is committed to comply with the Department of Defense – Environmental Laboratory Accreditation Program (DoD-ELAP).

5.1.4 AWAL is committed to comply with National Lead Laboratory Accreditation Program (NLLAP).

5.1.5 AWAL is committed to comply with the Wyoming Storage Tank Remediation Testing Laboratory program.

5.1.6 AWAL is committed to producing analytical data that is technically and legally defensible. AWAL management provides the necessary facilities, equipment, materials, and personnel to ensure that quality data is produced in a cost-effective and timely manner.

5.1.7 AWAL management defines and documents its QA policies and objectives. These policies and objectives are documented in this manual and laboratory SOPs in English and are communicated to and followed by all employees.

5.1.8 This plan provides general direction for handling and processing of environmental samples through data reporting. AWAL's SOPs are written to provide detailed steps necessary to produce consistent quality data.

5.1.9 The QM, SOPs, and external documents are controlled documents. The approval required for re-issuing resides with the Laboratory Director. Refer to Document Control and Records Management RM001 for further information.

5.2 Quality Manual

5.2.1 AWAL is dedicated to meeting or exceeding the analytical needs of our customers. This means consistently producing high quality analytical data within the required turnaround and holding times at a reasonable price. AWAL has developed an extensive QA and QC program to ensure that all analyses meet the needs of our customers and are technically and legally defensible.
This Laboratory's QM describes the laboratory's QA/QC policies and procedures established in order to meet the requirements of the State of Utah, The NELAC Institute (TNI), Department of Defense (DoD), ISO 17025, NLLAP, Wyoming UST, and other regulatory programs. TNI is a stringent quality standard developed by and is under control of the NELAC Institute. Compliance with these standards reflects AWAL's dedication to producing quality analytical data.
The QA program defines many important activities and requirements, which contribute to data quality. These activities and requirements include:

5.2.1.1 Personnel qualifications and training.

5.2.1.2 Facilities and equipment maintenance.

5.2.1.3 Sample handling procedures.

5.2.1.4 Control of supplies and services.

5.2.1.5 Maintenance of standard operating procedures.

5.2.1.6 Data reduction, verification, validation, and reporting.

5.2.1.7 Corrective action procedures.

5.2.1.8 Document maintenance and control.

5.2.2 As part of this QA system, AWAL analyzes and evaluates routine QC checks to measure system performance. These QC checks, in accordance with the individual methods, may include but are not limited to:

5.2.2.1 Method Blanks (MB).

5.2.2.2 Calibration Verification Standards (CCV and ICV).

5.2.2.3 Matrix Spikes (MS).

5.2.2.4 Matrix Spike Duplicates (MSD).

5.2.2.5 Laboratory Control Samples (LCS).

5.2.2.6 Surrogates (Surr).

5.2.2.7 Duplicate samples (DUP).

5.2.2.8 Field or Trip Blanks (FB or TB).

5.2.2.9 Calibration Blank Standards (CCB and ICB).

5.2.3 AWAL QM is revised annually or as needed.

6.0 Record Management

6.1 Controlled Records

6.1.1 AWAL has established a record system to comply with state, TNI, ELAP, ISO 17025, and DoD regulations. The record system allows for the historical reconstruction of laboratory activities that produced analytical data. The system is designed to facilitate retrieval of working files and archived data. These records are protected against theft, fire, loss, vermin, and magnetic sources. All analytical records describe above are maintained or transferred upon transfer of ownership or closure of the laboratory. AWAL follows GALP (Good Automated Laboratory Practices) and has established operation procedures for its microprocessors, computers, and Laboratory Information Management System. The following records are maintained for a period five years to facilitate reconstruction of data set:

6.1.1.1 All original data. Hard copy (logbook) or electronic, calibration data, sample analysis data, quality control measures, instrument files, and data output records.

6.1.1.2 Test methods, SOPs, and archived SOPs including computation steps.

6.1.1.3 Copies of final reports.

6.1.1.4 Laboratory correspondence with customers related to project requirements and COC clarifications.

6.1.1.5 Corrective action and audit responses.

6.1.1.6 Proficiency test results and raw data.

6.1.1.7 Results of data review and validation.

6.1.1.8 Identity of personnel involved in sample receipt, preparation, calibration, and testing.

6.1.1.9 Information relating to equipment, test method, sample receipt, sample preparation, and data validation.

6.1.1.10 Information associated with analysis.

6.1.1.11 Laboratory identification for sample.

6.1.1.12 Date and time of analysis.

6.1.1.13 Instrument identification and operating conditions.

6.1.1.14 Analytical method used.

6.1.1.15 Manual calculations including integrations.

6.1.1.16 Analyst initials or electronic signature.

6.1.1.17 Preparation methods including sample quantity, reagents, standards, instrument information.

6.1.1.18 Analysis results.

6.1.1.19 Standard and reagent origin, receipt, use, and preparation.

6.1.1.20 Calibration criteria, frequency, and acceptance limits.

6.1.1.21 Quality control utilized including method performance and its criteria.

6.1.1.22 All electronic data, software, and backups.

6.1.2 The following administrative records are maintained:

6.1.2.1 Personnel Qualifications, experience, and training records.

6.1.2.2 Records of demonstration of capability.

6.1.2.3 Log of name, initials, and signature for all individuals responsible for laboratory records.

6.1.3 Document Changes to Control Records

6.1.3.1 All SOPs are subject to review on an annual basis. A new revision is generated if there are any significant changes or inaccuracies.

6.1.3.2 The Laboratory Director and Quality Assurance Officer authorize all changes and SOP revisions prior to issue. Approved SOPs contain the

signature of both parties, along with signature of any other applicable supervisors, and the date signed.

6.1.3.2.1 Personnel are trained on changes and revisions through reading the revised SOP and updating their AWAL reading record file.

6.1.3.2.2 The laboratory maintains electronic copies of previous revisions and changes for a period of five years.

6.1.3.2.3 The QAO keeps a list of all current SOPs and revisions.

6.2 Obsolete Documents

6.2.1 SOPs, QM, etc are assigned a revision number when a new revision is performed. The old revision is removed from circulation and is no longer valid.

6.2.2 Laboratory notebooks are maintained with an inventory system. The notebooks are checked out to individual analysts and technicians and uniquely identified by a LIMS ID. Once completed the notebooks are checked into the tracking log, scanned into PDF format and saved on the "M" drive, and maintained in the assigned place until the end of the calendar year. After this period, all logbooks are collected, scanned, and all hard copies are shredded when the data has been backed up in duplicate, with one copy on-site and one copy off-site.

6.2.3 External documents such as instrument manuals, quality standards, etc are assigned a laboratory ID and kept in the master list. They are removed from the areas when obsolete.

6.3 Standard Operating Procedures

6.3.1 SOPs document routine administrative and technical activities performed at AWAL. The development and use of both technical (e.g. sample preparation, sample analysis) and administrative (e.g. document review, sample tracking) SOPs are an integral part of AWAL's quality system.

6.3.2 The development and use of an SOP promotes quality through consistency within the laboratory, even if there are personnel changes. When reviewing historical data, SOPs are valuable for reconstructing project activities when specific analytical detail is not available. Additional benefits of a SOP are reduced work effort, improved data comparability, and increased data defensibility.

6.3.3 SOPs must accurately reflect the activities of the laboratory. AWAL uses appropriate test methods and procedures for all tests and calibrations. Technical SOPs are consistent with established test procedures and reflect the required accuracy of the required tests. AWAL uses only the specific test methods for sample analysis as mandated or requested. AWAL has documented instructions for operation of all relevant equipment, sample handling, calibration and testing. The SOPs must be

logically organized and have the signature(s) of the approving authority. Each SOP clearly indicates the effective date of the document and the revision number. All SOPs and manuals are maintained up-to-date and electronically readily available to the staff. Laboratory personnel are required to follow the SOPs as written unless changes are clearly documented and communicated on the final report. SOPs are controlled documents and copies of print of them are only valid for the day they are printed on.

6.3.4 Administrative SOPs must accurately reflect the activities of the laboratory. Administrative SOPs are reviewed yearly or as needed by the QC department and by the user(s) to ensure that they are accurate and compliant with applicable quality standards. List of administrative SOPs are contained in Exhibit 6.1. Each administrative SOP includes, where applicable, the following:

6.3.4.1 Laboratory's name.

6.3.4.2 SOP Number and Title of the administrative method.

6.3.4.3 Revision number/ID and Effective Date.

6.3.4.4 Author.

6.3.4.5 Purpose.

6.3.4.6 Applicability.

6.3.4.7 Procedure.

6.3.4.8 Definition.

6.3.4.9 Responsibilities.

6.3.4.10 Quality Control.

6.3.4.11 References.

6.3.4.12 Tables, Exhibit, and Diagrams.

Exhibit 6.1 Administrative SOPs

SOP Title	LABORATORY ID
Chemical Hygiene Plan	CHP
Customer Confidentiality	CC001
Data Reduction and Validation	DRV001
Document Control and Records Management	RM001
Identification of Extracts, Digestates, and Subsamples	IDEDS001
LIMS	LIMS001

SOP Title	LABORATORY ID
LIMS Control Limits Generation	CL002
Laboratory Information Management System	LIMS001
Nonconformance/Corrective Action Report	NC/CAR002
Organic Standards Log in	OSL001
Handling Proficiency Tests	HPT001
Quality Manual	QM
Quality Assurance Officers Guide	QAO001
Sample Bottle Preparation	SBP001
Sample Receiving	SR003
Standards and Traceability	TRAC003
Supplies	SUP002
Training	TT001
Waste Management and Sample Disposal	WMSD001
AWAL Emergency Guide	05-R1-100A
Balance Calibration - Verification	BCV001
Calibration-Verification of Pipettors	CVP001
Thermometers Verification	TV001
Refrigeration Units	RU001
Estimation of Uncertainty of Analytical Measurements	EUAM001
AWAL MDL, LOD, and LOQ Calculation	MLL001
Laboratory Ethics and Data Integrity	LEDI001
Internal Assessments and Audits	IAA001
Wipe Sampling of Laboratory Work Surfaces for Lead Contamination	WPB001
Customer Communication	CUCOM001
Production and Verification for ASTM Type I and II Quality Water	STDWATER001
Computer Software Control	CSC001
Computer Program Testing	CPT001
Computer Software Security	CSS001
Advertising Policy	ADVERTISING001

6.3.5 Test Methods Technical SOPs which reference published methods must accurately reflect all relevant operational and quality control requirements of the method. Any deviation from the published method must be documented on the final report. Technical SOPs are reviewed and compared to the current reference methods on a yearly basis or when needed to ensure their accuracy and applicability. A list of technical SOPs is contained in Exhibit 6.2. Each technical SOP includes, where applicable, the following:

6.3.5.1 Laboratory's Name.

6.3.5.2 Revision number/ID and Effective Date.

6.3.5.3 Title of the Test Method.

6.3.5.4 Scope and Application.

6.3.5.5 Limits of Detection and Quantitation.

6.3.5.6 Summary of Method.

6.3.5.7 Definitions.

6.3.5.8 Interferences.

6.3.5.9 Safety.

6.3.5.10 Equipment and Supplies.

6.3.5.11 Reagents and Standards.

6.3.5.12 Sample Collection, Preservation, Shipment, and Storage.

6.3.5.13 Quality Control.

6.3.5.14 Calibration and Standardization.

6.3.5.15 Procedure.

6.3.5.16 Data Analysis and Calculations.

6.3.5.17 Method Performance.

6.3.5.18 Pollution Prevention.

6.3.5.19 Data assessment and acceptance criteria for quality control measures.

6.3.5.20 Corrective actions for out-of-Control data.

6.3.5.21 Contingencies for handling out-of-control or unacceptable data.

6.3.5.22 Maintenance.

6.3.5.23 Waste Management.

6.3.5.24 References.

6.3.5.25 Tables and Diagrams.

6.3.5.26 Clarification/Modifications of the Method.

Exhibit 6.2 Technical Methods/SOPs

Analyte/Test Name or Description	Program and Method			
	CW	DW	RCRA	
			SOLID	WATER
Acidity	SM2310B			
Alkalinity	SM2320B	SM2320B		
Ammonia	EPA350.1			
Base, Neutrals, and Acids (SEMIS)	EPA625		SW8270D	SW8270D
Biochemical Oxygen Demand (BOD)	SM5210B			
Bromide	EPA300.0		SW9056A	SW9056A
Carbonaceous Biochemical Oxygen Demand (CBOD)	SM5210B			
Cation Exchange Capacity of Soils (CEC)			SW9081	
Chemical Oxygen Demand (COD)	HACH8000			
Chloride	SM4500CIE	SM4500CIE		SW9251
Chloride	EPA300.0	EPA300.0	SW9056A	SW9056A
Chromium VI (Hexavalent Chromium)	SM3500CrB		SW7196A	SW7196A
Color	SM2120B	SM2120B		
Conductivity/Specific Conductance		SM2510B	SW9050A	
Corrosivity/Langelier Index		SM2330B		
Cyanide, Total, Free, and WAD	EPA335.4	EPA335.4	SW9012B	SW9012B
Cyanide, Amenable to Chlorination	EPA335.1		SW9012B	
Diesel Range Organics (DRO)			SW8015D	SW8015D
Pesticides EDB/DBCP		EPA504.1		
Pesticides EDB/DBCP				EPA8011
Fluoride	SM4500FC	SM4500FC		
Fluoride	EPA300.0	EPA300.0	SW9056A	SW9056A
Gel Permeation Cleanup (GPC)			SW3640A	SW3640A
Hardness	SM2340B			
Herbicides			SW8151A	SW8151A
Ignitability/Flash Point				SW1010A
Mercury (Hg)	EPA245.1	EPA245.1	SW7471B	SW7470A
Metals Acid Digestion of Liquids				SW3005A
Metals by ICP	EPA200.7	EPA200.7	SW6010C	SW6010C
Metals by ICP/MS	EPA200.8	EPA200.8	SW6020A	SW6020A
Metals Microwave Digestion Of Liquids				SW3015A
Metals Microwave Digestion of Solids			SW3051A	
Nitrate		SW353.2		
Anions-Nitrate	EPA300.0	EPA300.0	SW9056A	SW9056A
Nitrate/Nitrite	EPA353.2	EPA353.2		
Anions-Nitrate/Nitrite	EPA300.0	EPA300.0		
Nitrite		EPA353.2		
Anions-Nitrite	EPA300.0	EPA300.0	SW9056A	SW9056A
Non-Halogenated Org. by GC/FID			SW8015D	SW8015D
Odor		SM2150B		
Oil & Grease	EPA1664A/1664B			EPA1664A/1664B
Oil & Grease	SW9070A			SW9070A
Oil Range Organics (ORO)			SW8015D	SW8015D
Organic Accelerated Solvent Ext. (ASE)			SW3545A	
Organic Sample Prep. Liquid/Liquid Ext.				SW3510C

Analyte/Test Name or Description	Program and Method			
	CW	DW	RCRA	
			SOLID	WATER
Organic Sample Prep. Microwave Extraction			SW3546	
Organic Ultrasonic Extraction			SW3550C	
Organic Waste Dilution			SW3580A	
Orthophosphate		EPA365.1		
Anions-Orthophosphate	EPA300.0			SW9056A
Oxygen	SM4500OG			
Paint Filter Liquid Test			EPA9095B	
Pesticides	EPA608		SW8081B	SW8081B
Pesticides PCBs			SW8082A	SW8082A
pH	SM4500H+B	SM4500H+B		
pH				SW9040C, SW9041A
pH Soil and Waste			SW9045D	
Phenols	EPA420.4		SW9066	
Phosphorous, as Phosphate	SM4500PB&F			
Reactive Cyanide			7.3.3/8.3	
Reactive Sulfide			7.4.3/8.3	
Settable Solids (SS)	SM2540F			
SPLP Metals, Semivolatiles, and Volatiles			SW1312	SW1312
Anions-Sulfate	EPA300.0	EPA300.0	SW9056A	SW9056A
Sulfate		SM4500(SO4)-2E	SW9038	
Sulfide	SM4500S2-F		SW9034	
Sulfide	SM4500S2-D			
Sulfite	SM4500SO3-2B			
TCLP Metals, Semivolatiles, and Volatiles			SW1311	SW1311
Total Dissolved Solids (TDS)	SM2540C			
Total, Fixed, and Volatiles Solids (TFVS)	SM2540G			
Total Kjeldahl Nitrogen (TKN)	EPA351.2			
Total Organic Carbon (TOC)	SM5310B			
Total Organic Halides (TOX)				EPA9020B
Total Solids (TS)	SM2540B	SM2540B		
Total Suspended Solids (TSS)	SM2540D			
Total Volatile Solids (TVS) and Total Volatile Suspended Solids (TVSS)	EPA160.4	EPA160.4		
Turbidity	EPA180.1	EPA180.1		
Volatiles	EPA624		SW8260C	SW8260C
Volatiles Purge & Trap Aqueous				SW5030C
Volatiles Purge & Trap Solids			SW5035A	

6.4 Refer to Document Control and Records Management RM001 SOP for further information.

7.0 Review of Requests, Tenders, and Contracts

7.1 Procedure for the Review of Work Requests

7.1.1 Sample Receiving Officer (SRO) reviews the customer's Chain of Custody (COC, Refer to Exhibit 15.1) for completeness. See section 22.0 for details about the COC.

7.2 Documentation of Review

7.2.1 Each project, sample, and requested methods and analytes are entered into the LIMS. A Work Order Summary is printed and peer reviewed. If the set is free of errors, the peer review is documented on the Work Order Summary with "HOK" (Header OK) followed by the reviewer's initials. The AWAL Work Order Summary and COC are saved as PDF files and saved in the appropriate unique folder on the "RD" drive using the following naming scheme: Work Order-Customer ID-COC (i.e., 1306560-COC-AWAL100.pdf). If discrepancies are noted, they are pointed out, the information is corrected in the LIMS, a revised Work Order Summary is printed, and the peer review process is repeated.

7.2.2 If a customer requests an additional parameter, a method change, or any other changes to the COC including the customer sample IDs or project name, the request is documented on the COC, the information is updated in the LIMS, a new Work Order Summary is printed and "revised" is included on the Work Order Summary. The new Work Order Summary and updated COC are then saved as PDF files, saved onto the "M" drive in the appropriate "RD" file folder, and named uniquely for their sequential revision number (i.e., a second revision would be named 1306560-COC2-AWAL100.pdf).

7.3 Refer to Sample Receiving SR003 SOP for further information.

8.0 Subcontracting Tests

When required for a specific project, AWAL, in conjunction with the customer, may subcontract analytical work to other TNI/DoD-ELAP/ISO17025/NLLAP accredited laboratories. The laboratory advises customers of its intention to subcontract testing to another party in writing at the beginning of all projects. Walk-in customers are notified in writing upon the receipt of samples. Only with authorization from the customer is the work subcontracted out. When an accredited laboratory is not available, AWAL will notify the customer of the options available and will wait for the client confirmation. Subcontracted data is reported to the customer on the subcontracted laboratory's letterhead and is saved as a separate file to avoid confusion. AWAL requests current certification letters from subcontracted laboratories utilized. Refer to Sample Receiving SR003 and Customer Communication CUCOM001 SOPs for further information.

9.0 Purchasing Services and Supplies

Refer to Supplies (SUP002) SOP and Sample Bottle Preparation (SBP001). AWAL relies on many outside vendors for supplies and services which impact analytical quality. Controlling the quality of these materials and services is a high priority. An established procurement process is followed which includes the review of technical purchases by laboratory supervisors and QA personnel. The procurement process includes maintaining record of all suppliers of service and supplies. When there is no established quality assurance standard for outside support or supplies AWAL ensures that materials and supplies comply with analytical requirements.
AWAL seeks to establish and maintain strong relationships with high-quality vendors. Suppliers are sought which consistently produce the needed materials on time and for a fair price. In the same manner,

AWAL encourages positive relationships with vendors by clearly defining its needs, being prompt with payments, and providing immediate feedback when problems arise.

9.1 Laboratory Chemicals, Standards, and Reagents. Laboratory personnel ensure that reagents, chemicals, and standards are of appropriate quality. Standard Operating Procedures describe the purchase, reception, and storage of consumable materials used during the technical operations of the laboratory. In the absence of specific requirements in the individual analytical methods, the following guidelines are used when purchasing chemicals and reagents to be used in the laboratory:

9.1.1 All purchased primary standards and chemicals are ACS Reagent grade or better.

9.1.2 Only pesticide grade solvents (or better) are used to prepare standards for the organic department.

9.1.3 Only acids certified by the supplier as "trace metal", "omni trace", "omni trace ultra", or "optima" grade are used for the preparation of standards for metals analysis.

9.1.4 Only ASTM Type I or Type II DI water from the laboratory's DI system is used for preparation of aqueous solutions and standards. Reverse Osmosis (RO) is used in the Volatiles Laboratory.

9.2 The laboratory retains a copy of the certificate of analysis provided by the manufacturer in order to ensure traceability of each chemical and primary standard purchased. All purchased chemicals and standards are assigned a unique laboratory ID and labeled, making the item traceable to the following information:

9.2.1 Received date.

9.2.2 Vendor (manufacturer).

9.2.3 Receiving analyst.

9.2.4 Expiration date.

9.2.5 Lot number.

9.3 Reagents and secondary or tertiary standards that are made in the laboratory from purchased chemicals and primary standards are assigned a unique laboratory ID. Refer to Standards & Traceability TRAC003 SOP and Section 21.0.

10.0 Service to the Customer

10.1 Customer Confidentiality

10.1.1 All customer information maintained and accumulated by AWAL is considered proprietary to ensure inappropriate information is not released.

10.2 It is strictly forbidden for AWAL representatives (all employees of AWAL) to discuss customer information other than with the customer without written or verbal permission from the customer.

10.2.1 Written documentation must specifically state who is allowed to receive this information and the time frame applicable to the transmission of information.

10.2.2 It is forbidden for AWAL employees to discuss customer information with the news media, environmental organizations, other customers, and government agencies (state or federal see section 15.1.1).

10.3 Refer to Customer Confidentiality CC001 SOP for further information.

11.0 Complaints

11.1 In the event of a complaint or concern regarding the quality of data produced at AWAL, laboratory management immediately investigates and if needed initiates a CAR to correct the problem. Every effort is made to resolve the complaint in an equitable and timely manner. Following such a finding, laboratory QA systems is reviewed and updated, if necessary, to avoid similar problems in the future. A record is maintained of all complaints and of the action taken by the laboratory.

11.2 When a customer's complaint is unresolved, complaints may be reported to the accreditation body. This applies only to NLLAP projects.

11.3 Refer to Non/Conformance Corrective Action Report NC/CAR002 SOP for further information.

11.4 Refer to Customer Communication CUCOM001 SOP for further information.

12.0 Control of Non-Conforming Work

12.1 Where a complaint, or any other circumstance, raises doubt concerning the laboratory's compliance with the laboratory's policies, procedures, or with the relevant regulatory requirements or otherwise concerning the quality of the laboratory's calibrations or tests, the laboratory ensures that those areas of activity and responsibility involved are promptly audited in accordance with the QM.

12.2 All analyses performed by AWAL that do not meet a specific regulatory requirement must be qualified as specified on section 12.3. This includes but is not limited to TNI, DoD-ELAP, NLLAP, ISO17025 and individual state accreditation standards.

12.3 If an analyte not conforming is amongst others that are conforming, the non-conforming analyte is flagged and footnoted that this analyte does not comply with the applicable regulation. If all the analytes performed are non-conforming then the entire report is footnoted that it does not conform to the applicable regulation. This will also be noted on the cover letter of the report.

12.4 When any aspect of testing and/or the results of any work that AWAL performs does not conform with AWAL SOPs, method, or customer requirements, AWAL follows this procedure:

12.4.1 Employee stops the procedure (preparation, instrument calibration, analysis, etc.) when nonconforming work is identified and reports to the Area Supervisor.

12.4.2 Area Supervisor evaluates the significance of the nonconforming work and lets the Laboratory Director and/or QAO know about the situation.

12.4.3 Area Supervisor and Laboratory Director and/or QAO review the evaluation and decide about the action that needs to be taken.

12.4.4 Correction that was decided to be taken is communicated to personnel involved and implemented as soon as possible, together with any decision about the acceptability of the nonconforming work.

12.4.4.1 When there are not enough samples to re-prepare and/or re-analyze, the customer is notified about the situation by the Area Supervisor or designee.

12.4.4.2 When a report was submitted, the customer is notified and the report is recalled and/or cancelled.

12.4.5 The Laboratory Director or designee (QAO, Marketing Manager, and Area Supervisor) has the responsibility to authorize the resumption of work.

13.0 Corrective Action

13.1 Selection and Implementation of Corrective Actions

In order to achieve its goal of consistently producing high quality analytical data, AWAL has developed a formal system for initiating and implementing corrective actions (Refer to the NC/CAR002 SOP). Corrective actions and follow-ups are powerful tools for continuous improvement within the laboratory.
When any operation or process does not conform to the method, AWAL's QM, or customer's contract; a CAR is initiated. Corrective actions and follow-up are documented on the CAR located in the LIMS. The employee that finds the non-conformance notifies his/her supervisor and the QAO. The employee and the supervisor submit information about the non-conformance and the corrective action plan to take to the QAO. The QAO initiates the CAR and follows up until it is closed. Bench QC problems are often solved immediately by the chemist or supervisor without initiating a formal CAR. Administrative corrective action usually requires the use of a CAR.

13.1.1 Administrative or Systemic Problems. Administrative or systemic problems include errors in sample receipt, missed holding times, sample preservation, data transcription, data reporting, performance evaluation results, etc. These types of errors are usually discovered during data verification, internal audits, or external performance evaluation audits. They are also brought to the attention of the

laboratory by customers (i.e., customer complaints) or external auditors. These types of problems are very significant and corrective actions must identify the root cause of the problem (insufficient resources, training, internal checks, etc.) and recommend possible solutions (improve resources, training, internal checks). To the extent possible, samples are to be reported only if all quality control measures are acceptable. If a quality control measure is found to be out of control, and the data is to be reported, all samples associated with the failed quality control measure are reported with the appropriate data qualifiers.

13.1.2 Implementation. Specific corrective action procedures depend on the nature of the discrepancy or out-of-control situation. Ultimately, the QAO is responsible for identifying and correcting systemic quality problems within the laboratory. Individuals working in the laboratory, however, must be familiar with all QC policies and procedures and bring discrepancies to the attention of the appropriate supervisor or QC personnel. For guidance purposes, two types of analytical problems can be identified; bench analytical QC and administrative problems.

13.2 Monitoring of Corrective Action

13.2.1 After the CAR is completed, it is returned to the QA Department for review. QA department personnel accept the report or re-submit the report to the laboratory for further review. Once the CAR is completed and signed, the QAO reviews and initiates any recommended changes to the QA systems. A summary of all suggested corrective actions are submitted to laboratory management on a regular basis.

13.3 Technical Corrective Action

13.3.1 All laboratory personnel should be aware of the specific QC requirements associated with their analytical responsibilities. Data must not be released from the bench unless either all quality control results are within acceptable limits or the data has been clearly qualified as to the nature of the discrepancy and the corrective actions that has been attempted.

13.3.2 The corrective action is a function of the type or error encountered. Experienced analysts and supervisors are consulted when trouble-shooting these types of problems. A CAR may not be required as detailed in section 13.4. Possible corrective actions for these types of bench analytical problems include:

13.3.2.1 Re-analyze failed QC sample and/or calibration standards.

13.3.2.2 Re-prepare (or re-extract) and re-run QC sample and/or calibration curve.

13.3.2.3 Perform routine or non-routine instrument maintenance.

13.4 Policy for Exceptionally Permitting Departures from Documented Policies and Procedures

13.4.1 Bench analytical QC problems are those that occur during sample analysis. These types of errors include failed calibration, failed continuing calibration, failed spike or surrogate recovery, etc. Many of these problems are corrected at the time of analysis and do not require external documentation using the CAR.

13.4.1.1 Record any sample and standard preparation steps, as well as instrument maintenance in the LIMS and/or appropriate logbook.

14.0 Preventive Action

14.1 Rather than waiting for a failure to happen, it is necessary to identify potential problems before they occur and rectify them. Laboratory staff must be cognizant of their requirements and notice potential problems before they occur as well as areas that can be improved. Noted problems than can be addressed immediately can be performed by the employee without supervisor's consent or follow up.

14.2 Preventive action is achieved throughout the application of QC and QA principles that reduce the risk of obtaining products and/or services that do not meet the requirements of the customers. Some of the elements are:

14.2.1 Training.

14.2.2 Regular reading and updating of SOPs.

14.2.3 Internal audits.

14.2.4 Purchase of certified or best quality supplies.

14.2.5 Quality products within the internal customer-supplier chain.

14.2.6 Customer communication.

14.2.7 Efficient internal communication.

14.2.8 Suggestions-Comments' Box.

14.2.8.1 AWAL uses this program to motivate the personnel to identify opportunities for improvement.

14.2.8.2 This process helps personnel to privately communicate any potential sources of nonconformances, either technical or concerning the quality system.

14.2.8.3 Personnel deposit the suggestion-comments into the box located in the QAO office, QAO lets the Laboratory Director know that there is a comment-suggestion, and the Laboratory Director reads and assigns the item to the respective responsible for its review and

implementation. Area Supervisor monitors the implementation to ensure that it is effective.

14.3 During training sessions, employees are invited to make changes that will prevent problems from happening.

14.4 All AWAL employees have direct communication with the Laboratory Director and the QAO to communicate about any improvements to prevent deficiencies in the processes.

14.5 Laboratory Director requests from the Area Managers and QAO a list of the nonconformances that happened the most during the year and based on that creates a list of the items that the laboratory needs to work on during the following year. The Laboratory. Director assigns responsibility for each item, deadlines, and frequency or revision. Refer to M\QA-QC\ Preventive Actions folder for detailed information. QAO keeps records of progress.

15.0 Control of Records

15.1 Records Management and Storage

15.1.1 AWAL is required by law to release information if subpoenaed. Only information specifically stated on the subpoena is released.

15.1.2 All customers associated with released information is contacted immediately (verbally), followed by written notification.

15.1.2.1 The written notification documents what was subpoenaed: final report, COC, customer file, invoices, etc.

15.2 Legal Chain of Custody Records

15.2.1 To ensure the integrity of compliance samples, a sample must be in someone's possession from the time of collection until delivery to the laboratory. This process is referred to as a Chain-Of-Custody (COC).

15.2.2 A sample is considered to be under a person's custody if it is in the individual's physical possession, in the individual's sight, secured in a tamper-proof way by that individual, or secured in an area restricted to authorized personnel. If a sample is transferred to another person's custody, it must be documented on the COC. A completed COC record must accompany each sample or group of samples received by the laboratory.

15.2.3 Analyses to be performed on each sample must be clearly indicated on the COC form or attached documentation. This ensures the selectivity of the test meets its intended purpose. This information also includes specifically required analytical methods, reporting limits, turnaround time, and other pertinent information.

15.2.4 The COC/Analysis Request record includes the following information:

15.2.4.1 Name, address, and phone number of technical contact.

15.2.4.2 Project and/or site description, location, and field ID (if applicable).

15.2.4.3 Client Sample ID(s) (must be consistent with the identification on the sample bottles).

15.2.4.4 Sample collection date and time.

15.2.4.5 Sample matrix such as water, soil, oil, etc.

15.2.4.6 Comments such as required turnaround time, methods, detection limits, sample inspection etc.

15.2.4.7 Signature and name of collector.

15.2.4.8 Signature of persons involved in the chain of possession including the date and time of each transfer.

15.2.4.9 Requested analyses, with test method required if known by customer.

15.2.4.10 Information on the COC concerning the samples such as the temperature, physical status, preservation status, holding time status, COC Tape status, and any discrepancies are noted by laboratory personnel only.

15.2.4.11 Refer to Exhibit 15.1 for an example of a COC.

Exhibition 15.1 Chain of Custody

American West
Analytical Laboratories
463 W. 3600 S. Salt Lake City, UT 84115
Phone # (801) 263-8686 Toll Free # (888) 263-8686
Fax # (801) 263-8687 Email awal@awal-labs.com
www.awal-labs.com

CHAIN OF CUSTODY

All analysis will be conducted using NELAP accredited methods and all data will be reported using AWAL's standard analyte lists and reporting limits (PQL) unless specifically requested otherwise on this Chain of Custody and/or attached documentation.

AWAL Lab Sample Set #
Page _____ of _____

QC Level: 1 2 2+ 3 3+

Turn Around Time: 1 2 3 4 5 Stnd

Unless other arrangements have been made, signed reports will be emailed by **5:00 pm** on the day they are due.

Due Date:

Client: _____
Address: _____
_____
Contact: _____
Phone #: _____ Cell #: _____
Email: _____
Project Name: _____
Project #: _____
PO #: _____
Sampler Name: _____

	Sample ID:	Date Sampled	Time Sampled	# of Containers	Sample Matrix											Known Hazards & Sample Comments
1																
2																
3																
4																
5																

☐ Report down to the MDL
☐ Include EDD:
☐ Lab Filter for:
☐ Field Filtered For:

For Compliance With:
☐ NELAP
☐ RCRA
☐ CWA
☐ SDWA
☐ ELAP / A2LA
☐ NLLAP
☐ Non-Compliance
☐ Other:

Laboratory Use Only

Samples Were:

1 Shipped or hand delivered
2 Ambient or Chilled
3 Temperature _____ °C
4 Received Broken/Leaking (Improperly Sealed)
Y N
5 Properly Preserved
Y N Checked at bench
6 Received Within Holding Times
Y N

COC Tape Was:
1 Present on Outer Package
Y N NA
2 Unbroken on Outer Package
Y N NA

6																
7																
8																
9																
10																
11																
12																

3 Present on Sample
Y N NA

4 Unbroken on Sample
Y N NA

Discrepancies Between Sample Labels and COC Record?
Y N

Relinquished by: Signature	Date:	Received by: Signature	Date:
Print Name:	Time:	Print Name:	Time:
Relinquished by: Signature	Date:	Received by: Signature	Date:
Print Name:	Time:	Print Name:	Time:
Relinquished by: Signature	Date:	Received by: Signature	Date:
Print Name:	Time:	Print Name:	Time:
Relinquished by: Signature	Date:	Received by: Signature	Date:
Print Name:	Time:	Print Name:	Time:

Special Instructions:

16.0 Audits and Management Review

16.1 Internal Audits

16.1.1 AWAL performs or arranges for audits of its activities to verify that its operations continue to comply with the requirements of the quality system (Exhibit 16.1 Internal Assessment and Audit Checklist). The purpose of the audit is to detect any deviations from acceptable practices and procedures so that corrective actions are taken. Wherever possible, auditors are independent of the activity to be audited. Refer to Internal Assessments and Audits (IAA001) for further information.

16.1.2 QA personnel or designees perform annual internal audits at least once a year, by reviewing SOPs, analysis, reports, receipt, employee qualifications, and other supporting documentation; personnel are interviewed to determine if the analyses were performed in compliance with the QM, relevant SOPs, and method guidelines. Where audit findings cast doubt on the correctness or validity of the laboratory's results, the laboratory takes immediate corrective action and immediately notifies in writing, any customers whose work has been affected. All findings and corrective actions are documented.

EXHIBIT 16.1 AWAL INTERNAL AUDIT QUESTIONNAIRE

AMERICAN WEST ANALYTICAL LABORATORIES

INTERNAL ASSESSMENT AND AUDIT CHECKLIST

Laboratory Area/Method: _____

_____

Assessor / Auditor: _____ Date: _____ Personnel Audited: _____

1. _____Is the audited DOCd' to perform this analysis/preparation?

2. _____Does the audited know and have access to controlled current version SOPs, training files, Quality Manual, and Chemical Hygiene Plan?

3. _____Has the audited read and understood the current SOP, QM, and CHP? Is there a record of that?

4. _____Are the MDLs, LODs, LOQs, IDLs. LDRs, etc. up-to-date and updated in the LIMS?

5. _____Are preparation notebooks, sample logs, run logs, instrument logs, and maintenance logs, accurate, up-to-date, and properly signed and reviewed? Are cross-outs correctly done?

6. _____Are the analysts backing up the raw data from the hard drive to the "M" drive?

7. _____How does the audited maintain the sample integrity? Are the sample and extracts stored properly?

8. _____Are thermometers, balance, pipettes, and other instruments used in this method calibrated and/or verified? Is there calibration documentation available?

9. _____What is the process to follow when reagents and standards are purchased and/or prepared? What information do you need to write on the label? Ask the analyst to show the traceability of the standards.

10. _____What instrument and equipment information is necessary to keep available and updated to ensure the generation of defensible data?

11. _____What does the audited do to minimize contamination in the preparatory and analytical process?

12. _____Explain the procedure used to prepare/analyze samples. Does the follow procedure consistent with the SOP? Is the SOP consistent with the referenced method?

13. _____Explain what kind of quantitation is performed in this method: calibration, calculations. How do you verify the calibration curve? Are excel files' formulas blocked?

14. _____Explain what is the Corrective Action Report, how does it work, and comment the CARs filled in the last year. Note: The auditor must ensure that the implemented corrective action helped to prevent the problem and it is effective as well as to ensure that the CARs have been closed.

15. _____The auditor will review a report to verify that final product meets QA and customer's specifications.

16.2 External Audits

16.2.1 Regulators associated with laboratory accreditation have access to view all information related to data generation. This includes final reports containing companies (some high profile) and contacts performing business with AWAL. Before allowing these regulators to view final reports the data packs are stamped confidential, the customer's information is blacked out with a permanent marker on a paper document or obscured digitally in a PDF file. This ensures assessors handle the information in accordance to CFR 40, Part 2, Subpart B, Confidentiality of Business Information.

16.3 Performance Audits

16.3.1 Accreditation bodies plan performance audit at least every other year to ensure that the laboratory's quality system meets the requirements to provide analytical service.

16.3.2 AWAL participates in a semiannual CWA, SDWA, and SOIL PT study.

16.3.3 AWAL participates in a quarterly ELPAT PT study.

16.3.4 Blind samples are purchased or prepared to evaluate the quality system of the laboratory and the laboratory personnel.

16.3.5 Customers audit AWAL to ensure the quality system is efficient as needed.

16.4 System Audits and Management Reviews

16.4.1 The laboratory quality system is reviewed at least once a year by the laboratory management and QA personnel. Designated personnel review the QA Manual, SOPs, training records, proficiency tests, corrective and preventive actions, customer feedback, complaints, internal audits, external assessments by external bodies, and other documentation.

16.4.2 The quality system review is documented as noted in Internal Assessments and Audits IAA001 SOP to ensure continued suitability, effectiveness and discovering areas of improvement.

16.4.3 Laboratory Director requests from the Area Managers and QAO a list of the items that need to be improved and based on that creates a list of the items that the laboratory needs to work on during the following year. The Laboratory Director assigns responsibility for each item, deadlines and frequency or revision. Refer to M\QA-QC\Management Review Tracking folder for detailed information. QAO keeps records of progress.

17.0 Personnel, Training, and Data Integrity

17.1 Job Descriptions. Refer to Exhibit 17.1.

Exhibit 17.1 AWAL Technical Personnel Requirements

POSITION	MINIMUM REQUIREMENTS EDUCATION and/or EXPERIENCE
Laboratory Director	♦ Ph.D. degree in science or engineering with at least 4 years of specific experience (including at least 1 year of supervisory experience), or ♦ M.S. degree with at least 6 years specific experience (including at least 1 year of supervisory experience), or ♦ Bachelor's degree in science or engineering with at least 8 years specific experience (including at least 2 years of supervisory experience).

POSITION	MINIMUM REQUIREMENTS EDUCATION and/or EXPERIENCE
Department Supervisor	♦ Bachelor's degree in science or engineering with at least 2 years specific experience, and ♦ 24 credit hours in chemistry.
QA Officer	♦ Bachelor's degree in science or engineering or at least 3 years environmental laboratory experience, and ♦ Formal training and experience in laboratory quality assurance procedures, regulatory quality systems, and statistical quality control.
Marketing Manager	♦ Bachelor's degree in science or engineering with at least 2 years specific experience (including at least 1 year of supervisory experience), and ♦ Marketing experience.
LIMS Supervisor	♦ Bachelor's degree in information technology, science or engineering with at least 2 years specific experience, and/or ♦ Laboratory Information Management System experience.
Bookkeeper	♦ Bachelor's degree, and ♦ Bookkeeping experience.
Chemist	♦ Bachelor's degree in science or engineering, no experience, or ♦ Bachelor's degree in non-science area with at least 2 years of specific experience, or ♦ A.S. degree with at least 5 years of specific experience, or ♦ At least 10 years specific experience, minimum of 3 chemistry classes.
Analyst	♦ Bachelor's degree in science or engineering, no specific experience, or ♦ Bachelor's degree in non-science area with no specific experience, minimum of 1 series of chemistry classes or specialized formal training, or ♦ A.S. degree with no specific experience, minimum of 1 series of chemistry classes or specialized formal training, or ♦ At least 2 years specific experience, minimum of 1 chemistry class or specialized formal training.
Technician	♦ B.S. degree and no experience, or ♦ Minimum of high school diploma with at least 6 months of equivalent experience, or ♦ Minimum of high school diploma with no experience and provided highly supervised training.
Intern	♦ Current college student with no experience with highly supervised training. ♦ Minimum of high school diploma with no experience and provided highly supervised training ♦ Temporary position.

POSITION	MINIMUM REQUIREMENTS EDUCATION and/or EXPERIENCE
Technician Assistant	♦ Current high school student with no experience and provided highly supervised training.
Sample Custody or Receiving Officer	♦ Minimum of high school diploma with at least 6 months of equivalent experience, or ♦ Minimum of high school diploma with no experience and provided highly supervised training.

17.2 Laboratory Director

17.2.1 The Laboratory Director

17.2.1.1 Has overall responsibility for the performance of the laboratory. This includes quality control, operations, and staffing. In the Laboratory Director's absence a deputy is assigned to carry out the assigned task and duties. The deputy possesses the educational requirements and experience necessary as depicted in Exhibit 17.1.

17.2.1.2 Manages daily operations of the laboratory.

17.2.1.3 Ensures the quality of laboratory data through a secure quality program.

17.2.1.4 Provides technical guidance.

17.2.1.5 Ensures the laboratory employs the most relevant methods.

17.2.1.6 Provides a safe working environment for the employees.

17.2.1.7 Ensures that waste is disposed in accordance with government regulations.

17.2.1.8 Maintains availability to customers for specific requests, questions, and complaints.

17.2.1.9 Administers the total quality management approach in the laboratory.

17.2.1.10 Recommends instruments and other hardware and software changes to the laboratory.

17.2.1.11 Assists in the marketing of the laboratory.

17.2.1.12 Provides accurate information on the laboratory capacity.

17.2.1.13 Approves SOPs, time cards, and purchases.

17.2.1.14 Interviews and recommends staffing hires.

17.2.1.15 Reviews department supervisors' performance on an annual basis.

17.2.1.16 Manages the overall staff including changing job positions, layoffs, or terminations.

17.2.1.17 Provides guidance in the purchase of computer hardware and software.

17.2.1.18 Communicates technical, organizational, financial, and laboratory goals to the staff.

17.2.1.19 Communicates to the Board of Directors the status of the laboratory on a weekly basis.

17.2.1.20 Holds daily meetings with senior staff to review work status, quality control, safety, and technical issues.

17.2.1.21 Ensures the ratio of supervisors to non-supervisors is sufficient to meet stated quality goals.

17.3 Technical Director(s)

17.3.1 The Department Supervisors

17.3.1.1 Report to the Laboratory Director and are responsible for specific analytical personnel and methods (organic and inorganic). The Department Supervisors are familiar with the test methods and the assessment of the results. Department Supervisors are responsible for daily data reviews and periodic corrective action report reviews.

17.3.1.2 The Department Supervisors address QA/QC problems at the bench level and make decisions based upon method, regulatory, and AWAL's QA/QC criteria. Department Supervisors work closely with analytical personnel, providing guidance and training relative to their specific job functions. They ensure on a daily basis that the laboratory data meet method, project, and laboratory quality control requirements and operations are properly documented. AWAL's Department Supervisors, Laboratory Director, and Quality Assurance Officer are responsible for assuring corrective actions have been initiated, necessary resolutions implemented, and are properly documented.

17.3.1.3 The Department Supervisors and Laboratory Director have the responsibility to: oversee that the QM, SOPs, and the CHP are being followed; perform final validation of raw data and final reports; evaluate

analytical techniques, procedures, instrumentation, and preventative maintenance schedules; and coordinate sample analysis flow in the laboratory.

17.3.1.4 The Department Supervisors and Laboratory Director ensure employees have received proper training and continue training for the positions they hold.

17.3.1.5 When the Department Supervisor is absent for a period of time exceeding 15 consecutive calendar days, he/she designates another full-time staff member meeting the qualifications listed on Exhibit 17.1 to temporarily perform this function. If this absence exceeds 35 consecutive calendar days, the Accreditation Bodies are notified in writing.

17.4 Quality Manager

17.4.1 The Quality Assurance Officer (QAO)

17.4.1.1 Reports directly to the Laboratory Director and is responsible for the quality system and its implementation. The QAO has direct access to the highest level of management (Laboratory Director) where policies are established. The QAO serves as the focal point for QA/QC and is responsible for the oversight and review of quality control data. The QAO conducts analytical data audits and overall system audits on a periodic basis and reports the findings to the Laboratory Director. The QAO is responsible for the maintenance of AWAL's Laboratory QM, SOPs, employee signature/initial log, and other quality-related documentation. The QAO informs the Laboratory Director and Department Supervisors of compliance and noncompliance issues in QA/QC criteria.

17.4.1.2 The QAO functions independently from the data production process, ensuring data is evaluated objectively, and assessments are performed without managerial influence. The QAO must have documented training and experience in QA/QC procedures, and knowledge of regulatory QC requirements. In addition, the QAO must have a general knowledge of analytical methods reviewed. The QAO is responsible for periodic review and generation of corrective action reports. Upon the QAO's prolonged absence, a deputy is assigned to carry out the assigned task and duties. The deputy possesses the educational requirements and experience necessary as depicted in Exhibit 17.1, and performs the task in a non-biased manner. Refer to Exhibit 17.2 for further information.

17.4.2 Refer to Quality Assurance Officer Guide QAO001 SOP for further information

Exhibit 17.2 QAO Assessment and Monitoring Responsibility and Schedule

Frequency	QA Task or Assessment	Personnel	Action
Daily	Checks refrigerator temperatures	QAO or designee	Record daily temps. Notify QAO if out of control.
Daily	Perform balance verification	Technical staff	Verify balance daily. Notify QAO if out of control.
Daily	Attend managers meeting document discussions	QAO, laboratory director, supervisors, and SROs.	Discuss how to handle, correct and problems.
As needed	Perform a data pack review	QAO	Track report to raw data, trace one standard & reagent per method and document.
During internal audits and when turned in	Review laboratory logbooks for completeness and calculation errors	QAO or designee	Perform corrective action as needed.
Daily	Pipette calibration checks	Technical staff	Ensure that it is performed and documented.
Quarterly	Pipette and dispenser verification	QAO or designee	Perform and document the pipette and dispenser verification.
Quarterly	Participation in approved PT Study (ELPAT)	QAO	Place order for study in November
Quarterly	Verify balance and area weights	QAO or designee	Perform corrective action as needed.
Semi-annually	Participate in approved PT Study (WS, WPs, DMRQA and Soil)	Technical staff	Place order for studies in December.
Annually	Update control limits that are lab. generated.	Technical staff, QAO, and designee	Use LIMS to update limits that are lab generated.
Annually	Ethics review/training	QAO	Train personnel annually.
Annually or as specified in SOP	NIST balances and digital thermometer calibration.	Certified company	Ensure that it is performed, with documentation filed.
Annually	SOP review	Employee, Department Supervisor, QAO, or designee	Perform SOP review/updates. May be merged with bench review
Annually or as needed	Adherence review of all laboratory methods at the bench.	QAO and designee	Interview and/or observe procedure. Perform corrective action as needed. May be merged with SOP review
Annually	Initiate MDL studies	QAO	Alert Technical staff of which methods need MDL's.
Annually or as needed	Review and amend QM, annually is a minimum.	QAO	Update to meet laboratory or TNI changes. Document in a checksheet or on a QM copy.
Annually	Review Training files for completeness	Department Supervisor, Technical staff, QAO, or designee	Notify personnel of deficiencies.
Annually	Review Records Management	QAO	Initiate CAR as needed

17.5 LIMS Supervisor.

17.5.1 LIMS Supervisor is responsible, in conjunction with the laboratory director, to specify, procure, and maintain all computer hardware and software used in the laboratory.

17.5.2 Programs and maintains the LIMS.

17.5.3 Performs backups and safely archive stored data.

17.6 Sample Custody/Receiving Officer (SRO).

17.6.1 Sample Custody/Receiving Officer in coordination with the Project Manager are responsible for timely communication between the customers and the laboratory.

17.6.2 SROs are responsible to receive the samples, verify that the information on the COC is consistent with the information on the samples, and log the samples into the LIMS.

17.6.3 SROs are responsible to purchase, preserve, prepare, and ship the containers to the customers.

17.7 Data Deliverables Personnel.

17.7.1 Data Deliverables Personnel (DDP) are responsible to generate the report in hard copy or electronic based on customers' requirements and deliver it to the Laboratory Director or designee for final review and signature.

17.7.2 DDP is responsible to send the report and EDD (if applicable) to the customer via fax, mail, or e-mail once the report is signed.

17.8 Analysts/Chemists

17.8.1 Analysts and Chemists perform analyses based on specified methods. They are responsible to implement the requirements of the QM, SOPs, and methods.

17.8.2 Provide maintenance to the instruments when required or as necessary.

17.9 Technician/Technician Assistants.

17.9.1 Technicians work under the direction of a chemist or analyst to perform analyses/preparations. They are responsible to implement specific procedures in keeping with the QM and client QA/QC requirements. Technician exercise technical judgment as assigned based upon training and experience.

17.10Data Integrity and Ethics

17.10.1 Refer to Laboratory Ethics and Data Integrity LEDI001 SOP for further information. Without exception, AWAL requires honest and ethical behavior of its employees. Laboratory personnel must never intentionally report data values, dates of analysis, or times of analysis other than the actual values, dates, or times observed. Laboratory personnel must never intentionally represent another individual's work as his/her own or misrepresent any other aspect of the analytical or reporting process. In addition, laboratory personnel must inform laboratory management of any unethical behavior observed of other employees within the laboratory.

17.10.2 The AWAL ethics policy is discussed with each new employee during initial orientation, and annually to emphasize its importance. A copy of the Ethics and Data Integrity Agreement (see Exhibit 17.3) is then signed by all employees and retained in the employee's training file. Violation of the agreement is basis for immediate termination of employment.

17.10.3 As part of initial training the employee reads the Employee Policy Guide and the Laboratory Ethics and Data Integrity SOP and signs the Acknowledgement Forms.

Exhibit 17.3 AWAL's Ethics and Data Integrity Agreement

American West Analytical Laboratories

Ethics and Data Integrity Agreement

I, _____ (insert name), understand the high standards and integrity required of me with regard to the duties I perform and the data I report in connection with my employment at American West Analytical Laboratories (AWAL).

I agree that in my performance of my duties at AWAL:

1. I shall not intentionally report data values that are not the actual values obtained or observed;
2. I shall not intentionally report the dates and times of the data analysis that are not the actual dates or times of analysis;
3. I shall not intentionally represent another individual's work as my own;
4. I shall not intentionally misrepresent any other aspect of the analytical or reporting process;
5. I shall not adjust another's work without concurrence;
6. I understand manual integrations may only be performed when necessary and must take in the full peak (tails and all). When performed, it must be documented and the entire batch (samples & QC) must be reviewed to ensure manual integration is appropriate.
7. I understand that I should read, use, and understand the latest revision of the AWAL Quality Manual as it relates to my job performance; and,
8. I will not knowingly create a conflict of interest with AWAL, its suppliers, and its customers. If a conflict of interest is generated I will notify AWAL immediately.
9. Customer confidentiality is a major responsibility of all AWAL employees. Customer information shall not be discussed with anyone outside of AWAL and the customer. Disclosure of information to the news media, radical organizations, and State & Federal Regulators is forbidden unless otherwise specified (SOP CC001).
10. If data integrity issues have been discovered, or are known to be occurring they may be reported in confidence to any AWAL manager, who will then bring the issue to the managers meeting for a decision (further investigation, corrective action, training, or disciplinary action).
11. I understand that there are penalties and punishments for improper, unethical, or illegal actions. This may include termination of employment and/or civil or criminal penalties.

Furthermore, I agree to inform AWAL of accidental reporting of non-authentic data by myself, or intentional reporting of non-authentic data by other employees in a timely manner.

_____ _____
Employee's Signature Date

17.11Data Integrity and Ethics Training

17.11.1 AWAL personnel are trained on Data Integrity and Ethics the date of hiring and annually. Records are kept by the QAO.

17.12General Training

Refer to Training TT001 SOP for further information. AWAL knows that its strongest assets are its well-trained and experienced personnel. AWAL has established employment standards and formal training opportunities for its employees to maintain a high level of technical expertise.
All laboratory personnel are responsible for complying with all QA and QC requirements that pertain to their technical function. Each laboratory staff member has an adequate combination of experience and education to demonstrate a specific knowledge of their particular functions and a general knowledge of laboratory operations, analytical methods, QA/QC procedures, and applicable records management.

17.12.1 Employee Orientation. Personnel training procedures begin with an established orientation program designed to familiarize new employees with corporate policies, federal and state regulations, as well as safety practices. New employees are required to read and understand the Laboratory Quality Manual, Chemical Hygiene Plan, Employee Policy Guide, Laboratory Ethics and Data Integrity LEDI001, and applicable SOPs.

17.12.2 Basic Training Requirements. AWAL has a structured training program for all new and cross-training resident employees. A mentor is assigned to the employee. With direction from the supervisor, the mentor has a very strong role in the proper training process. Basic training involves reading of SOPs and Methods; followed by supervised training by the mentor involving a step by step process of the analytical or preparation procedure, along with detailed training in the use of laboratory equipment (balances, pipettes, etc.).

17.12.3 Analytical Proficiency Certification. Preparation personnel, general chemistry personnel, instrumental chemists, and other designated employees must demonstrate initial analytical proficiency for each method or operation for which they are responsible. Documentation of current proficiency is in place in order to report analytical data for customer samples. Analytical proficiency is demonstrated by:

17.12.3.1 Reviewing the latest edition of the Laboratory Quality Manual.

17.12.3.2 Reviewing the latest edition of each applicable Laboratory SOP for which proficiency certification is sought.

17.12.3.3 Completing DOCs as specified in section 19.0.

17.12.4 Additional Training. Depending on the complexities of the area being taught, formal instruction may be needed from outside sources, like instrumentation or software vendors. AWAL provides this training. AWAL expects continuous improvement of its employees. This is done by ongoing reading of the methods, technical

magazines and books, networking with peers, and memberships in organizations. AWAL does sponsor memberships and conducts in-house seminars.

17.13 Minimum Qualifications. Laboratory management is responsible for defining the minimal level of qualification, experience, and skills necessary for all positions within the laboratory. Unless an extenuating circumstance is documented, personnel must meet the minimum requirements for employment listed in Exhibit 17.1.

17.14 Training Documentation. Employee training files include documentation of pre-employment education and/or experience (such as a resume), copies of relevant certificates, and other qualification information. Post-employment training and experience also are documented in the employee's training file. This training documentation includes the AWAL Employee Orientation, a detailed job description, ethics statement, SOP and QM reading records, Demonstration of Capability if applicable, and external training courses if provided. The employee, area supervisor, and QA Officer ensure that personnel training files are kept up to date.

18.0 Accommodations and Environmental Conditions

18.1 AWAL is located in Salt Lake City, Utah at 463 West 3600 South. The laboratory facility incorporates approximately 12,000 square feet. Administrative space accounts for approximately 3,500 square feet of this area, laboratory space for 7,000 square feet and storage space 1,500 square feet. See Exhibit 18.1 for the layout of the laboratory.

18.2 Work Areas. AWAL is divided into five central working areas with controlled access and entry ways to the laboratory: sample receiving and log in; sample preparation; analysis and reviewing; data handling and storage; and chemical storage, waste storage and sample disposal. These areas are designed to provide a safe and comfortable working environment with special attention given to preventing cross-contamination between areas. The volatile laboratory maintains positive pressure to eliminate laboratory contamination. Administrative offices are strategically located to facilitate supervisory access and efficient handling of paperwork and results.

18.3 Utilities. Each laboratory has the necessary utilities required for the process being performed. The laboratory has a generator that supplies enough energy to keep the instruments working in the event of a power outage or disruption. High purity gases are plumbed to each individual instrument from one central location. Deionized water (ASTM Type II & I) is prepared in the water supply room and delivered throughout the laboratory by a constant circulating system. Before installing new equipment or performing new functions in the laboratory, a non-documented review of the laboratory utilities and space is performed to ensure the proper resources and facilities are available for the function required. Reverse Osmosis (RO) is used in the Volatiles Laboratory.

18.4 Environmental Conditions. The laboratory ensures that equipment and facilities are in place to monitor, control and record environmental conditions as appropriate. Variables such as temperature, humidity, electrical power, vibration, electromagnetic fields, dust, direct sunlight, ventilation, and lighting are controlled so that quality data is produced. Environmental conditions that are specified in a particular method are documented.

18.5 Safety and Housekeeping. AWAL's facilities are designed to provide a safe and pleasant work environment. Specific safety equipment includes ventilation systems, hoods, sinks, eyewash bottles, safety showers, and fire extinguishers. Good housekeeping practices are required within the laboratory. A clean work area also contributes to data quality by reducing chances for contamination and other errors. Laboratory safety and housekeeping policies and procedures are detailed in the AWAL's Chemical Hygiene Plan.

18.6 Security. Sample and data security is critical for maintaining data quality and defensibility. AWAL is a limited-access facility and is protected by an electronic security system. Visitors to the laboratory are escorted at all times. Access to and use of certain critical areas within the laboratory (data storage files, customer files, sample storage, etc.) is limited to designated personnel by the means of physical or electronic controls.

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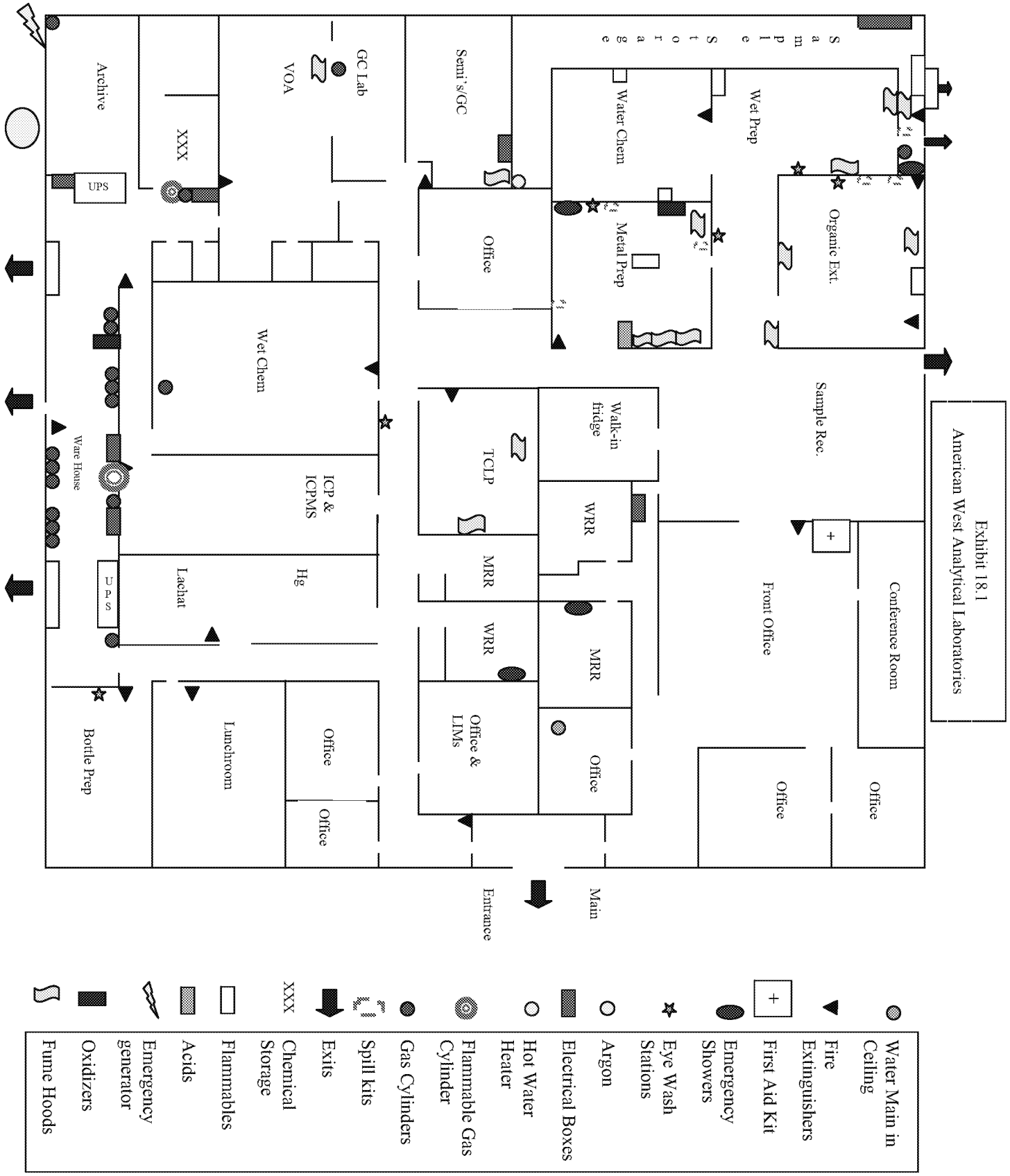
Exhibit 18.1
American West Analytical Laboratories
Conference Room
Office
Sample Rec.
Front Office
Office
Organic Ext.
Wet Prep
Sample Storage
Water Chem
Metal Prep
Office
Semi's/GC
GC Lab
VOA
Archive
XXX
UPS
Walk-in fridge
WRR
MRR
Office
TCLP
MRR
WRR
Office & LIMs
Entrance
Main
Wet Chem
ICP & ICPMS
Hg
Lachat
UPS
Ware House
Office
Office
Lunchroom
Bottle Prep
Water Main in Ceiling
Fire Extinguishers
First Aid Kit
Emergency Showers
Eye Wash Stations
Argon
Electrical Boxes
Hot Water Heater
Flammable Gas Cylinder
Gas Cylinders
Spill kits
Exits
Chemical Storage
Flammables
Acids
Emergency generator
Oxidizers
Fume Hoods

19.0 Test Method and Method Validation

19.1 Demonstration of Capability (DOC). Refer to Training TT001 SOP.

19.1.1 An initial demonstration of method performance (precision & accuracy) is made prior to using any method, and at any time there is a significant change of equipment, personnel, instrumentation, or procedures. A certification statement is maintained for each method for each employee as required (Exhibit 19.1).

19.1.2 These statements are maintained with training files. The following steps, which are adapted from TNI Quality Systems V1M4 and DoD QSM Appendix C, are performed:

19.1.2.1 Quality control check samples are prepared by the laboratory using stock standards that are prepared independently from those used in instrument calibration.

19.1.2.2 The concentrate is diluted in a volume of laboratory pure water sufficient to prepare four aliquots at the required method volume to a concentration approximately 1-4 times the laboratory calculated reporting limit.

19.1.2.3 The four aliquots are prepared and analyzed according to the method.

19.1.2.4 Using the four results, calculate the mean recovery in the appropriate reporting units (such as µg/L) and the standard deviation (in the same units) for each parameter of interest.

19.1.2.5 For each parameter, compare the standard deviation and the mean to the corresponding acceptance criteria for precision and accuracy against laboratory-generated acceptance criteria. If the standard deviation and mean for all parameters meet the acceptance criteria, the analysis of actual samples may begin. If any one of the parameters exceed the acceptance range, the performance is unacceptable for that parameter.

19.1.2.6 When one or more of the tested parameters fail at least one of the acceptance criteria, the analyst must proceed according to the following:

19.1.2.6.1 Locate and correct the source of the problem and repeat the test for all parameters of interest beginning with 19.1.2.3 above.

19.1.2.6.2 Beginning with 19.1.2.3 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 19.1.2.3.

19.1.3 Those analytes that cannot be spiked (pH, TS, VS, turbidity, TSS, TDS, TVS, Color, Odor, and DO) shows demonstration by the performance of a duplicate or blind audit if available. If the results of the duplicate fall within laboratory established RPDs the analyst is considered capable.

19.1.4 Other laboratory approved methods for demonstrating initial capability are:

19.1.4.1 Acceptable performance of single blind samples by the analyst.

19.1.4.2 At least four consecutive LCS with acceptable levels of accuracy and precision.

19.1.4.3 Passing analysis of a Proficiency Testing (PT) study parameter.

19.1.4.4 MDL study.

19.2 On-Going (or Continued) Proficiency

19.2.1 AWAL employees maintain up-to date training by certifying that they use the most up to date version of a method SOP and performing on-going demonstration proficiency on an annual basis. The following measures of proficiency are suitable for on-going demonstration of capability:

19.2.1.1 At least four consecutive LCS with acceptable levels of accuracy and precision.

19.2.1.2 Passing analysis of a PT study parameter.

19.2.1.3 Acceptable performance of single blind samples by the analyst.

19.2.1.4 MDL study.

19.2.1.5 Another Demonstration of Capability, using the same procedure described in section 19.1.2.

Exhibit 19.1 Initial and Continuing Demonstration of Capability

American West Analytical Laboratories

Demonstration of Capability

	Analyst or Prep Tech Name	DOC Type	Last Analytical Date	DOC Expiration Date	Test Code	Method Number	Test Description	Matrix
Analysis:	Lewis Cox	CDOC	01/08/2014	01/08/2015	PHENOLS-W-420.4	E420.4	Phenolics, Aqueous	Aqueous
Prep:	Connie Roberts	CDOC	01/08/2014	01/08/2015	PHENOLS-W-PR	1.1ExtW	Phenolics Prep, Aqueous	

IDOC: Initial Demonstration of Capability CDOC: Continuing Demonstration of Capability

Analysis SOP Name and Revision: 420.4_9066 Rev 10.0 Analysis SOP Applicable Date: 10/12/2010 DOC Code: PHENOLS-S-W-9066-420.4

Analysis EPA/Method Revision: [420.4: EPA Rev. 1, 1993]; [9066: EPA Rev. 0, 1986]

Prep SOP Name and Revision: 420.4_9066 Rev 10.0 Prep SOP Applicable Date: 10/12/2010 Prep DOC Code: PHENOLS-S-W-PR

Prep EPA/Method Revision: [420.4: EPA Rev. 1, 1993]; [9066: EPA Rev. 0, 1986]

See Raw Data for Standards/Spike IDs, and LIMS/Logbook for Expiration Dates

Raw Data is located in: Attached or See Corresponding Set

QAO Files MDL Location: 2014

Notes:

WE, the undersigned certify that, to the best of our knowledge:

The analyst identified above, using cited test method(s), which is in use in this facility for the analyses of samples under the National Environmental Laboratory accreditation program, have met Demonstration of Capability.

The test method(s) was performed by the analyst(s) identified on this certification. A copy of the test method(s) and the laboratory-specific SOP are available for all personnel on-site.

The data associated with the demonstration of capability are true, accurate and self-explanatory.

All raw data (including a copy of this certification form) necessary to reconstruct and validate these analyses have been retained at this facility and that the associated information is well organized and available for review by authorized assessors.

	DOC 1:		DOC 2:		DOC 3:		DOC 4:	
DOC Sample ID:	LCS-29817		LCS-29692		LCS-29569		LCS-29466	
Prep Date and Batch ID:	01/08/14 - 29817		01/02/14 - 29692		12/20/13 - 29569		12/17/13 - 29466	
Analytical Date and Run No	01/08/14 - 63505		01/08/14 - 63504		12/20/13 - 62982		12/19/13 - 62954	
Instrument ID:	WC-LACHAT8500-1		WC-LACHAT8500-1		WC-LACHAT8500-1		WC-LACHAT8500-1	
Corresponding Set:	1312033		1312541		1312401		1312296	

Analyte	**DOC 1: Result**	**DOC 1: % REC**	**DOC 2: Result**	**DOC 2: % REC**	**DOC 3: Result**	**DOC 3: % REC**	**DOC 4: Result**	**DOC 4: % REC**	**Spike Amount**	**Units**	**Avg. % REC**	**Low Limit**	**High Limit**	**Mean of Results**	**Std. Dev. of Results**	**Pass/Fail**	**Spike Values Equal**
Phenolics	0.502	100.34%	0.541	108.26%	0.533	106.53%	0.54	107.96%	0.5	mg/L	105.77%	90	110	0.529	0.0185	P	y

The Pass/Fail criteria is that each individual % recovery is within the limits. The percent recovery is calculated for each sample off their respective spike amounts, but the final Pass/Fail criteria is calculated off the displayed Spike amount and Limits from DOC 1. If the units and spike amount are not the same between all the analytes, this may give a Fail to an analyte that actually passed all the individual recoveries.

Approved by Supervisor: Or see cover sheet for signature if raw data is attached.

Heather Reese

Digitally signed by Heather Reese
DN: cn=Heather Reese, o=AWAL, ou, email=heather@awal-labs.com, c=US
Date: 2014.01.14 08:44:54 -07'00'

Approved by QAO:

Jose G. Rocha

Digitally signed by Jose G. Rocha
DN: cn=Jose G. Rocha, o=American West Analytical Laboratories, ou=Quality Assurance Officer, email=jose@awal-labs.com, c=US
Date: 2014.01.13 08:20:19 -07'00'

19.3 Initial Test Method Evaluation

19.3.1 Method Detection Limit (MDL)

19.3.1.1 The Method Detection Limit (MDL) is defined as the minimum concentration of a substance that is measured and reported with 99% confidence when an analyte concentration that is greater than zero is determined in a specific matrix containing the analyte.

19.3.1.2 MDLs are determined as detailed in 40 CFR Part 136, Appendix B unless otherwise specified by a method or program. The MDL is determined for the compounds of interest in an appropriate matrix such as laboratory pure water or reagent soil.

19.3.1.3 Analyte detection limits are determined initially, annually, and for each significant change in the analytical procedure or instrument for each analytical method and analyte. The MDL ensures the laboratory is utilizing the appropriate determinative method for the detection limit required. All associated preparation and analysis procedures and results are documented.

19.3.1.4 Refer to MDL, LOD, and LOQ MLL001 SOP for further information.

19.3.2 Limit of Detection (LOD)

19.3.2.1 The Limit of Detection (LOD) is defined as the smallest amount or concentration of a substance that must be present in a sample in order to be detected at a high level of confidence (99%). At the LOD, the false negative rate (Type II error) is 1%. The LOD only needs to be determined for test codes that will be used for specific projects.

19.3.2.2 The laboratory has established a procedure to determine the LOD by spiking a quality system matrix of approximately two to three times the MDL (for a single-analyte standard) or greater than one to four times the MDL (for a multi-analyte standard). It is specific to each combination of analyte, matrix, method (including sample preparation), and instrument configuration. The LOD is verified quarterly. The following requirements apply to the MDL and LOD determinations and to the quarterly LOD verifications:

19.3.2.2.1 The apparent signal to noise ratio at the LOD must be at least three and the results must meet all method requirements for analyte identification (e.g., ion abundance, second-column confirmation, or pattern recognition). For data that systems that do not provide a measure of noise, the signal produced by the verification sample must produce result that is at least three standard

deviations greater than the mean method blank concentrations.

19.3.2.3 Verify the LOD on each instrument when multiple instruments are used for a given method.

19.3.2.4 If the LOD verification fails, repeat the MDL determination and LOD verification at a higher concentration or perform and pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher.

19.3.2.5 Document the MDL determinations and LOD verifications.

19.3.2.6 The LOD must be reported for all methods unless it is not applicable to the test or specifically excluded by project requirements.

19.3.2.7 Refer to MDL, LOD, and LOQ MLL001 SOP for further information.

19.3.2.8 LODs must be determined if there is a change in the test method that affects how the test is performed, or if there is a significant change in instrumentation.

19.3.3 Limit of Quantitation (LOQ)

19.3.3.1 The reporting limit is the value below which results are reported as "none detected" or "less than the reporting limit." The reporting limit is always greater than the analyte MDL. Ideally, it is set near the MDL (2 to 5 times greater is recommended) and below the regulatory level (i.e., drinking water, groundwater, or other standard). Reporting limits are evaluated after each new MDL study to ensure their appropriateness. As with reported values, reporting limits are corrected for dilution, concentration, and other sample manipulations.

19.3.3.2 For DoD projects, the LOQ is set within the calibration range (including the low calibration point) prior to sample analysis. The LOQ is verified quarterly including the precision and bias. If the method is modified, precision and bias at the new LOQ is demonstrated and reported.

19.3.3.3 Refer to MDL, LOD, and LOQ MLL001 SOP for further information.

19.3.4 Precision

19.3.4.1 AWAL utilizes QC samples such as sample duplicates, matrix spikes, and matrix spike duplicates among others to determine the precision. The frequency of these samples is specified by method, DoD, and TNI requirements.

19.3.5 Selectivity

19.3.5.1 When reporting data for methods that require confirmation using a second column or detector, mass spectral tuning, ICP inter-element interference checks, chromatography retention windows, sample blanks, spectrochemical absorption or fluorescence profiles, and electrode response factors; project-specific reporting requirements are followed. If project-specific requirements have not been specified, follow the reporting requirements in the method. If the method does not include reporting requirements, then report the results from the primary column or detector, unless there is a scientifically valid and documented reason for not doing so.

19.3.5.2 Results that are unconfirmed, or for which confirmation was not performed, are identified in the analytical report, using appropriate data qualifier flags, and explained in the case narrative, if applicable. The laboratory use method-specified acceptance criteria for analyte confirmation. If method-specific criteria do not exist, the laboratory must develop acceptance criteria and document them in the SOP.

19.4 Estimation of Uncertainty

19.4.1 Uncertainty is determined only when it is relevant to the validity or application of the rest of the results, when it is required by customers, or when it affects compliance to a specification limit.

19.4.2 Refer to Estimation of Uncertainty EUAM001 SOP for further information.

19.5 Laboratory-Developed or Non-Standard Method Validation

19.5.1 Where it is necessary to employ methods that have not been established as standard, these are subject to agreement with the customer, be fully documented and validated, and be available to the customer and other recipients of laboratory data.

20.0 Equipment

20.1 General Equipment Requirements

20.1.1 AWAL has all items of equipment required for correct performance for all certified methods which the laboratory performs. In order to produce accurate and reliable data, analytical equipment must be properly maintained and calibrated.

20.1.2 Manufacturer's instructions and AWAL's SOPs provide guidance for the proper maintenance, inspection, and cleaning of analytical equipment and instrumentation. All equipment maintenance is documented in the equipment paper or electronic logbooks. Any item of equipment proven to give suspect results or found to be defective is removed from service until repairs are performed and a proper calibration is established.

20.2 Support Equipment

20.2.1 Support Equipment Maintenance

20.2.1.1 Specified measurement equipment, such as balances, thermometers, and mechanical pipettes, must be calibrated (or the calibration verified) on a daily, monthly, quarterly, or annual basis. All routine maintenance, repair, and service calls are recorded in the appropriate Instrument Maintenance Logbooks.

20.2.2 Support Equipment Calibration

Prior to each day use, balances, ovens, refrigerators, freezers, and water baths must be traceable to NIST references in the expected range of use. AWAL establishes and maintains correction factors for measurement equipment. If the result of a verification check indicates that the item is outside of acceptance ranges, the equipment is removed from service. Additional measurements and acceptability requirements are prescribed by the individual methods, i.e. room temperature or cycle time. All checks are documented and retained. Each item of equipment is, when appropriate, labeled, marked, or otherwise identified to indicate its calibration status.

20.2.2.1 Balances. An external certified service engineer on an annual basis provides services to all balances. Analytical balances and top loading balances are verified daily using class S weights or equivalent by the technician before its use. All verifications are recorded in the maintenance log associated with each balance. The QAO oversees or designee the verification of balances quarterly, maintains documentation, and coordinates annual service. Refer to Balance Calibration –Verification BCV001 SOP for further information.

20.2.2.2 Thermometers. Glass and equipment thermometers are verified annually and electronic thermometers are verified quarterly. against an NIST-traceable reference thermometer, which is calibrated every 5 years through a NIST service vender. If correction factors are required as a result of verification, the thermometer is labeled with the correction factor or it is discarded in favor of a thermometer that does not require correction. Refer to Refrigeration Units RU001 SOP for further information.

20.2.2.3 Mechanical volumetric dispensing devices. Quantitative pipettes are verified daily by the person before its use and quarterly by the QAO or designee. Quantitative dispensers are verified quarterly. Refer to Calibration-Verification of Pipettors and Dispensers CVP001 SOP and Thermometers Verification TV001 SOP for further information.

20.2.2.4 Weights. Laboratory weights are ASTM 1, Class S or equivalent. Each balance in the laboratory has a set of weights needed for its daily

verification. QAO has a set of NIST weights that are used to verify the weights placed throughout the laboratory, these are controlled and only used by the QAO. External weight calibrations are performed every 5 years through a NIST/ISO17025 service vender. Refer to Balance Calibration –Verification BCV001 SOP for further information.

20.3 Analytical Equipment

20.3.1 Maintenance for Analytical Equipment

20.3.1.1 A list of instruments and equipment used at AWAL are listed in Exhibit 20.1. AWAL maintains full service contracts on all major equipment. AWAL utilizes technical phone support whenever needed for the equipment or instruments not under contract.

20.3.1.2 To minimize down time and interruption of analytical work, routine preventive maintenance is performed on each analytical instrument. Schedules for preventive maintenance are listed in the instruments' maintenance logbooks. Each analyst is trained to maintain their instrument properly according to the manufacturers' recommended suggestions.

20.3.1.3 Maintenance activities are recorded in the appropriate Instrument Maintenance Logbooks. These logbooks include documentation on all routine and non-routine maintenance situations. Maintenance logbooks document any troubleshooting and diagnostic approaches to problems. The books are used to record information given when making any service calls. Instruments that are not able to meet method calibration or tune requirements do not conduct sample analysis until requirements are met.

Exhibit 20.1 AWAL Equipment List 2011

Type of Instrument	Instrument Lab ID	Manufacturer	Model #	Options, detector, etc.	LIMS ID (where applicable)	Methods Performed
GC/MS	5973-A	HP/HP	5973/6890	MS, Solotek 72 & 3100 concentrator	V-5973-A	8260C, 624
GC/MS	5973-B	HP/HP	5973/6890	MS & 7683 Injector	SV-5973-B	8270D, 625
GC/MS	7890-E	Agilent	5975C/7890A	MS & 7693 INJECTOR	SV-7890A-E	8270D, 625
GC/MS	5973-C	HP/HP	5973/6890	MS, ATOMX	V-5973-C	8260C, 624
GC/MS	5973-D	Agilent/Agilent	6890N/5973N	MS ATOMX	V-5973-D	8260C, 624
GC	#5	HP	5890	ECD	GC-5890-5	8082A, 8151A
GC	#1	Agilent	6890N	ECD	GC-6890-1	8082A
GC	C	Agilent	7890A	7693 Autosampler, Front and Back FID Detectors	GC-7890A-1B / GC-7890A-1F	8015D
GC	A	HP	6890 G1530A	ECD	GC-6890-A	8081B,608,504.1, 8011
GC	B	HP	5890 Series II	ECD	GC-5890-B	8081B,608
GC	#2	HP	5890E	PID & FID	GC-5890-2	8015D, 8021B
ICP/MS	ICP-MS	Perkin Elmer	Elan 6100 DRC II	MS & Auto Sampler	M-ICPMS6100-1	200.8, 6020A
ICP/MS	ICP-MS	Agilent	7700	MS & Autosampler	M-ICPMS7700-1	200.8, 6020A
ICP	ICP-8300	Perkin Elmer	Optima 8300	Auto Sampler	M-ICP8300-1	200.7, 6010C
ICP	ICP 5300	Perkin Elmer	5300 DV	Auto Sampler	M-ICP5300-1	200.7, 6010C
Cold Vapor	Hg	CETAC	M-7500	Quick Trace Mercury Analyzer	M-HG7500-1	245.1, 7470A, 7471B
IC	IC	Metrohm-Peak	IC System 2	Pump, interface, liquid handling unit, conductivity detector, autosampler, guard column and anion suppressor.	WC-IC-1	300.0. 9056A
Ion Analyzer	Lachat FIA 8500	Lachat	8500		WC-LACAHAT8500-1	350.1, 351.2, 420.4, 9066, 365.1, 335.4, 335.1, 353.2 9012B& 8.3, 7196A, 3500Cr B, 4500 CL E,
Ion Analyzer	Larry	Orion	EA 940	Probes (pH, Fluoride)	WC-ORION940-1	9040C, 9045D, 4500-F C, 2310B, 2320B
pH Meter	Accumet 15	Fisher Scientific	Accumet 15	pH probe	WC-MISC	5210B
pH Meter	Yo-Yo Ma	VWR Symphony	SB70P	Thermo-triode pH probe	WC-MISC	5210B (pH adj.)
TOC	TOC	Teledyne Tekmar	Apollo 9000	223 sample challenger	WC-APOLLO9000-1	5310B
TOX	TOX/AO3	MCI/Dohrman	TOX10/AO3	None	WC-MCI-TOX10-1	9020B

Type of Instrument	Instrument Lab ID	Manufacturer	Model #	Options, detector, etc.	LIMS ID (where applicable)	Methods Performed
Conductivity Meter	Corning Conductivity Meter 441	Corning	441	None	WC-CORNING441-1	2510B
Spectrophotometer	DR2000	HACH	DR 2000	Curvettes & COD adapter	WC-HACH2000-1	HACH 8000, 4500SO4-2E
Turbidimeter	HF Micro 100	HF Scientific	Micro 100	None	WC-HF100-1	180.1
Flash	Pensky Martin Flash Tester	Fisher Scientific	N/A	None	WC-MISC	1010A
DO Meter	YSI 58	YSI	58	DO probe	WC-YSI58-1	5210B
COD Block Digester	HACH Reactor	HACH	45600-00	None	WC-HACH2800-1	HACH 8000
COD Block Digester	Top Hat	Thermo Electron Corporation	F101A0125TO	None	WC-MISC	HACH 8000
Accelerated Solvent Extractor	ACE	Dionex	ASE 200	None	N/A	3545A
GPC	GPC	J2 Scientific	Accuprep	UV detector	N/A	3640A
Microwave	TINA	Milestone Ethos EX	MA074	None	N/A	3646
Cyanide Distillation	Midi-Vap	Midi-Vap	MCS103	None	N/A	9012B, 335.4, 335.1
Midi Distillation	Steve	Lab Crest	110-10P-PA	Ammonia glassware	N/A	350.1
Hot Block	Miss B	Environmental Express	SC-154	None	N/A	200.7, 200.8, 3005A, 3010A, 3020A
Phenol/Fluoride Distillation	Mental Block	Environmental Express	MicroBlock 5	Fluoride and Phenol Glassware	N/A	420.4, 9066, 340.2
TKN Block Digester	Old Smokey	Technicon/Lachat	BD-20/BD-26	None	N/A	365.1, 351.2
Muffle furnace	MF	Satellite	J-201	None	N/A	160.4
Oven	TSS Oven	Quincy Lab.	40GC	None	N/A	SM2540B, 2540D
Oven	Slim Jim	Lindberg	MO 1450A-1A	None	N/A	2540C
Oven	Evil	Fisher Scientific	M526G	None	N/A	2540B, 2510D
Oven	Hot Flash	Cermaco		None	N/A	1311/1312 filter drying
Oven	Oven-VOA	Fisher Scientific	615G	None	N/A	N/A
Org. concentrator	A	Zymark	TurboVap II	None	N/A	3510C
Org. concentrator	B	Zymark	TurboVap II	None	N/A	3510C
Incubator	Frosty	Frigidaire	FFU20FC6AW4	HACH Incutrol/2	N/A	5210B
Incubator	BOD-1	VWR	2030	None	N/A	5210B
Balance	Level Headed	Shimadzu	AUW320	None	N/A	3051A, 2540B
Balance	Ashley	Mettler	AE 166	None	N/A	Various reagent/ standard prep
Balance	Courtney	Mettler-Toledo	ML3001E	None	N/A	Various reagent/standard prep
Balance	GIZMO	Mettler-Toledo	PB3002-S/FACT	None	N/A	Various reagent/standard prep

Type of Instrument	Instrument Lab ID	Manufacturer	Model #	Options, detector, etc.	LIMS ID (where applicable)	Methods Performed
Balance	Opie	Fisher	XL 3000D	None	N/A	3550B, 3545A, 3546
Balance	Waste Chem	Mettler	AE 160	None	N/A	160.2, 160.4, 2540B, 2510D
Balance	Shadow	Denver Instruments	XS 210	None		8260C
Centrifuge	Tilt O Whirl	International Equipment Co	SBV	None	N/A	Various sample preps
Microwave	Black Monday	Panasonic	NN-H3658F	OI Analytical Vessels	N/A	3051A
Hot Plate	Hot Stuff	VWR / Henry Troemner	730 Advanced	None	N/A	Customer specific methods
Hot Plate	Napoleon	Corning	PC-520	None	N/A	1664A, 9070A
Hot Plate	Corning Hotplate	Corning	PC-500	None	N/A	Misc. use
Hot Plate	HP-VOA	VWR	986954	None	N/A	N/A
Sonicator	Vibra cell	Sonics Materials	VC600-C	Various cones	N/A	3550B
Ultrasonic	Solid State	Fisher Scientific	FS-28	None	N/A	Reagent degassing & cleaning
Shaker	Shaker	Burrell Corp	75	None	N/A	Various preps
Sep Funnel Shaker	Glass-col	Glass-col	3D shaker	None	N/A	3510C
Stir Plate	Cyclone	Thermolyne	S47035	None	N/A	Various reagent preps
Stir Plate	Hurricane	Thermolyne	S47035	None	N/A	Various reagent preps
Stir Plate	Whirlpool	Thermolyne	S47035	None	N/A	Various reagent preps
Hot Plate	Hg PREP.	Corning	6795PR	None	N/A	7470A, 7471B, others
TCLP Box	Tumbler	Dayton	2Z794D	None	N/A	1311, 1312
TCLP ZHE	ZHE	Analytical Testing	N/A	None	N/A	1311, 1312
Refrigerator	Sample Rec. 3	Fisher Scientific	Isotemp	None	N/A	Sample Storage
Refrigerator	Stratosphere	Frigidaire	N/A	None	N/A	Standard Storage
Refrigerator	VOA-1	Lacrosse	Sum40A	None	N/A	Archive Sample Storage
Refrigerator	VOA-2	GE	N/A	None	N/A	Sample Storage
Refrigerator	VOA-3	Sears	Gold spot	None	N/A	Sample Storage
Freezer	It's a Gas	GE	N/A	None	N/A	Standard Storage
Refrigerator	Semi-1	Hotpoint	CTF18E	None	N/A	Extract Storage
Refrigerator	Semi-2	Frigidare	LFPH44M4LM	None	N/A	Standard Storage
Refrigerator	Johnny Cash	Frigidaire		None	N/A	Distillate Storage
Refrigerator	WC-2	Whirlpool	N/A	None	N/A	Standard Storage
Freezer	Semi-3	GE	Fum5snww	None	N/A	Standard storage
Freezer	Org Ext 1	Whirlpool	ETV161WRO	None	N/A	Standard Storage
Freezer	Org Ext 2	Haier	N/A	None	N/A	Standard Storage
Walk-in	US Cooler	US Cooler	FFR 3476PGI	None	N/A	Sample Storage

20.3.2 Initial Instrument Calibration

20.3.2.1 Where possible, measurements made by the laboratory are traceable to national standards of measurement. Certificates of analysis, which indicate the traceability to national standards of measurement, are maintained in the laboratory. Refer to Standards and Traceability TRAC003 SOP for further information.

20.3.2.2 All calibration raw data must be dated and labeled with the method, instrument, analysis date, analyte concentrations, analyte response (or response factor), and maintained for a period no less than 5 years. When a calibration curve is used, the axes must be clearly labeled. The equation for the curve and the correlation coefficient are recorded. In general, a correlation coefficient for the calibration curve must be 0.995 or greater. Initial instrument calibrations are verified with a second source when available. Details of initial instrument calibration procedures and continuing calibration verification are referenced in the test method SOP. Data associated with unacceptable initial calibration are not reported.

20.3.3 Continuing Instrument Calibration

20.3.3.1 Initial Calibration Verification. Initial calibrations are verified with standards obtained from a second or different source. These verification standards are analyzed with each initial calibration. When not specified by the analytical method, the value of the analyte(s) in the calibration verification standards should be within 15% of the true value unless the laboratory can demonstrate that wider limits are applicable. When an initial calibration curve is not run on the day of analysis, the integrity of the initial calibration curve is verified on the day of use (or 24 hour period) by initially analyzing a blank and a standard at the mid-level concentration or the method specified concentration.

20.3.3.2 Continuing Calibration Verification. The instrument calibration is verified with a mid-range Continuing Calibration Verification (CCV) standard which is analyzed every 10 samples, 12 hours, or as specified by the method or SOP. The CCV is a standard used in the original calibration curve or a standard from another source.
The concentration of these standards is determined by the anticipated or known concentration of the samples and/or method specified levels. To the extent possible, the samples in each interval (i.e., every 20 samples or every 12 hours) are bracketed with standard concentration closely representing the mid-range of reported sample concentrations. If possible, the standard calibration checks should vary in concentration throughout the range of the data being acquired.

20.3.4 Unacceptable Continuing Instrument Calibration Verifications

20.3.4.1 A new curve is run if one of the two successive continuing calibration checks is outside acceptable limits. Affected samples are re-analyzed after a new calibration curve has been established, evaluated and accepted. When the continuing calibration acceptance limit is exceeded high (i.e., high bias), non-detect samples prior to the continuing calibration are reported with an appropriate qualifier. Samples may not be quantitated from the continuing calibration verification.

21.0 Measurement Traceability

21.1 Reference Standards

Where possible, measurements made by the laboratory are traceable to national standards of measurement. Certificates of analysis, which indicate the traceability to national standards of measurement, are maintained in the laboratory. Refer to Standards and Traceability TRAC003 SOP for further information.
All calibration raw data must be dated and labeled with the method, instrument, analysis date, analyte concentrations, analyte response (or response factor), and maintained for a period no less than 5 years. When a calibration curve is used, the axes must be clearly labeled. The equation for the curve and the correlation coefficient are recorded. In general, a correlation coefficient for the calibration curve must be 0.995 or greater. Initial instrument calibrations are verified with a second source when available. Details of initial instrument calibration procedures and continuing calibration verification are referenced in the test method SOP. Data associated with unacceptable initial calibration are not reported.

21.1.1 Calibration Standards. Analytical standards used for calibration include neat (reference) materials, stock solutions, intermediate solutions, working/calibration standards, and calibration verification standards and are discussed below.

21.1.2 Neat Materials. Pure or Primary Standard grade (reference) materials used for preparation of other standards must be accompanied by certificates of analysis or similar proof of purity. Where applicable, EPA certified reference materials or customer-supplied certified analytical reference materials are used. All standard materials are labeled with the receiving date, laboratory ID, expiration date and receiving analyst initials, name, or LIMS ID upon receipt. If the manufacturer does not supply an expiration date it is deemed stable and given a shelf life of twenty years and verified during the analysis of the method blank sample for contamination or expiration. Expiration dates are checked before any reference material is used within the laboratory. In addition, the LIMS does not allow expired chemical, reagents, spikes, or standards to be entered into preparation or analytical batches, or to be used when adding a new primary or intermediate reagent or spike/standard solution.

21.1.3 Stock Solutions. Stock solutions are prepared by dissolving known amounts of reference material(s) in a suitable solvent. Alternatively, stock solutions are purchased from vendors capable of supplying appropriately certified solutions.

21.1.4 Intermediate Standard Solutions. Intermediate standard solutions are often used during the preparation of calibration, verification, and surrogate standard solutions. Intermediate standard solutions are prepared by diluting known quantities of stock solutions to concentration ranges between the stock and finals standards. The preparation of intermediate standard solutions is recorded and the containers labeled the same way as stock solutions and are generally included in the same logbook/LIMS or laboratory record.

21.1.5 Calibration Standards. Final calibration standards are prepared by diluting stock or intermediate solutions to the concentration(s) required by the analytical method. Preparation is recorded in a standards logbook/LIMS in the same way as stock and intermediate solutions so that the final record provides traceability of daily standards to a certified material or supplier. Each calibration standard container is labeled with or traceable to the laboratory ID, reagent, concentration, expiration date, and preparer's initials, name, or LIMS ID.

21.1.6 Calibration Verification Standards. Initial Calibration Verification (ICV) standards are prepared from reference materials or stock solutions that have been obtained from a different source or lot number than that used for the calibration standards.

21.2 Reference Materials. SRMs are purchased samples with known values. The values are not made known to the analyst until analysis is complete. SRMs are utilized as internal laboratory check on performance. The laboratory performs these checks when needed.

21.3 Transport and Storage of Reference Standards and Materials

21.3.1 Purchased and prepared standards are stored between -10°C and -20°C for organics or 0°C and 6°C for inorganics (or following manufacturer's recommendations) when not in use and are kept separated from samples and extracts. Expiration dates are assigned by the vendor and/or are checked before stock solutions are used in the laboratory

21.3.1.1 Prepared and verified standards are stored in refrigerated areas separate from samples and extracts.

21.4 Labeling of Reference Standards, Reagents, and Materials

21.4.1 Whether prepared in the laboratory or purchased from a suitable source, the following information is recorded on the bottle containing the solution:

21.4.1.1 Contents, name or identification #.

21.4.1.2 Concentration(s).

21.4.1.3 Date prepared/Purchased.

21.4.1.4 Initials, LIMS ID number, or name of the analyst preparing the standard (Lot number if purchased).

21.4.1.5 Expiration date.

21.4.1.6 Other information regarding the stock solution is entered into the standards logbook or laboratory record specific to the analysis or area where the solution was prepared. The information must include:

21.4.1.6.1 Preparation procedure.

21.4.1.6.2 Solvent used.

21.4.1.6.3 Lot number of solvent used.

21.4.1.6.4 Date prepared.

21.4.1.6.5 Concentration(s).

21.4.1.6.6 Reference material source, purity, lot number.

21.4.1.6.7 Expiration date.

21.4.1.6.8 Analysts' initials, LIMS ID number, or name.

22.0 Sample Management

AWAL is considered a controlled-access facility, therefore the samples maintained in the laboratory are considered in possession of the laboratory for custody purposes. Although AWAL is not a primary provider of sample collection services, it recognizes the importance of proper sample collection and preservation. AWAL works closely with its customers to ensure samples are properly collected and preserved. Such discussion is essential to ensuring the selection of samples and analytical methods that provide data consistent with the objectives of the project.

22.1 Sample Receipt. Refer to Sample Receiving SR003 SOP for further information

22.1.1 Upon arrival of samples at AWAL:

22.1.1.1 Sample Receiving Officer (SRO) reviews the customer's Chain of Custody (Refer to Exhibit 15.1) for completeness. The COC includes the following information:

22.1.1.2 Name, address, phone number, fax number (optional) and email (optional) of the company and/or technical contact.

22.1.1.3 Project/site ID (location).

22.1.1.4 Customer sample ID. This must be consistent with the identifiers on the sample bottles.

22.1.1.5 Sample collection date and time.

22.1.1.6 Sample matrix and number of containers.

22.1.1.7 Name of sampler.

22.1.1.8 Signature of the delivery person. If the samples are shipped to the laboratory, it is noted under the "Laboratory Use Only" section of the COC.

22.1.1.9 Turn Around Time (TAT).

22.1.1.10 QC level.

22.1.1.11 The following information is added to the COC by the SRO:

22.1.1.11.1 The time and date of when samples are received at the laboratory is documented on the COC along with the signature of person receiving them.

22.1.1.11.2 The laboratory Work Order or set identification number.

22.1.1.12 Sample receiving information must be entered into the Check-in logbook, and assigned a unique laboratory set identification number. This identification number follows the formula YYMM###, where YY is the last two digits of the year, MM is the two digit code for the month, and ### is a sequential three digit number that starts at 001 each month.

22.1.1.12.1 The sample check-in logbook documents the following information: initials of a receiving personnel, date in, time in, company, samples (quantity & matrix), analysis requested, temperature, comments, rush (if applicable), and laboratory identification.

22.1.1.12.2 If a non AWAL COC is used, complete and attach Exhibit 22.2 to the COC received.

22.1.1.12.3 The temperature is taken of a representative sample using the calibrated infrared thermometer, and documented in the space provided (item #3 in "laboratory use only" box under "samples were:") on the laboratory COC.

22.1.1.12.3.1 The IR temperature beam is pointed at the white section of the sample label.

22.1.1.13 Other requested information is completed in the Laboratory Use Only section: shipped or hand delivered, ambient or chilled, received

broken/leaking (improperly sealed), properly preserved, if the preservation will be checked at the bench, received within hold times. Circle the appropriate response: yes (Y); no (N); or write in a comment.

22.1.1.13.1 Broken samples: coolers containing broken or leaking samples are immediately moved to a hood in the login area that is properly calibrated to 100 cfm where safe cleanup is conducted. The customer is notified to determine whether to proceed with analysis or obtain new sample(s).

22.1.1.13.2 Additional pH preservation documentation: Samples are checked for proper preservation as described in Exhibit 22.2, Sample Volume and Preservation Requirements. All samples (except those that would have their integrity compromised by opening, e.g., VOAs and TOX) must be checked for preservation or whose matrices prevent an accurate check. To check sample pH, a small portion of sample is poured into the sample lid and then poured from the lid gently over wide range pH paper. This information is recorded on Exhibit 22.3, the Preservation Check Sheet.

Note: Samples must be preserved by the customer at the time of collection when physically possible. This is required by the USEPA.

22.1.1.13.3 Samples not preserved or insufficiently preserved must be preserved by receiving personnel. These samples are qualified as received with insufficient preservative or not preserved on the COC and on the preservation check sheet that is attached to each COC requiring an acid or base preservation. Samples requiring chlorine neutralization is checked for chlorine by the analyst performing the analysis (checked at bench). This is documented in the LIMS by the analyst.

22.1.1.13.4 Samples that have preservation issues have their container flagged by the SRO to let the analyst know a qualifier has to be added to the sample results. The information is also added to the "WorkOrder Comments" section of the LIMS.

22.1.1.14 The "COC Tape Was" section describes the condition of COC seals on the samples with the following questions: present on outer package, unbroken on outer package, present on sample, unbroken on sample. A yes (Y), no (N) and not applicable (NA) response have been provided under each question. If the question cannot be answered with a simple yes, no, or not applicable response, it is explained in the notes section provided.

22.1.1.14.1 A broken seal is defined as a complete tear along the surface area between the sample container cap and bottle (a tear in any other location is acceptable), one that is no longer contacting the container (peeled off), or one that was not utilized correctly.

22.1.1.15 If there are discrepancies between the COC and sample labels, the "Y" is circled and the situation is described in the notes section provided. When a discrepancy is noted, the customer must be contacted for clarification. The SRO may contact the customer or pass the responsibility to the laboratory marketing manager, laboratory director, QAO, or technical supervisors when technical knowledge is required. If a discrepancy is not present then "N" must be circled.

22.1.1.15.1 Other discrepancies that might occur that need customer clarification and documentation include: method version requested if not performed by the laboratory, sample received in the wrong container, preserved incorrectly, and sample received outside holding time limit.

22.1.1.15.2 Records of such correspondence must be maintained as part of the laboratory records.

22.1.1.15.2.1 If the samples are returned to the customer the original or a copy of the original COC must be signed and returned with the samples. A scanned copy of the COC is retained for AWAL's records. Refer to Exhibit 22.1 for further information.

22.2 Sample Acceptance

22.2.1 AWAL understands that sample integrity is a vital part of Quality Assurance. Samples submitted to the laboratory are logged in immediately. If there must be a delay in this process, log-in personnel are made aware of those samples requiring refrigeration and store them accordingly. AWAL has an established sample acceptance policy (Exhibit 22.1). Any sample that is suspected of being contaminated, improperly stored, improperly preserved, or improperly prepared, is reported to the customer and/or department supervisor immediately for resolution. Unresolved problems concerning sample integrity are clearly documented on the COC and on the final report.

22.2.2 During sample receipt, a visual observation is made to check the integrity of the sample and its container. All required checks are documented on the COC or a preservation checklist attached to the COC. Refer to Exhibit 22.2 or Exhibit 22.3.

Exhibit 22.1 AWAL Sample Acceptance Policy

American West Analytical Laboratories
Sample Acceptance Policy

Under the requirements of the State of Utah, The NELAC Institute (TNI), the Department of Defense (DoD), and other regulatory programs, American West Analytical Laboratories (AWAL) is required to have a Sample Acceptance Policy (SAP) and to provide it to the customers. To conform to these rules AWAL is making the SAP available to our customers.

Samples which are received by AWAL will be inspected to determine the suitability for sample analysis. Samples, which do not meet the proper sampling criteria, will be flagged on the chain of custody and/or the final report. A copy of the chain of custody will be provided as part of the final report, and this fact will be noted on the final report in order to alert the data user of any improper sample handling. During the check in procedure, the sample will be checked for the following information:

- Proper, full, and complete chain of custody which shall include sample identification, the project identification, date, and time of collection, collector's name, sample type (matrix), and any special instructions concerning the sample.
- Proper sample labeling to include unique identification on a durable label with indelible ink.
- The appropriate sample container was used.
- The holding times have not been exceeded.
- There is sufficient sample volume to perform all tests that have been requested.
- Thermal preservation (Temperature of sample)
- The sample should show no signs of damage or contamination.

If the sample does not meet the above mentioned criteria, then AWAL will inform the customer of such occurrences and explain the options and consequences for further analysis. Documentation on the chain will be made of any conversations between AWAL and the customer regarding improper sample handling, and directives to proceed with analysis. Ultimately it is the customers' decision to proceed with or halt analysis when the sample has been mishandled.
In the instances when the sample has not been properly pH preserved and this discovery cannot be made until sample is prepared or analyzed, the customer will be notified only if they have requested in writing that AWAL not proceed with analysis. In these cases where the sample is not properly pH preserved, the final analytical report will indicate that the sample pH was not appropriate. Preparation logbooks, and/or injection logbooks will also reflect inappropriate preservation. Additionally, AWAL at its discretion may subcontract analytical work to other state/TNI and DoD approved laboratories. Subcontracted analysis will be distinguishable from AWAL analysis by the unique (their letterhead) analytical reports from the subcontracted laboratory.

Exhibit 22.2 Preservation Check Sheet B

Preservation Check Sheet B

Lab Set ID:

Samples Were:	**COC Tape Was:**	**Container Type:**	No. Rec.
☐ Shipped By:	**Present on Outer Package**	☐ AWAL Supplied Plastic	
☐ Hand Delivered	☐ Yes ☐ No ☐ N/A	☐ AWAL Supplied Clear Glass	
☐ Ambient	**Unbroken on Outer package**	☐ AWAL Supplied Amber Glass	
☐ Chilled	☐ Yes ☐ No ☐ N/A	☐ AWAL Supplied VOA/TOC/TOX Vials	
Temperature °C	**Present on Sample**	☐ Amber ☐ Clear ☐ Headspace ☐ No Headspace	
Rec. Broken/Leaking ☐ Yes ☐ No ☐ N/A	☐ Yes ☐ No ☐ N/A	☐ Non AWAL Supplied Container	
Notes:	**Unbroken on Sample** ☐ Yes ☐ No ☐ N/A	**Notes:**	
Properly Preserved ☐ Yes ☐ No ☐ N/A	**Notes:**		
Notes:			
Rec. Within Hold ☐ Yes ☐ No		**Discrepancies Between Labels and COC** ☐ Yes ☐ No	
Notes:		**Notes:**	

Exhibit 22.3 Preservation Check Sheet

Sample Set: _____

Sample Set Extension and pH

Bottle Type	Preservative	1	2		3	4	5	6	7	8	9	10	11	12	13	14
Ammonia	pH <2 H_2SO_4															
COD	pH <2 H_2SO_4															
Cyanide	PH >12 NaOH															
Metals	pH <2 HNO_3															
NO_2 & NO_3	pH <2 H_2SO_4															
Nutrients	pH <2 H_2SO_4															
O & G	pH <2 HCL															
Phenols	pH <2 H_2SO_4															
Sulfide	pH > 9NaOH, ZnAC															
TKN	pH <2 H_2SO_4															
T PO_4	pH <2 H_2SO_4															

Procedure:

1) Pour a small amount of sample in the sample lid
2) Pour sample from Lid gently over wide range pH paper
3) **Do Not** dip the pH paper in the sample bottle or lid
4) If sample is not preserved properly list its extension and receiving pH in the appropriate column above
5) Flag COC and sample, notify customer if requested
6) Refer to Footnotes on Sample Receiving SOP Section 8.5

22.2.3 Samples requiring a specified temperature of 4°C, are acceptable if received in the temperature range of 0 to 6°C. Samples that are hand delivered to the laboratory immediately after collection may not meet this criterion. In these cases, the samples are considered acceptable if they are delivered on ice. Samples requiring freezing are accepted if received at ≤ 10ºC. Refer to Exhibit 22.4.

Exhibit 22.4 Sample Volume and Preservation Requirements

Analyte or Test	Volume Required. *	Preservation & Container	Hold Time
Acidity	100 mL	0° to 6°C, HDPE	14 days
Alkalinity	100 mL	0° to 6°C, HDPE	14 days
Ammonia	50 mL	0° to 6°C, pH <2 H_2SO_4, HDPE	28 days
Bromide	100 mL	0° to 6°C, HDPE	28 days
BOD	1000 mL	>0° to 6°C, HDPE	Grab: 48 hours Composite: 24 hours
Cation Exchange Capacity (CEC)	6g	HDPE or glass, no refrigeration or preservation required	6 months
CBOD	1000 mL	0° to 6°C, HDPE	Grab: 48 hours Composite: 24 hours
COD	2 mL	>0° to 6°C, pH <2 H_2SO_4, HDPE	28 days
Chloride	50 mL	0° to 6°C, HDPE	28 days
Color	50 mL	0° to 6°C, Glass	48 hours
Corrosivity-Langelier	Calculation involving: pH, Alkalinity, TDS, Ca	See individual Analyte or Test	See individual Analyte or Test (Immediately to 6 months)
Cyanide Amendable Free Total WAD	 50 mL 50 mL 200 mL 200 mL	0° to 6°C, pH >12 NaOH, HDPE	14 days
Dissolved Oxygen	300 mL	None required, HDPE with no head space	Analyze Immediately
EH (Oxygen Red. Potential)	600 mL	0° to 6°C, Glass or HDPE	24 hours
Ferric Iron	Calculation: Total Fe-Ferrous Fe	See individual Analyte or Test	See individual Analyte or Test (Immediately to 6 months)
Ferrous Iron	200 mL	None required, HDPE	Analyze Immediately
Fluoride	300 mL	None required, HDPE	28 days
Hardness (Total)	Calculation involving Ca and Mg	0° to 6°C, pH < 2 HNO_3, HDPE	6 months
Hexavalent Chromium	200 mL	0° to 6°C, HDPE liquids	24 hours
Ignitability	100 mL	0° to 6°C, glass	7 days
Metals ICP and/or ICP/MS	200 mL or 2g	pH < 2 HNO_3, HDPE liquids, CWM or plastic bag solids	6 months
Mercury	200 mL or 2g	0° to 6°C for solids pH < 2 HNO_3, HDPE liquids, CWM or plastic bag solids	28 days

Analyte or Test	Volume Required. *	Preservation & Container	Hold Time
Nitrate	100 mL	0° to 6°C, HDPE	48 hours
Nitrate/Nitrite	100 mL	0° to 6°C, pH <2 H_2SO_4, HDPE	28 days
Nitrite	50 mL	0° to 6°C, HDPE	48 hours
Oil & Grease	1000 mL or 20g	0° to 6°C, pH <2 HCL, A.J. liquids, CWM solids	28 days
Odor	1000 mL	0° to 6°C, glass	6 hours
Paint Filter	100 g	0° to 6°C, CWM or HDPE	24 hours
pH	50 mL	HDPE	Analyze Immediately
Phenol	250 mL	0° to 6°C, pH <2 H_2SO_4, A.J.	28 days
Phosphate, Ortho	100 mL	0° to 6°C, HDPE	48 hours
Phosphate, Total	125 mL	0° to 6°C, pH <2 H_2SO_4, HDPE	28 days
Reactivity Cyanide & Sulfide	250mL or 10g	0° to 6°C, HDPE liquids, CWM or plastic bag solids	7 days
Settleable Solids	1000 mL	0° to 6°C, HDPE or glass	48 hours
Specific Conductance	50 mL	0° to 6°C, HDPE or glass	28 days
Sulfate	25 mL	0° to 6°C, HDPE	28 days
Sulfide	200 mL	0° to 6°C, HDPE pH>9 NaOH, Zn Acetate	7 days
Sulfite	100 mL	0° to 6°C, HDPE	Analyze Immediately
TCLP/SPLP	1L or 200g per TCLP test	See individual methods for temperature requirements, A.J liquids, CWM and/or plastic bag solids/misc., Volatiles no-headspace.	7 days to 6 months, see individual methods used for prep/analysis.
TKN	500 mL	0° to 6°C, pH <2 H_2SO_4, HDPE or A.J.	28 days
TOC	100 mL or 10g	0° to 6°C, pH <2 H_3PO_4, 40mL VOA vials, no headspace	28 days
TOX	2 – 40 mL vials	0° to 6°C, pH <2 H_2SO_4, Amber 40 mL vial, no headspace	28 days
TDS	250 mL	0° to 6°C, HDPE	7 days
TS and Percent Moisture	250 mL	0° to 6°C, HDPE	7 days
TSS	1000 mL	0° to 6°C, HDPE	7 days
Turbidity	100 mL	0° to 6°C, HDPE	48 hours
TVS	250 mL	0° to 6°C, HDPE	7 days
TVSS	250 mL	0° to 6°C, HDPE	7 days
EDB/DBCP	30mL	0° to 6°C, ph <2 $Na_2S_2O_3$ 40mL VOA liquids	Preserved: 14 days Unpreserved: 7 days
Pesticides	1000 mL or 30g	0° to 6°C, A.J. liquids, CWM solids	40 days to analyze after extraction. Waters: 7 days to extract Soils/Wastes: 14 days to extract
Herbicides	1000 mL or 50g	0° to 6°C, A.J. liquids, CWM solids	40 days to analyze after extraction. Waters: 7 days to extract Soils/Wastes: 14 days to extract
PCBs	1000 mL or 30g	0° to 6°C, A.J. liquids, CWM solids, 40mL VOA oils	40 days to analyze after extraction. Waters: 7 days to extract Soils/Wastes: 14 days to extract

Analyte or Test	Volume Required. *	Preservation & Container	Hold Time
VOC by 5030	5 mL or 5g	0° to 6°C, 4 drops HCl 40mL VOA liquids with no headspace, 0° to 6°C CWM solids	Preserved: 14 days Unpreserved: 7 days
VOC low levels by 5035A	5g	40mL amber or clear glass vial, transport on dry ice or at 0° to 6°C and frozen at the laboratory within 48hours	Not Frozen: 48 hrs Frozen: 14 days
VOC high level by 5035	10g	40mL amber or clear glass vial with 10 mL methanol, 0° to 6°C	14 days
SEMIS	1000 mL or 30g	0° to 6°C, A.J. liquids, CWM solids	40 days to analyze after extraction. Waters: 7 days to extract Soils/Wastes: 14 days to extract
TPH - DRO or ORO	1000 mL -4 oz	0° to 6°C, Liquids 1L A.J. Solid: CWM	40 days to analyze after extraction Waters: 7 days to extract Soils/Wastes: .14 days to extract

* Additional volume may be required to perform QC on a specific sample.

22.2.4 Holding time specified on Exhibit 22.4 starts counting from time collected unless otherwise noted.

22.2.5 Samples that do not meet the acceptance criteria are flagged in an unambiguous manner clearly defining the nature and substance of the variation. Where there is any doubt as to samples suitability for testing, where the sample does not conform to the description provided, or where the tests required are not fully specified, the laboratory SRO consults the customer for further instruction before proceeding. The laboratory retains correspondence and/or records of conversations concerning the final disposition of rejected samples. If the decision is made to proceed with the analysis, the condition of the samples is noted on the COC. In addition, the affected analysis is appropriately documented on the final report.

22.3 Sample Identification

22.3.1 Samples are clearly marked by the customer to avoid misidentification and be consistent with information found on the COC. Permanent labels or tags are usually adequate. Tags of self-adhesive labels are affixed to the sample containers before, or at the time of, sample collection. Dark waterproof ink is used to provide the label information.

22.3.1.1 Sample containers provided by AWAL are pre-labeled (unless specifically requested by the customer). The label includes:

22.3.1.1.1 The laboratory logo and "American West Analytical."

22.3.1.1.2 A field for the date collected.

22.3.1.1.3 A field for the time collected.

22.3.1.1.4 A field for the description, which includes the customer sample ID, and may include other information such as the project name, location of the sample, or the sampler's name.

22.3.1.1.5 The preservation and the date the preservation was added to the container, if applicable.

22.3.1.2 If AWAL did not provide the sample containers, the containers should be marked with the following:

22.3.1.2.1 Sample ID.

22.3.1.2.2 Name of collector.

22.3.1.2.3 Date and time of collection.

22.3.1.2.4 Place of collection.

22.3.1.2.5 Sample preservative.

22.3.1.2.6 Number of containers.

22.3.2 The laboratory has a documented system for uniquely identifying the items to be tested, to ensure that there is no confusion regarding the identity of such items at any time. The laboratory sample ID is used in the laboratory and associates the sample with related records of laboratory activities such as sample preservation, sample preparation, sample analysis, analytical instrument, sample hold time, standards and reagents, method performance, quality control protocols, calibration, and calibration criteria. The laboratory assigns a unique laboratory ID to each sample container received in the laboratory.

22.3.2.1 Laboratory Sample ID hierarchy.

22.3.2.1.1 Each sample received in the laboratory is given a laboratory sample number, consisting of the laboratory Work Order number and a three-digit sample number, which starts at 001 and continues sequentially within the Work Order. All analyses and containers are included within this laboratory sample number. (E.g., 0909009-001.)

22.3.2.1.2 Within each sample number, a sample may include multiple fractions, indicated by an alphabetic letter following the sample number. Sample fractions are

defined by the laboratory to group similar sample containers or analyses together. (E.g., 0909009-001B).

22.3.2.1.3 Within each fraction, each container is uniquely identified by a separate container ID. (E.g., 0909009-001B Container 2 of 3).

22.3.2.2 The laboratory affixes a unique self-adhesive label to each sample container received. The label does not obscure any other labels and information previously affixed to the container. The labels placed on each sample container include the following information:

22.3.2.2.1 The laboratory sample ID.

22.3.2.2.2 The customer sample ID.

22.3.2.2.3 The laboratory storage location.

22.3.2.2.4 The date and time collected.

22.3.2.2.5 The date received.

22.3.2.2.6 The Project Location/Site ID, if provided by the customer.

22.3.2.2.7 The customer's company name.

22.3.2.2.8 The container ID.

22.4 Sample Storage

22.4.1 AWAL stores samples to avoid deterioration or contamination. Samples requiring storage at 4°C are stored in refrigerators that are maintained from 0°C to 6°C. Samples that require freezing temperatures are maintained in freezers between -10°C and -20°C

22.5 Sample Disposal

22.5.1 At AWAL, the laboratory waste management process includes both waste minimization and waste disposal. Every effort is made to reduce the amount of hazardous waste generated in the laboratory. The hazardous waste that is produced is managed in accordance with all applicable regulations governing the generation, accumulation, and disposal of wastes.

22.5.2 Waste Minimization. Waste minimization, or pollution prevention, makes good environmental and economic sense. The volume of waste generated in the laboratory is reduced using methods such as source reduction, recycling, and reclamation.
Basic analyst training includes an introduction to laboratory waste minimization and

disposal. Analysts are encouraged to use prudence when purchasing and using laboratory chemicals and reagents.

22.5.3 Waste Treatment and Disposal. Potential hazardous wastes sources at AWAL include unused portions of customer samples as well as laboratory process wastes (acids, bases, solvents, etc.) generated as a result of sample preparation and testing. Hazardous customer samples are returned to the customer unless other specific arrangements have been made. Refer to the laboratory Waste Management and Sample Disposal WMSD001 SOP for specifics.
Waste streams are categorized and segregated where possible to keep non-hazardous waste from becoming hazardous waste through contact with hazardous waste. Common waste categories in the laboratory include:

22.5.3.1 Acidic liquids.

22.5.3.2 Flammable liquids.

22.5.3.3 Mercury waste.

22.5.3.4 Oily wastes.

22.5.3.5 PCB waste.

22.5.3.6 Cyanide waste.

22.5.4 Disposal of wastes is arranged for through licensed waste contractors. All hazardous waste shipments are properly manifested according to DOT (Department of Transportation) regulations. All paperwork is created by the hazardous waste transporter and signed by the laboratory. Refer to Waste Management and Sample Disposal WMSD001 SOP for further information.

22.6 Sample Transport

22.6.1 Notification of Safety Concerns. Field samples and accompanying paperwork must be adequately labeled to indicate any known or potential hazards such as flammability, corrosivity, toxicity, radioactivity, etc. Laboratory receiving personnel are responsible for communicating safety considerations to laboratory management and to laboratory personnel so that appropriate precautions are taken during sample handling, storage, and disposal.

22.6.2 Sample Delivery to the Laboratory. Samples should be delivered to the laboratory as soon as possible after collection. Where short holding times are required, special arrangements with the laboratory may be necessary. Samples that are shipped by commercial carrier should be packed carefully to avoid breakage. A completed COC and analysis request as described above must accompany samples. Most samples are transported on ice to minimize degradation, refer to Exhibit 22.1 for exceptions. The Sample Custody Officer (SCO) has the responsibility to reject samples received with improper containers, preservation, exceeded holding times,

or improper temperature (cooling not attempted) at the time of receipt. The SCO upon recognition of the problems immediately notifies the customer

22.7 Sampling Records

22.7.1 Records are kept in accordance with Document Control and Records Management RM001 SOP.

23.0 Quality of Test Results

23.1 Essential Quality Control Procedures

The elements of Laboratory QC are the method-specific measures that ensure the sample analysis process is in control. Method QC measures include operator certification and instrument calibration, as well as (but not limited to) the use of Method Blanks, Matrix Spikes, Matrix Spike Duplicates, and Laboratory Control Samples.
Quality assessment is the process of using internal and external quality control measures to determine the quality of the data produced by the laboratory. Laboratory assessment is accomplished using control charts, performance evaluation samples, internal audits, and annual quality system review. Where no method or regulatory QC requirements exist, AWAL establishes acceptance/ rejection criteria.

23.2 Internal Quality control Practices

23.2.1 Internal Standards. Internal standards are added to a standard, blank, matrix spikes/duplicate, LCS, or sample at a known concentration. The response is monitored to determine when changes in instrument response change quantification or if matrix interference affects quantification of the target analyte.

23.2.2 Interference Checks (Inorganic analysis only). When appropriate interference check standards, sample dilution, and post digestion spikes are incorporated into the analytical sequences to ensure interferences are not operating on any of the analyte elements to distort the accuracy of the reported value.

23.2.3 Control Charts. AWAL's objective for control limits of analytical data is to use either the method-specified limits or to use AWAL's historical data base limits. Analytical personnel or QC Officer uses the data transferred into the LIMS to generate control charts using the charting program within the LIMS. Control charts and/or the resulting acceptance ranges are reviewed and updated in the LIMS. Generally, control limits are used internally to evaluate and improve system quality. Where available, published acceptance limits are used to determine data acceptability for reporting purposes.
The charts are used to establish and maintain historical data base control limits. The MS/MSD and LCS control limits are reviewed annually for inorganics and semiannually for organics. The control ranges are set at $\pm$ 3 Standard Deviations from the mean for accuracy and precision.

23.3 Method Blanks. MBs are performed at a frequency of one per batch of 20 or fewer samples per matrix type per sample extraction or preparation method. This blank is processed exactly like the samples, consists of a similar matrix, and is known to be free of target analytes. The results of the MB analysis are used to evaluate contamination in the analytical process.
If blank contamination is found above the method criteria, the analysis of all samples associated with the blank is stopped until the source of the contamination is identified and measures taken to correct, minimize or eliminate the problem. The results of samples affected by the contamination blank is either reprocessed for analysis or reported with appropriate data qualifying codes. If insufficient sample volume is available for reprocessing, the data will be reported with data qualifying codes.
If required by the project, the method blanks are analyzed to 0.5 of the PQL, and flagged if appropriate.

23.3.1 Unless superseded by an individual method, SOP, or project requirement, method blanks with contamination found above criteria may be reprocessed or the data qualified if:

23.3.1.1 The concentration of the target analyte in the blank is at or above the established limit and is greater than 1/10 of the amount measured in any sample.

23.3.1.2 The contamination otherwise affects the sample results per method or project requirements.

23.4 Laboratory Control Samples. A Laboratory Control Sample (LCS), also called a QC Check Sample or Laboratory Fortified Blank (LFB), is analyzed at a minimum of 1 per batch of 20 or fewer samples per matrix type per sample extraction or preparation method. A known controlled matrix free of target analytes is spiked with the matrix spiking solution. The recovery determines if the analytical process (from sample preparation to analysis) was performed properly by the laboratory. The LCS is charted and reviewed with the MS/MSD. The LCS percent recovery must fall within the control limits based on statistical evaluation of the historical database or as determined by the test method, SOP, or regulatory or project requirement. Control limits are evaluated and updated as needed, as defined in the test method or SOP, or annually for inorganics and semiannually for organics. Samples associated with an out of control LCS are reprocessed for analysis or reported with appropriate data qualifying codes.

LCS percent recovery (%R) is calculated as follows:

$$\%R = \frac{SSR \times 100}{SA}$$

Where: SSR is the spiked sample result.
SA is the spike amount.

23.4.1 Analytes will be spiked as required by an individual method, SOP, or project requirement.

23.4.1.1 If spiking analytes simultaneously causes interference, such as technical chlordane, toxaphene, and PCB's, an analyte is chosen that represents the chemistries and elution patterns of other target analytes.

23.4.1.2 All target analytes are included in the spike mixture as available over a two year period. The minimum number of analytes that need to be spiked for an individual batch depends on the number of target analytes in the method or project.

23.4.1.2.1 Spike all the analytes for methods that have 1-10 targets.

23.4.1.2.2 Spike at least 10 or 80% of the analytes, whichever is greater, for methods that have 11-20 targets.

23.4.1.2.3 Spike at least 16 analytes for methods that have more than 20 targets.

23.4.1.2.4 If required by the project, all target analytes must be spiked per project requirements, with the exception of PCB analysis, which is always spiked per the method.

23.4.1.3 Spike concentration is at or below the midpoint of the calibration curve or as defined in the method, SOP, or project requirement.

23.5 Matrix Spikes and Matrix Spike Duplicates. Matrix Spikes (MS) are used to measure the effect of a matrix, on the methods ability to recover. The Matrix Spike Duplicate (MSD) samples are used to measure analytical accuracy and precision. The MS and MSD are performed in the laboratory at a frequency of one in 20 samples per matrix type per sample extraction or preparation method. (There are analytes for which spiking solutions are not available and would not require a MS/MSD, such as: total suspended solids, total dissolved solids, total volatile solids, total solids, pH, color, odor, temperature, dissolved oxygen, and turbidity). For Level I and II reports, the sample(s) used for spiking are selected at random so that various matrix problems are noted and/or addressed. For Level II+ and higher the customer's sample is used for spiking. If insufficient sample volume is available from the customer, it will be noted with data qualifying codes and/or in the case narrative. Specific spiking compounds are recommended in the method and in each analytical SOP. The MS/MSD results are used to determine if the matrix is interfering with the analytical process.

The percent recovery (%REC) for the MS and MSD are calculated as follows:

$$\%RE\ C= \frac{(SSR - SR) \times 100}{SA}$$

Where: SSR is the spiked sample result.
SR is the non-spiked sample result.
SA is the spike amount.

Calculation of the relative percent difference (RPD) between the MS and MSD percent

recoveries is given by the following equation:

$$\%RPD = \frac{(MSR - MSDR) \times 100}{(MSR + MSDR)/2}$$

Where: MSR is the MS sample result
MSDR is the MSD sample result

The MS/MSD recoveries and relative percent differences are charted and the control limits are updated as needed, as defined in the test method or SOP, or annually for inorganics and semiannually for organics. Samples associated with an out of control MS/MSD are reported with appropriate data qualifying codes.

23.5.1 Analytes will be spiked as required by an individual method, SOP, or project requirement.

23.5.1.1 If spiking analytes simultaneously causes interference, such as technical chlordane, toxaphene, and PCB's, an analyte is chosen that represents the chemistries and elution patterns of other target analytes.

23.5.1.2 All target analytes are included in the spike mixture as available over a two year period. The minimum number of analytes that need to be spiked for an individual batch depends on the number of target analytes in the method or project.

23.5.1.2.1 Spike all the analytes for methods that have 1-10 targets.

23.5.1.2.2 Spike at least 10 or 80% of the analytes, whichever is greater, for methods that have 11-20 targets.

23.5.1.2.3 Spike at least 16 analytes for methods that have more than 20 targets.

23.5.1.2.4 If required by the project, all target analytes must be spiked per project requirements, with the exception of PCB analysis, which is always spiked per the method.

23.5.1.3 Spike concentration is at or below the midpoint of the calibration curve or as defined in the method, SOP, or project requirement.

23.5.2 If required by the project, the MS/MSD results may be evaluated using the same limits as the LCS.

23.6 Surrogate Spikes. A surrogate standard is a pure compound added to a sample in the laboratory just before processing so that the overall (sample injection, extraction, and/or purging) efficiency of a method is determined. They provide a measure of recovery for every sample and matrix. Whenever possible, surrogate compounds are added to all samples,

standards, and blanks for all organic chromatography methods. The acceptance criteria specified by the method is used to evaluate sample acceptance

23.6.1 Surrogates are chosen to reflect the chemistries of the target analytes and as defined by the test method or SOP.

23.6.2 Surrogates are evaluated against limits as defined in the test method, SOP, or project. Surrogates outside of the control limits may be reprocessed as per the test method or SOP or reported with appropriate data qualifying codes.

23.7 Proficiency Test Samples or Interlaboratory Comparisons. AWAL demonstrates its analytical expertise through the participation in semiannual proficiency testing programs.

23.7.1 Proficiency Evaluation (PE) Samples. PE samples are obtained from a NELAP/A2LA approved supplier. Prior to ordering the samples, approval of the supplier is obtained from the Utah Bureau of Laboratory Improvement (BLI). The results from PE samples are sent directly to BLI, A2LA, Utah, among other states, and AWAL by the provider. In the event the PE supplier changes, BLI and A2LA must be notified prior to ordering any PE samples.

23.7.2 PE sample analysis. Each PE sample is analyzed in the same manner (as much as possible) as a customer sample. Normal standard operating procedure is followed, except in log-in and reporting where PE samples do not mimic real life samples. Only AWAL personnel analyze the PE samples. All results are reported prior to the deadlines established by the provider. Laboratory management ensures compliance with this requirement. In the event of a failed PE sample, the laboratory management and the analyst must work together to identify the problem, decide on a corrective action, and perform a makeup PE no sooner than 15 days from the closed date of the failed PE. All actions are documented.

23.7.3 PE samples are performed for all methodologies performed by AWAL and certified by under the CWA, SDWA, RCRA, and ELAP where available.

23.7.4 Frequency.

23.7.4.1 AWAL performs a minimum of 2 PE samples per act (CWA, SDWA and RCRA); with passing results per year to maintain certification. These PE samples are performed at 5 to 7 month intervals per act.

23.7.4.2 AWAL performs a minimum of 4 ELAP PE samples per act; with the passing results of 75% per year to maintain certification. These PE samples are performed quarterly.

23.7.5 Interlaboratory Comparison of PE Results. AWAL does not discuss PE sample results with any person not employed by AWAL or any other organization prior to the closing date of the audit series. AWAL does not send or accept PE samples to or from other laboratories. If a suspected sample is received from another laboratory BLI and A2LA are notified.

23.7.6 Records. AWAL retains all records received and generated from PE activities for a minimum of five years. Such records are sufficient to allow historical reconstruction of the results submitted for compliance.

23.8 Data Review. Data verification is an independent check of the quality of the analytical run and subsequent processing steps. These checks are performed by an independent analyst (peer review), qualified supervisors, or QA personnel. At AWAL, data verification is performed on 100% of the data and includes the following elements:

23.8.1 Review of the analytical QC results (including the results of MS, MSD, LCS, blank, surrogate, sample duplicate and/or other check sample analyses).

23.8.2 Manual re-check of calculations and/or data entry steps.

23.8.3 Approval of data.

23.8.4 Comparability review of results for different parameters of a sample.

23.9 Matrix Duplicates. Matrix Duplicates (DUP), also called sample duplicates or laboratory replicates, are a replicate aliquot of a sample of unknown composition processed the same way as all the samples in the batch. The DUP may be used to measure the precision of the results for that specific sample matrix and method. This measure of precision is only applicable when target analytes are found in the duplicated sample. The DUP may also provide a measure of sample homogeneity. Unless specifically stated in the test method or SOP, the DUP is performed in the laboratory at a frequency of one in 20 samples per matrix type per sample extraction or preparation method. The DUP may be used on test methods that do not have a spiking solution or require an MS/MSD. The limits are defined in the test method or SOP. Samples associated with a DUP outside of the control limits are reported with appropriate data qualifying codes.

$$\%RPD = \frac{(SAMP - DUP) \times 100}{(SAMP + DUP) / 2}$$

Where: SAMP is the original Sample result
DUP is the DUP sample result

23.9.1 If allowed by the project, a DUP may be performed in place of the MSD, but in addition to the MS, for a sample with a known concentration of the target analyte of greater than 5 times the LOQ.

24.0 Reporting of Results

24.1 Test Reports. The results of each test or series of tests carried out by the laboratory are reported accurately, clearly, unambiguously, and objectively, in accordance with any instructions in the test methods.
After issuance of the report, it remains unchanged. Amendments to a test report after issuance are made only in the form of a further document that clearly states a revised report

or an addendum to a report. The laboratory promptly notifies customers electronically, in writing, or by telephone, of any finding or event that casts doubt on the validity of results given in any test report or amendment to a report.
Final reports are considered proprietary and are released only to the original customer. Verbal or written permission from the customer is necessary to release data to others. Where customers require transmission of test results by telephone, electronic, physical, facsimile, and/or electromagnetic means the laboratory ensures that customer confidentiality is preserved. AWAL's Laboratory reports contain the following information:

24.1.1 Title of analytical report.

24.1.2 Name and address of AWAL, signature, title and phone number of laboratory contact and person approving the report.

24.1.3 Identified samples' set with a unique identifier as indicated by the laboratory Workorder ID.

24.1.4 Customer ID.

24.1.5 Name and address of customer.

24.1.6 Project name or Site ID if provided by the customer.

24.1.7 Appropriate qualifiers for samples not meeting sample acceptance criteria.

24.1.8 Identification of test methods including those that do not meet TNI requirements.

24.1.9 Date and time of collection and date of receipt.

24.1.10 Date and time (if applicable) sample analyzed.

24.1.11 Date and time (if applicable) sample extracted or prepared.

24.1.12 Analyte(s).

24.1.13 Data qualifiers as needed for QC failure, method modifications, or statement of uncertainty.

24.1.14 Clear identification of numerical or text results with reporting limits as applicable.

24.1.15 Units of concentration.

24.1.16 TNI/A2LA/ELAP certification statement.

24.1.17 Date of issue.

24.1.18 Total number of pages and unique identifier of each page.

24.1.19 Hand or electronic signature based on customer requirements of electronic or hard copy report.

24.1.20 Statement of reproducibility without permission.

24.1.21 References to sampling procedure where relevant.

24.1.22 The COC or a copy of the COC.

24.1.23 Reports may also contain the following:

24.1.23.1 Case Narrative

24.1.23.1.1 Summarizes any conditions that may affect the usability of the data.

24.1.23.1.2 Summarizes any extractions or analyses that were performed out of the holding times.

24.1.23.1.3 Summarizes the IDs of any deviations of calibration samples or QC sample results from the acceptance limits. Summarizes any corrective actions taken by the laboratory.

24.1.23.1.4 Identification of samples and analytes for which manual integration was necessary, if specified by the project.

24.1.23.2 Sample Summary

24.1.23.2.1 Summarizes Client Sample ID, the corresponding Laboratory Sample ID, and the analytical test methods performed.

24.1.23.3 The sample matrix.

24.1.23.4 Identification of all preparation methods.

24.1.23.5 LODs, LOQs, and/or MDLs.

24.1.23.6 Dilution factors.

24.1.23.7 Percent Moisture.

24.1.23.8 Spike concentrations, results percent recoveries, and control limits for surrogates.

24.1.23.9 The spike concentrations, results, limits, percent recoveries, and relative percent differences for matrix spikes, LCSs, duplicates, and other QC samples (as needed).

24.1.23.10 Method blank results.

24.1.23.11 Preparation, analysis, and other batch numbers as needed.

24.2 Supplemental Test Report Information. The QC Level is requested by the customer. Exhibit 24.1 lists the components of each QC level.

Exhibit 24.1 QC Levels Reporting

QC Item, as required by the analysis and method	Level 1	Level 2	Level 2+	Level 3	Level 3+	Level 3+ RD	Special Services
Chain of Custody (COC)	X	X	X	X	X	X	
Analytical Results and Cover Letter	X	X	X	X	X	X	
Case Narrative				X	X	X	
Surrogates (Surr:)	X	X	X	X	X	X	
Method Blank (MB)		X	X	X	X	X	
Laboratory Control Sample (LCS)		X	X	X	X	X	
Laboratory Control Sample Duplicate (LCSD)		X	X	X	X	X	
Matrix Spike (MS)		X	X*	X*	X*	X	
Matrix Spike Duplicate (MSD)		X	X*	X*	X*	X	
Sample Duplicates (DUP)		X	X*	X*	X*	X	
Quality Control Sample (QCS)		X	X	X	X	X	
Quality Control Sample Duplicate (QCSD)		X	X	X	X	X	
Table of Contents					X	X	
Sample Summary Report					X	X	
Chromatograms for GC or GC/MS				X	X	X	
Initial Calibration Verification (ICV)					X		
Continuing Calibration Verification (CCV)					X		
Initial Calibration Blank (ICB)					X		
Continuing Calibration Blank (CCB)					X		
Lower Limit of Quantitation (LLOQ)					X		
Instrument Performance Check (IPC)					X		
Serial Dilution (SD)					X*		
Post Digestion Spike (PDS)					X*		
Interference Check Solution A (ICSA)					X		
Interference Check Solution AB (ICSAB)					X		
Inter Element Correction (IEC)					X		
Instrument Detection Limit (IDL)					X		
Linear Dynamic Range (LDR)					X		
Preparation Logbooks					X		
Individual Set Worksheet					X		
Calibration Summary Sheet					X		
Raw Data Packet, paginated					X		
Raw Data Packet, unpaginated						X	
Special Requests, including CLP-like data packages with appropriate forms							X

* Performed on field sample from the customer that requested this QC level.

24.3 Environmental Testing Obtained from Subcontractors

24.3.1 When required for a specific project, AWAL, in conjunction with the customer, may subcontract analytical work to other qualified laboratories. The laboratory advises customers of its intention to sub-contract testing to another party in writing at the beginning of all projects. Walk-in customers are notified in writing upon the receipt of samples. Only with authorization from the customer that the work is subcontracted out. The subcontracted samples are placed with a TNI/DoD/ELAP certified laboratory if applicable. Subcontracted data is reported on the subcontracted laboratory's letterhead and a copy is saved electronically as a separate file to avoid confusion. AWAL requests current certification letters from subcontracted laboratories utilized.

24.4 Transmission of Results

24.4.1 Final reports are considered proprietary and are released only to the original customer. Verbal or written permission from the customer is necessary to release data to others. Where customers require transmission of test results by telephone, electronic, physical, facsimile, and/or electromagnetic means the laboratory ensures that customer confidentiality is preserved.

24.5 Amendments to Test Reports

After issuance of the report, it remains unchanged. Amendments to a test report after issuance are made only in the form of a further document that clearly states a revised report or an addendum to a report. The laboratory notifies customers promptly, in writing, electronically, or by telephone, of any finding or event that casts doubt on the validity of results given in any test report or amendment to a report.

25.0 Appendices

25.1 Appendix A. Glossary and Acronyms. Refer to Section 3.3

25.2 Appendix B. Key Personnel Qualifications

Kyle F. Gross – Laboratory Director

Education:

Master of Science Chemistry, 1988
Saint Joseph's University, Philadelphia, PA
Bachelor of Science Chemistry, 1978
Millersville University, Millersville, PA
Total Quality Management
Crosby College, Princeton, NJ
Professional Project Management, Combustion Engineering
Sugarloaf, ME
Effective Management of Chemical Analysis Laboratories
ACS, New Orleans, LA
Supervision of People
Philadelphia, PA

Experience:

2001 – Present Laboratory Director, American West Analytical Laboratories

Provides leadership for a 26 member independent, environmental testing laboratory. Responsibilities include; technical direction, personnel management, financial stability, customer support, and sales/marketing assistance. Ensure quality analytical results through QA/QC guidance.

1995 – 2007 Vice President, Kestrel Environmental Technologies, Inc.

Provides technical guidance for data validation, data usability, and laboratory audits. Primary computer graphics developer of Kestrel marketing tools, data validation packages and laboratory audit forms.

1997 – 2001 Laboratory Director, Environmental Science Corp.

Responsible for technical direction and quality assurance of a 25 member independent environmental testing laboratory. Responsible for increasing efficiency and reduction in supply costs. Pursued and obtained NELAP accreditation.

1994 – 1995 Corporate Technical Consultant, Pace, Inc.

Provided technical on-site guidance to a 15 member nationwide laboratory with particular focus on the PACE LIMS "EPIC". Assisted corporate Quality Assurance Officer with laboratory quality control issues. Chairman of the EPIC Laboratory Analysis Team that employed members from six different laboratories.

1993 – 1994 Technical Director, PACE, Inc., Westbrook ME

Responsible for technical issues of a 55 members laboratory including review of proposals, and interfacing with clients. Functioned as a mentor for the CLP deliverables group and other staff requiring PC assistance. Worked with the QA/QC officer to determine and resolve analytical problems in the laboratory. Chairman of the Safety Committee responsible for overall laboratory health and safety. Provided final review of organic data and backup for inorganic.

1988 – 1993 Organics Department Manager, CCAS, Inc., Westbrook ME

Managed GC, GC/MS, and Organic Preparation staff of 16. Responsible for P & L budgeting, personal administration, scheduling, data management, and all technical aspects of the department. Project

manager for several projects including the USEPA SAS program. Played key role in design and startup of new laboratory in Westbrook. Designed laboratory staffing performance review form and criteria.

1979 – 1988 Laboratory Supervisor, RMC, Pottstown, PA

Supervised a staff of 23. Responsible for operations, staff administration, and all technical aspects of the laboratory. Managed many projects and interfaced with numerous clients. Wrote and implemented laboratory QA/QC manual. Trained many employees in GC, GC/MS, metals and wet chemistry analyses. Developed an emergency response program for polychlorinated biphenyl (PCB) analysis by gas chromatography. Appeared as an expert witness involving GC/MS volatile analysis.

1976 – 1982 Chemist, RMC, Pottstown, PA

Analyst in all technical areas of the laboratory including wet chemistry, metals, GC, GC/MS, and microbiology. Other areas included inorganic sample prep., sample receipt, and field sampling. Worked as hands on mentor in GC/MS area while functioning as Laboratory Supervisor during the end of this time period.

Patrick Noteboom – Project Manager/Marketing

Education:

Bachelor of Science, Chemistry, June 1989
University of Texas, Austin TX
ICP Operators Training School
Applied Research Laboratories

Experience:

1997 – Present Marketing/Project Manager, American West Analytical Laboratories

Coordinates flow of information between the customer and the laboratory staff.

1994 – 1997 Inorganic Supervisor, American West Analytical Laboratories.

Supervised water chemistries and metal analyses. Reviewed all raw data, QC data, and final reports. Reviewed and updated SOPs. Assisted the lab manager in procedure development of new projects. Maintained inventory of reagents, supplies, and spare parts. Responsible for training and method development.

1993 – 1994 ICP/GFAA Chemist, American West Analytical Laboratories.

Performed metals analysis on groundwater, wastewater, and soils. Generated and maintained all laboratory quality control data and present data to management. Assured instrument reliability through conformance to EPA protocol. Performed daily maintenance of Baird M2000 and TJA ICAP 25 ICPs.

1992 – 1993 Analytical Chemist, Ford Analytical Laboratory, Salt Lake City, UT

Prepared and analyzed water, solid, and waste samples for metals using ICP and GFAA. Duties included preparation of standards, daily calibration of the instrument, and preventative maintenance on PE 400ICP, PE 5100GFAA, PE 5000GFAA, and PE 5000FA. Utilized 200.7, 200.9, 6010 and GFAA methods from SW-846 and Standard Methods, 17th Ed.

1990 - 1992 Chemist, Root & Norton Laboratories

Environmental Analysis of water samples for mine related pollutants. Extensive experience in the geochemical analysis of precious metals ores utilizing ICP. Developed procedures to eliminate the matrix affect in geologic samples.

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Heather Reese – Inorganic Department Supervisor

Education:

Master of Science & Technology, May 2011
University of Utah, Salt Lake City, UT
B.S., Botany 2005
Weber State University, Ogden, UT
AWAL Employee of the Year, 2008
Awarded Weber State University Botany Academic Fellowship, Spring 2005

Experience:

August 2010 – Present Inorganic Department Supervisor, American West Analytical Laboratories. Salt Lake City, UT

Oversees inorganic area: inorganic extraction, distillation, digestions and analysis; data generation; data validation; performance of MDLs; analyst DOCs; analyst scheduling; trouble shooting; method development and maintenance.

2007 – August 2010 Inorganic Rover/Assistant Supervisor, American West Analytical Laboratories, Salt Lake City, UT

Training new employees, peer reviewing, and assisting inorganic employees during vacation and sick time.

2004 – 2007 Inorganic Analyst, American West Analytical Laboratories, Salt Lake City, UT

Responsible for analyzing water and soil samples or metal contaminants using Perkin Elmer Optima ICPs and training personnel on various equipment and inorganic procedures.

1999 – 2006 Admitting Lead, Intermountain Healthcare LDS Hospital, Salt Lake City, UT

Responsible for registering and admitting patients in a confidential, accurate, and timely manner.

Jennifer Osborn – Organic Department Supervisor

Education:

BS in Environmental Biology and BS in Composite Teaching Biological Sciences with minors in Chemistry and Chemistry Teaching
Utah State University, Logan, Utah
Experience with Tekmar Precept II autosampler, Tekmar 3100 concentrator, Agilent 5973 MS, Tekmar Solatek 72 multi-matrix vial sampler, Tekmar Velocity XPT concentrator, Agilent 6890N GC with Agilent 5973 MS, and HP Chemstation Enviroquant Macro Languages.
Forklift trained

Experience:

2008- Present Organic Department Supervisor, American West Analytical Laboratories. Salt Lake City, UT

Oversees Organic area: Organic extraction, distillation, digestions and analysis; data generation; data validation; performance of MDLs; analyst DOCs; analyst scheduling; trouble shooting; method development and maintenance.

2002-2008 Organic Chemist, American West Analytical Laboratories. Salt Lake City UT.

Responsible for running water and soil samples using EPA methods 8260B, 5030B, 5035, 624, and 524.

1997 - 2002 Garden Department Manager, K-mart. Logan Utah

Keep compliance with state and federal regulations. Monitoring and maintaining the health of the plants; ordering merchandise, pricing designing layouts setting up displays, assisting customers.

Jan. – May 2001 Biology Teacher, Beaver River High School. Garland, Utah.

Preparing and teaching lessons.

Jose G. Rocha – Quality Assurance Officer

Education:

Master of Business Administration, February 2006
University of Phoenix, Salt Lake City Utah
Master of Business Administration 1998
Universidad Autonoma del Noreste, Torreon Coahuila, Mexico
Bachelor Chemical Engineering, June 1989
Instituto Tecnologico de la Laguna, Torreon Coahuila Mexico
Drinking Water Laboratory Certification, inorganic, organic and micro
USEPA
Flame and cold vapor systems. Operation and Maintenance
NELAC and Laboratory Accreditation in Utah, State of Utah
ELCP Certification Process Training
State of Utah
ELCP Proficiency Testing
State of Utah
ISO 9000, Documentation and Internal Auditor
Statistics tools application
Supervision of people

Experience:

2007 – Present Quality Assurance Officer, American West Analytical Laboratories

Oversees all aspects of laboratory quality control, data generation, data validation, control charts, SOP development, QAP updates, employee training, performs internal audits, schedules external audits, documentation and calibration of support equipment.

2002 – 2007 Quality Assurance Chemist, DataChem Laboratories, Inc. Salt Lake City, UT

Oversees all aspects of laboratory quality control, data generation, data validation, control charts, SOP development, QAP updates, employee training, performs internal audits, schedules external audits, documentation and calibration of support equipment.

1990 – 2001 Process Engineer, Metalurgica Mexicana Penoles, S.A. de C.V., Torreon, Mex.

Planned and managed projects to develop and advance new process technology from the lab to pilot, plant scales then to final implementation (for zinc and bismuth plants, lead smelter and the gold and silver refinery).

1989 – 1990 Chief of Shift, Siderurgica Lazaro Cardenas Las Truchas, Michoacan, Mex.

Supervised and operated an electric furnace.

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APPENDIX B

REFERENCES

United States Environmental Protection Agency (EPA). 2006. Data Quality Assessment: Statistical Methods for Practitioners, EPA QA/G-9S. February 2006.

United States Environmental Protection Agency (EPA). 2010. Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Data Review. 9240.1-51, USEPA 540/R-10/011. January 2010.

United States Environmental Protection Agency Region 8, United States Bureau of Land Management, United States Fish and Wildlife Service, Utah Department of Environmental Quality, and State of Utah Natural Resource Trustee (EPA et al.). 2014. Administrative Settlement Agreement and Order on Consent for EE/CA Investigation and Removal Action for Richardson Flat Tailings Site Operable Units 2 and 3 Park City, Utah. March 6, 2014.

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APPENDIX C

EPA Region 8 QA Document Review Crosswalk

EPA REGION 8 QA DOCUMENT REVIEW CROSSWALK

QAPP/FSP/SAP for: *(check appropriate box)*	**Entity** *(grantee, contract, EPA AO, EPA Program, Other)*	**Regulatory Authority**	___**40 CFR 31 for Grants**
GRANTEE		**and/or**	___**48 CFR Part 46 for Contracts**
CONTRACTOR	*Other: PRP Consultant, Resource Environmental Management Consultants, Inc. d.b.a. RMC*	**Funding Mechanism**	___ **Interagency Agreement**
EPA			___ **EPA Administrative Order**
Other			___ **EPA Program Funding**
			___ **EPA Program Regulation**
			___ **EPA CIO 2105**
Document Title *[Note: Title will be repeated in Header]*	QUALITY ASSURANCE PROJECT PLAN - Richardson Flat Tailings Site Operable Units 2 and 3, Revision 0		
QAPP/FSP/SAP Preparer	Resource Environmental Management Consultants, Inc. d.b.a. RMC		
Period of Performance *(of QAPP/FSP/SAP)*	2014-2015	**Date Submitted for Review**	7/21/14
EPA Project Officer **EPA Project Manager**	Kathryn Hernandez (EPA RPM)	**PO Phone #** **PM Phone #**	
QA Program Reviewer or Approving Official	Kristen Keteles (R8 DAO) Dan Wall	**Date of Review**	

Documents to Review:

1. QAPP written by Grantee or EPA must also include for review:
   Work Plan(WP) / Statement of Work (SOW) / Program Plan (PP) / Research Proposal (RP)

2. QAPP written by Contractor must also include for review:
   a) Copy of signed QARF for Task Order
   b) Copy of Task Order SOW
   c) Made available hard or electronic copy of approved QMP
   d) If QMP not approved, provide Contract SOW

3. For a Field Sampling Plan (FSP) or Sampling & Analyses Plan (SAP), the Project QAPP must also be provided.
   OR
   The FSP or SAP must be clearly identified as a stand-alone QA document and must contain all QAPP required elements (Project Management, Data Generation/Acquisition, Assessment and Oversight, and Data Validation and Usability).

Documents Submitted for QAPP Review:

1. **QA Document(s) submitted for review:**

QA Document	Document Date	Document Stand-alone	Document with QAPP
QAPP		No	
FSP		No	Yes
SAP	**7/21/14**	Yes	Yes
SOP(s)			Yes

2. **WP/SOW/TO/PP/RP Date** _____
   WP/SOW/TO/RP Performance Period
   _____
3. **QA document consistent with the:**
   WP/SOW/PP for grants? Yes / No
   SOW/TO for contracts? Yes / No
4. **QARF signed by R8 QAM** Yes / No / NA
   Funding Mechanism IA / contract / grant / NA
   Amount _____

Summary of Comments *(highlight significant concerns/issues)*:

Element	Acceptable *Yes/No/NA*	Page/ Section	Comments
A. Project Management			
A1. Title and Approval Sheet			
a. Contains project title	Y	COVERS	
b. Date and revision number line (for when needed)	Y	COVERS	
c. Indicates organization's name	Y	COVERS	
d. Date and signature line for organization's project manager	NA		Required signatures on preceding signature page
e. Date and signature line for organization's QA manager	NA		Required signatures on preceding signature page
f. Other date and signatures lines, as needed	Y	Precedes cover	Required signatures on preceding signature page
A2. Table of Contents			
a. Lists QA Project Plan information sections	Y	Q – ii	
b. Document control information indicated	Y	Cover	
A3. Distribution List			
Includes all individuals who are to receive a copy of the QA Project Plan and identifies their organization	Y	Q §A3	
A4. Project/Task Organization			
a. Identifies key individuals involved in all major aspects of the project, including contractors	Y	Q §A4	
b. Discusses their responsibilities	Y	See A4.a	
c. Project QA Manager position indicates independence from unit generating data	Y	Q Figure 1	
d. Identifies individual responsible for maintaining the official, approved QA Project Plan	Y	Q §A4.4 and C2	

e. Organizational chart shows lines of authority and reporting responsibilities	Y	Q Figure 1	
A5. Problem Definition/Background			
a. States decision(s) to be made, actions to be taken, or outcomes expected from the information to be obtained	Y	Q §A6, F §2 and 3.2	
b. Clearly explains the reason (site background or historical context) for initiating this project	Y	F §1.1	
c. Identifies regulatory information, applicable criteria, action limits, etc. necessary to the project	Y	Q Table 3	
A6. Project/Task Description			
a. Summarizes work to be performed, for example, measurements to be made, data files to be obtained, etc., that support the projects goals	Y	F §2, 3, Table 3-1 Q §A6, Table 1	
b. Provides work schedule indicating critical project points, e.g., start and completion dates for activities such as sampling, analysis, data or file reviews, and assessments	Y	Q Table 2	
c. Details geographical locations to be studied, including maps where possible	Y	F §1.1.1, 3.2	
d. Discusses resource and time constraints, if applicable	Y	Q §A4.3	
A7. Quality Objectives and Criteria			

a. Identifies - performance/measurement criteria for all information to be collected and acceptance criteria for information obtained from previous studies, - including project action limits and laboratory detection limits and	Y Y		
b. Discusses precision	Y	Q §A7.2	
c. Addresses bias	Y	Q §A7.2	
d. Discusses representativeness	Y	Q §A7.2	
e. Identifies the need for completeness	Y	Q §A7.2	
f. Describes the need for comparability	Y	Q §A7.2	
g. Discusses desired method sensitivity	Y	Q §A7.4	
A8. Special Training/Certifications			
a. Identifies any project personnel specialized training or certifications	Y	Q §A4	
b. Discusses how this training will be provided	Y	Q §A4	
c. Indicates personnel responsible for assuring training/certifications are satisfied	Y	Q §A4.4	
d. identifies where this information is documented	Y	Q §A8.1	
A9. Documentation and Records			
a. Identifies report format and summarizes all data report package information	Y	Q §A9	
b. Lists all other project documents, records, and electronic files that will be produced	Y	Q §A9	
c. Identifies where project information should be kept and for how long	Y	Q §B10	
d. Discusses back up plans for records stored electronically	Y	Q §B10.1	
e. States how individuals identified in A3 will receive the most current copy of the approved QA Project Plan, identifying the individual responsible for this	Y	Q §A4.4	
B. Data Generation/Acquisition			
B1. Sampling Process Design (Experimental Design)			
a. Describes and justifies design strategy, indicating size of the area, volume, or time period to be represented by a sample	Y	F §3.2	
b. Details the type and total number of sample types/matrix or test runs/trials expected and needed	Y	F §3.2.x	
c. Indicates where samples should be taken, how sites will be identified/located	Y	F §3.2	
d. Discusses what to do if sampling sites become inaccessible	Y	F §3.2	
e. Identifies project activity schedules such as each sampling event, times samples should be sent to the laboratory, etc.	Y	F Table 2-2, Table 2-3, Table 3-1	
f. Specifies what information is critical and what is for informational purposes only	Y	Q §B1	
g. Identifies sources of variability and how this variability should be reconciled with project information	Y	Q §A7.2	
B2. Sampling Methods			

a. Identifies all sampling SOPs by number, date, and regulatory citation, indicating sampling options or modifications to be taken	Y	F §3.4-3.17	
b. Indicates how each sample/matrix type should be collected	Y	F §3.4-3.17	
c. If *in situ* monitoring, indicates how instruments should be deployed and operated to avoid contamination and ensure maintenance of proper data	Y	F §3.5, 3.9	
d. If continuous monitoring, indicates averaging time and how instruments should store and maintain raw data, or data averages	NA		No continuous monitoring
e. Indicates how samples are to be homogenized, composited, split, or filtered, if needed	Y	F §3.4-3.17	
f. Indicates what sample containers and sample volumes should be used	Y	F Table 3-1	
g. Identifies whether samples should be preserved and indicates methods that should be followed	Y	F Table 3-1	
h. Indicates whether sampling equipment and samplers should be cleaned and/or decontaminated, identifying how this should be done and by-products disposed of	Y	F §3.18	
i. Identifies any equipment and support facilities needed	Y	F Table 3-3, Appendix A Q § 4.8, Appendix A	
j. Addresses actions to be taken when problems occur, identifying individual(s) responsible for corrective action and how this should be documented	Y	Q §C1.5	
B3. Sample Handling and Custody			
a. States maximum holding times allowed from sample collection to extraction and/or analysis for each sample type and, for in-situ or continuous monitoring, the maximum time before retrieval of information	Y	Q §B3.1 F §4.1	
b. Identifies how samples or information should be physically handled, transported, and then received and held in the laboratory or office (including temperature upon receipt)	Y	F §3.3-3.17, 4.0	
c. Indicates how sample or information handling and custody information should be documented, such as in field notebooks and forms, identifying individual responsible	Y	F §3.22	
d. Discusses system for identifying samples, for example, numbering system, sample tags and labels, and attaches forms to the plan	Y	F §3.20	
e. Identifies chain-of-custody procedures and includes form to track custody	Y	F §4.1, Appendix B	
B4. Analytical Methods			
a. Identifies all analytical SOPs (field, laboratory and/or office) that should be followed by number, date, and regulatory citation, indicating options or modifications to be taken, such as sub-sampling and extraction procedures	Y	F Appendix A Q Appendix A	
b. Identifies equipment or instrumentation needed	N	Q §B2.3, B4, Table 8	
c. Specifies any specific method performance criteria	Y	Q Tables 4-6	

d. Identifies procedures to follow when failures occur, identifying individual responsible for corrective action and appropriate documentation	Y	Q §C1.5	
e. Identifies sample disposal procedures	Y	F §3.18	
f. Specifies laboratory turnaround times needed	Y	Q Table 8	
g. Provides method validation information and SOPs for nonstandard methods	Y	F Appendix A	
B5. Quality Control			
a. For each type of sampling, analysis, or measurement technique, identifies QC activities which should be used, for example, blanks, spikes, duplicates, etc., and at what frequency	Y	Q §B5.1.1 –B5.1.3	
b. Details what should be done when control limits are exceeded, and how effectiveness of control actions will be determined and documented	Y	Q §C1.5	
c. Identifies procedures and formulas for calculating applicable QC statistics, for example, for precision, bias, outliers and missing data	Y	Q §A7.2	
B6. Instrument/Equipment Testing, Inspection, and Maintenance			
a. Identifies field and laboratory equipment needing periodic maintenance, and the schedule for this	Y	Q §B6	
b. Identifies testing criteria	Y	Q §B6	
c. Notes availability and location of spare parts	Y	Q §B6	
d. Indicates procedures in place for inspecting equipment before usage	Y	Q §B7.1	
e. Identifies individual(s) responsible for testing, inspection and maintenance	Y	Q §B7.1	
f. Indicates how deficiencies found should be resolved, re-inspections performed, and effectiveness of corrective action determined and documented	Y	Q §C1.5	
B7. Instrument/Equipment Calibration and Frequency			
a. Identifies equipment, tools, and instruments that should be calibrated and the frequency for this calibration	Y	Q §B7.1	
b. Describes how calibrations should be performed and documented, indicating test criteria and standards or certified equipment	Y	F Appendix A	
c. Identifies how deficiencies should be resolved and documented	Y	Q §C1.5	
B8. Inspection/Acceptance for Supplies and Consumables			
a. Identifies critical supplies and consumables for field and laboratory, noting supply source, acceptance criteria, and procedures for tracking, storing and retrieving these materials	Y	F Table 3-3, Appendix A Q Appendix A	
b. Identifies the individual(s) responsible for this	Y	Q §A4.5	
B9. Use of Existing Data (Non-direct Measurements)			
a. Identifies data sources, for example, computer databases or literature files, or models that should be accessed and used	Y	F §1.1.4, Table 1-1	
b. Describes the intended use of this information and the rationale for their selection, i.e., its relevance to project	Y	Q §A6 F §2.0	
c. Indicates the acceptance criteria for these data sources and/or models	Y	F Table 2-2, 2-3	

d. Identifies key resources/support facilities needed	NA		
e. Describes how limits to validity and operating conditions should be determined, for example, internal checks of the program and Beta testing	NA		
B10. Data Management			
a. Describes data management scheme from field to final use and storage	Y	Q §B10.1	
b. Discusses standard record-keeping and tracking practices, and the document control system or cites other written documentation such as SOPs	Y	Q §B10.1	
c. Identifies data handling equipment/procedures that should be used to process, compile, analyze, and transmit data reliably and accurately	Y	Q §B10.1	
d. Identifies individual(s) responsible for this	Y	Q §A4	
e. Describes the process for data archival and retrieval	Y	Q §10.2.3	
f. Describes procedures to demonstrate acceptability of hardware and software configurations	N		
g. Attaches checklists and forms that should be used	Y	F Appendix C	
C. Assessment and Oversight			
C1. Assessments and Response Actions			
a. Lists the number, frequency, and type of assessment activities that should be conducted, with the approximate dates	Y	Q §C1.1 through C1.4	
b. Identifies individual(s) responsible for conducting assessments, indicating their authority to issue stop work orders, and any other possible participants in the assessment process	Y	Q §A4	
c. Describes how and to whom assessment information should be reported	Y	Q §C1.4	
d. Identifies how corrective actions should be addressed and by whom, and how they should be verified and documented	Y	Q §C1.5	
C2. Reports to Management			
a. Identifies what project QA status reports are needed and how frequently	Y	Q §C1.5	
b. Identifies who should write these reports and who should receive this information	Y	Q §A4	
D. Data Validation and Usability			
D1. Data Review, Verification, and Validation			
Describes criteria that should be used for accepting, rejecting, or qualifying project data	Y	Q §D1 and D1.1	
D2. Verification and Validation Methods			
a. Describes process for data verification and validation, providing SOPs and indicating what data validation software should be used, if any	Y	Q §D1	
b. Identifies who is responsible for verifying and validating different components of the project data/information, for example, chain-of-custody forms, receipt logs, calibration information, etc.	Y	Q §D1, A4	
c. Identifies issue resolution process, and method and individual responsible for conveying these results to data users	Y	Q §D1, A4	

d. Attaches checklists, forms, and calculations	Y	F Appendix A F Appendix C	
D3. Reconciliation with User Requirements			
a. Describes procedures to evaluate the uncertainty of the validated data	NA		Data uncertainty will be discussed in RA.
b. Describes how limitations on data use should be reported to the data users	NA		Data uncertainty will be discussed in RA.

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United Park Health and Safety Plan
Richardson Flat Tailings Site
Operable Units 2 and 3
Park City, Utah

Site ID Number: UT980952840

Prepared for:

United Park City Mines Company
P.O. Box 1450
Park City, Utah 84060

Prepared by:

Resource Management Consultants, Inc.
8138 South State Street, Ste. 2A
Midvale, Utah 84047
801-255-2626

September 5, 2014

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1.0 INTRODUCTION

This Health and Safety Plan (HASP) was prepared in accordance with EPA's Standard Operating Safety Guide (PUB 9285.1-03, PB 92-963414, June 1992 or subsequently issued guidance). In addition, the plan complies with all currently applicable Occupational Safety and Health Administration (OSHA) regulations found at 29 C.F.R. Part 1910.

A Site Map is included as Attachment A.

1.1 Scope and Applicability of the Health and Safety Plan

This Health and Safety Plan (HASP) is intended to protect all employees, general contractors, subcontractors, construction workers and/or visitors conducting or observing any activities under the direction of United Park City Mines Company (United Park). This HASP is intended to govern all activities conducted pursuant to the Settlement Agreement and any appendices thereto, including but not limited to the to the EE/CA Work Plan attached as Appendix C to the Settlement Agreement and the Scope of Work for Injury Assessment and Restoration Alternatives Analysis for the Richardson Flat Tailings Site, Operable Units 2 and 3 attached as Appendix D to the Settlement Agreement.

The HASP is intended to minimize potential exposures and/or accidents that may occur, and details the actions to be taken during an emergency. The HASP will establish required procedures intended to minimize exposures of United Park personnel, contractors, visitors and the surrounding community. Guidelines contained herein that are appropriate to the activities conducted pursuant to the Settlement Agreement will be observed at all times.

All personnel will be required to understand and observe the provisions of this plan. Any tasks associated with investigation or removal activities conducted pursuant to the Settlement Agreement must be performed in accordance with this policy, which is designed to ensure that employees are adequately protected from any potential chemical and/or physical hazards present at OU2 or OU3. To help ensure safety compliance, all field participants and observers must read this plan and sign a certification stating that they agree to comply with the conditions of the policy. All activities will be conducted in accordance with 29 CFR Part 1910, *OSHA standards for general industry.*

1.2 Visitors

Visitors to OU2 or OU3 are not required to have completed any specific training in health and safety, although it is strongly recommended that they be familiar with the hazards on-site as well as PPE, decontamination procedures, and the emergency plan. Visitors may

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not enter any hazardous area (e.g., exclusion or decontamination zones) without the proper training.

2.0 KEY PERSONNEL/IDENTIFICATION OF HEALTH AND SAFETY PERSONNEL

2.1 Key Personnel

Key management responsibilities are as follows:

Individual	Role/Responsibility
Kerry Gee	United Park Project Manager
Jim Fricke	RMC Project Manager
Kathryn Hernandez	EPA Remedial Project Manager
Mohammad Slam	UDERR Project Manager
Christine Cline	U.S. Fish and Wildlife Service
Dan Dean	RMC – QA Official/Field Manager/Health and Safety Manager

2.2 Site-Specific Health and Safety Personnel

2.2.1 Project Manager

The RMC Project Manager is responsible for implementation of the work plan and compliance with the HASP.

2.2.2 Health and Safety Manager

The Health and Safety Manager will have a thorough working knowledge of state and federal occupational safety and health regulations in addition to thorough knowledge and understanding of this plan. The Health and Safety Manager will have the authority to temporarily suspend operations at OU2 and OU3 in order to ensure safety and resume normal operations once the appropriate measures have been taken. The Health and Safety Manager will report directly to the RMC Project Manager.

Note: The aforementioned personnel may be increased, or personnel may share responsibilities dependent upon specific site conditions.

2.3 Organizational Responsibility

All OU2 and OU3 personnel will report any significant issues to Kerry Gee, the United Park Project Manager. Mr. Gee will determine the appropriate chain of command.

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3.0 TASK/OPERATION SAFETY AND HEALTH RISK ANALYSIS

3.1 Historical Overview

Mining in the Park City area began around 1869 and continued sporadically through 1982. Copper, gold, lead, silver, and zinc were the metals of primary economic interest, but other metals were associated with the ore. Historically, there have been as many as ten mills operating along the banks of Silver Creek. The majority of these milling companies, including the Grasselli, Broadwater and E.J. Beggs mills were located near the Prospector Square area of Park City on the Silver Maple Claims. Within the lower part of the watershed, the primary operating mill was the Big Four Mill, located near the Pace Ranch building that is adjacent to Promontory Road, between the Summit County Sheriff's facility and the Pivotal Promontory, LLC development. The mill straddled the Promontory Roadway in the area of the Pace Ranch building.

Numerous investigations of OU2 and OU3 have been conducted by the following organizations:

- Tetra-Tech, for the United States Environmental Protection Agency;
- The United States Environmental Protection Agency;
- The United States Geological Survey;
- The State of Utah; and
- United Park City Mines Company.

The site is composed of wetland and upland habitats and plant communities. Currently there are no residential properties or populations residing within OU2 or OU3.

The site is characterized by a cool, dry, semi-arid climate. Long-term meteorological observations have not been kept at the site. The two nearest meteorological data stations are located in Park City, Utah which is located 500 feet higher in elevation three miles to the southeast in the Wasatch Mountains, and Kamas, Utah located at a similar elevation to the site and nine miles to the east. The annual precipitation for the site likely falls in-between the values for the two meteorological stations. Annual precipitation at Park City is 21.44 inches of water with an annual average high temperature of 56.3 degrees and an annual average low temperature of 30.8 degrees. Annual precipitation at Kamas is 17.27 inches of water per year with an average annual low temperature of 29.0 degrees and an average annual high temperature of 58.7 degrees (www.wrc.dri.edu, 2001).

Long-term wind data have not been kept in the vicinity of the site. The prevailing wind direction is from the northwest to southeast as determined by the EPA contractor Ecology and Environment during an air monitoring assessment conducted in 1986.

The Rail Trail State Park runs north-south through the site, paralleling the valley bottom between the floodplain and higher ground to the east. The Rail Trail is a former Union Pacific Railroad rail bed.

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3.2 Task-by-Task Risk Analysis

3.2.1 Chemical Specific Risks

The primary Contaminants of Potential Concern (COPCs) are heavy metals.

The COPCs are found in soil, sediment, surface water and shallow groundwater. The sources of contamination at OU2 and OU3 are related to tailings and impacts to sediments, soils, surface and shallow groundwater from multiple sources located upstream in the Silver Creek Watershed.

Risks to human receptors potentially include:

- Incidental ingestion of tailings;
- Incidental ingestion of affected surface water;
- Ingestion of fish;
- Incidental inhalation of affected sediment and tailings;
- Incidental ingestion of affected sediment; and
- Incidental ingestion of wind-deposited tailings.

The tasks in which workers at OU2 and OU3 potentially would be exposed to COPCs include:

- Investigation;
- Removal Action;
- Restoration; and
- Operations and Maintenance (O&M).

Exposure risks are proportional to contact with COPCs. Risk will increase with disturbance at OU2 and OU3. Risks will be mitigated on an as-needed basis.

3.2.2 Physical Hazard Specific Risks

Investigation and removal activities may expose field personnel to potential physical hazards including, but not limited to:

- Holes and ditches;
- Water features;
- Uneven terrain;
- Slippery surfaces;
- Biological hazards such as snakes and poisonous plants;
- Electrical equipment;
- Mobile equipment;
- Overhead hazards;
- Underground hazards; and

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- Construction equipment.

4.0 PERSONNEL TRAINING REQUIREMENTS

4.1 Preassignment and Annual Refresher Training

All full-time, part-time and short-duration personnel must hold current certification of the Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) 40-hour training. Visitors shall be escorted at all times by the United Park Project Manager, the RMC Project Manager or the RMC Field Manager.

4.2 Supervisors Training

All supervisors will comply with the requirements presented in Section 4.1.

4.3 Training and Briefing Topics

Prior to construction, all field participants and observers must read this plan and sign a certification stating that they agree to comply with the conditions of the policy. During any construction or excavation activities, the Health and Safety Manager will conduct mandatory weekly safety meetings for all personnel. The meetings will provide time for refresher courses, and new site conditions will be examined as they are encountered.

5.0 PERSONAL PROTECTIVE EQUIPMENT TO BE USED

Personal Protective Equipment (PPE) should be used only when engineering controls and work practices are insufficient to adequately protect against exposure.

5.1 Levels of Protection

Levels of PPE are determined by anticipated site conditions. The primary PPE level, as described in Section 5.2, is Level D. This is based on the results of air monitoring conducted during remedial activities at Richardson Flat OU1. Air monitoring conducted during remedial activities at OU1 indicated that OSHA Permissible Exposure Limits (PELs) and Action Levels (ALs) were not exceeded during five-years of remediation (2007 through 2012).

5.2 Primary PPE Level

The minimum level of protection used during any construction activities is Level D, requiring the following items:

- Hardhat;

- Steel-toed boots;
- Safety glasses;
- Work gloves;
- Sampling gloves (when needed); and
- Hearing protection (when needed).

In addition to Level D PPE, traffic vests will be worn on-site when needed.

6.0 MEDICAL SURVEILLANCE REQUIREMENTS

The medical surveillance program is required for monitoring the health status of personnel who are potentially exposed to hazardous substances in the field and who wear respirators 30 days or more per year. The medical surveillance program is not required for personnel who are potentially exposed to hazardous substances in the field and do not wear respirators 30 days or more per year.

6.1 Baseline or Preassignment Monitoring

Baseline or preassignment monitoring will include initial medical examinations.

6.2 Periodic Monitoring

Periodic monitoring will include yearly medical examinations.

6.3 Site-Specific Medical Monitoring

Site-specific medical monitoring will focus on exposure to the COPCs.

6.4 Exposure/Injury/Medical Support

Exposure/Injury/Medical support will be obtained if personnel:

- Receive, or may have received, a possible overexposure to on-site contaminants;
- Sustain an injury requiring medical attention or hospitalization;
- Experience an unexplained or serious illness.

6.5 Exit Physical

Exit physicals will be conducted upon completion of the project or termination of employment.

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7.0 FREQUENCY AND TYPES OF AIR MONITORING/SAMPLING

7.1 Direct-Reading Monitoring Instruments

Direct Reading Monitoring instruments will be limited to the use of a field portable X-Ray Fluorescence Meter (XRF). The XRF provides real-time data on metals concentrations in soils. OU2/OU3 personnel will use a Niton Corporation portable XRF as outlined in the Niton Corporation User's Guide which details the Nuclear Regulatory Commission's requirements. Registration needed for the Niton XRF instrument will be obtained prior to use on-site.

7.2 Air Monitoring and Sampling Program

During remediation construction involving contact with contaminated materials, personal air monitoring will be conducted to verify and document that exposures to COPCs do not exceed the OSHA PELs and ALs. If monitoring reveals exposures above an OSHA PEL, then field personnel will be upgraded to Level C protection which requires chemical resistant PPE and an air-purifying respirator in addition to the Level D PPE described in Section 5.2. Prior to donning respirators, all personnel will be briefed on proper cleaning and maintenance of respirators, fit tested and a baseline spyrometer test will be used to ensure that all personnel are able to draw air from the device.

OSHA PELS and ALs for COPCs:

Metal	PEL (mg/m^3)	AL (mg/m3)
Arsenic	.2	.005
Cadmium	.005	.00025
Lead	.05	.03

8.0 OU2/OU3 CONTROL MEASURES

8.1 Buddy System

Where advisable, activities conducted pursuant to the Settlement Agreement will not be conducted by lone personnel. This will include situations such as test pit sampling, water sampling during extreme flow events and use of heavy equipment for trenching.

Exceptions to this may include activities with minimal objective hazards including but not limited to:

- Surface and shallow soil sampling,
- Surface water sampling during low-flow events;
- Vegetation sampling; and
- Groundwater sampling

8.2 Communications Plan

Communication will be conducted via cell phones which provide ample coverage throughout OU2 and OU3.

8.3 Work Zone Definition

The work zone includes all areas necessary to conduct activities required pursuant to the Settlement Agreement. Individual work zones will be identified on an as-needed basis. A map depicting OU2 and OU3 is included in Appendix A.

8.4 Nearest Medical Assistance

The nearest medical assistance is located at the Park City Medical Center located at 900 Round Valley Drive, Quinn's Junction, Park City, Utah, approximately four miles from OU2 and OU3. The Park City Medical Center's telephone number is: (435) 658-7000 or (800) 544-2885. Personnel will be required to drive to the location of the hospital prior to beginning of work to familiarize themselves with the emergency route.

An Emergency Route Map to the Park City Medical Center is included as Attachment C.

8.5 Safe Work Practices

8.5.1 Cleaning/Maintenance Area

At the entrance(s) of each work zone, a decontamination area will be provided. United Park or other personnel having contact with any potentially contaminated material will be required to remove gross contamination from their vehicles, equipment, boots and coveralls prior to leaving OU2/OU3. Decontamination plans and procedures are further described in Section 9.0.

8.5.2 General Maintenance

Regular cleaning and maintenance is key to maintaining acceptable exposure levels for metals. Cleaning and maintenance will be required for all equipment and facilities used by on-site and off-site personnel.

8.5.3 Equipment Safety

All mobile equipment with limited rear visibility will be equipped with audible back-up alarms. If mobile equipment operates at night, it will be equipped with headlights and taillights. All equipment will be maintained in good working condition. When an operator leaves their equipment, emergency brakes will be set and any hydraulics released. If a truck is parked on an incline, the tires will be chocked.

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When refueling, engines will be shut off. All mobile equipment will be supplied with a fire extinguisher.

8.5.4 Electrical Safety

Electrical power tools will be routinely inspected. Electric tools with frayed cords or broken housings will be tagged and taken out of service.

If tools are used in wet conditions, they must be listed or labeled as double insulated. All extension cords will be of the three-wire ground type and be connected to a ground fault circuit interrupter (GFCI). If extension cords are not plugged into a permanently mounted GFCI, then the extension cord must be supplied with a waterproof GFCI. Extension cords that are spliced, worn, or frayed will not be used. Extension cords must have the manufacturers rating on the cord and it must be legible; if it is not legible the cord will be taken out of service.

8.5.5 Miscellaneous Safety Rules

Miscellaneous Safety Rules include the following:

- No misbehavior is permitted at any time;
- Vehicles used to transport personnel will have seats firmly secured and enough seats for the number of persons to be carried; and
- Seat belts and anchors meeting the requirements of 49 CFR part 571 (Department of Transportation, federal motor vehicle safety standards) will be installed in all motor vehicles.

8.5.6 Fugitive Dust

While performing any construction or excavation, engineering controls will be used to ensure worker exposure remains below the applicable OSHA PEL. Engineering controls will include wetting down excavation areas as needed during any excavation where visible fugitive dust is present. A water truck or equivalent equipment will be used for fugitive dust control. The Health and Safety Officer will be responsible for monitoring dust control when needed. Weekly air monitoring will be conducted during removal activities. Air monitoring will be conducted to determine compliance with OSHA PELs for COPCs (Section 7.2).

9.0 DECONTAMINATION PLAN

Any property where hazardous waste cleanup operations occur must have a plan that outlines decontamination procedures (29 CFR §1910.120(k)).

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9.1 Standard Operating Procedures

RMC Standard Operating Procedure 6 regarding decontamination of sampling equipment is focused on the removal of gross contamination from equipment.

9.2 Levels of Decontamination Protection Required for Personnel

Decontamination procedures for field personnel shall be:

- Removal of gross contamination from clothing and boots prior to leaving OU2/OU3;
- Wash hands and face at facility provided (wipes may be substituted);
- Containment of dirty coveralls (if used);
- Launder coveralls at commercial laundry (if necessary).

9.3 Equipment Decontamination

The decontamination procedures for equipment shall be:

- Soils or dusts that cling to equipment and personnel or that become lodged in PPE materials can be removed with water or a liquid rinse;
- Clean vehicles (inside and out) as needed prior to leaving OU2/OU3;
- Construction equipment, backhoes, loaders, dump trucks, hand tools, trailers, hoses, etc. contacting any contaminated material will be cleaned of gross contamination before leaving OU2/OU3 and pressure washed when scheduled work is completed; and
- Sampling equipment and hand tools contacting potentially contaminated materials will be cleaned of gross contamination prior to leaving OU2/OU3.

9.4 Disposition of Decontamination Wastes

Where possible, all decontamination wastes (e.g. gross contamination) will be considered Investigation Derived Waste (IDW) and be disposed of onsite.

10.0 EMERGENCY RESPONSE/CONTINGENCY PLAN

10.1 Pre-Emergency Planning

All workers will be briefed prior to conducting activities pursuant to the Settlement Agreement. The briefing will included at a minimum:

- The contents of this HASP;
- General safety procedures; and

- Potential hazards for specific activities.

Prior to start-up of the project, communication procedures will be established that will ensure emergency services are summoned in a timely manner.

10.2 Personnel Roles and Lines of Authority

The Incident Command System (http://ops.fhwa.dot.gov/publications/ics_guide/glossary.htm) used on this project will utilize different senior response officials depending on the nature of the incident. Front line supervisors are the initial "Senior Official" until the United Park or RMC Project Manager or the Health and Safety Manager arrives. When emergency officials arrive, they shall become the "Senior Official".

10.3 Emergency Recognition/Prevention

Common forms of emergency include, but are not limited to fires, explosions, spills, sudden changes in weather, and personal illness or injury. The following emergency response procedures (Sections 10.4 through 10.12) have been developed to help ensure a timely and efficient response to emergency situations that may arise.

10.4 Evacuation Routes/Procedures

Due to the dispersed nature of OU2/OU3, evacuation routes will generally follow the route that was taken to each specific work zone.

A map to the Park City Medical Center is presented in Attachment C.

10.5 Emergency Contact/Notification System

Emergency Contacts will be made in the order of priority. For example, 911 will be the first call in emergency situations.

An emergency phone list is included as Attachment B.

10.6 Emergency Medical Treatment Procedures

If field personnel are injured, the incident scene will be evaluated for immediate hazards and actions taken to eliminate those hazards. Once the incident scene is safe, the "Senior Official" will make an evaluation of the injured person. Seriously injured personnel should not be moved unless their life is in immediate danger and until a person trained in first-aid and CPR has made an assessment.

If the victim is conscious, first-aid may only be administered with the injured person's permission. If the victim is unconscious or unable to respond, then no permission is required to provide standard first aid. If no outside emergency services are needed, the

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"Senior Official" will arrange for the injured person to be transported to a medical facility. The RMC Project Manager and the RMC Heath and Safety Manager are both trained and certified in first aid and CPR.

If it is determined that emergency medical services are needed, the emergency services listed in Attachment B will be contacted as soon as possible. Calling for help is often the most important action to be taken. If you are the only person with the injured employee and urgent care is needed, provide initial critical care and then contact the outside emergency services. Return to care for the victim as soon as possible.

First-aid or other appropriate actions can be administered by the initial "Senior Official" or by the victim. For injuries requiring medical treatment such as a laceration requiring stitches or a sprained ankle, the "Senior Official" shall arrange transportation to the emergency facility as noted in Figure 1. For major injuries, the "Senior Official" may administer first-aid. The "Senior Official" rendering assistance will not place themselves in a situation of unacceptable risk.

10.7 Fire or Explosion

Fire or explosion hazards are limited to vehicles and equipment. Each piece of equipment will carry an appropriate fire extinguisher.

If a fire or explosion occurs, the area will be evacuated to a safe distance prior to calling 911. Due to the nature of contaminants at OU2/OU3 (metals in soil and sediments), fire or explosion hazards are the only situations where evacuation to safe distances or refuge locations are anticipated.

10.8 Spill or Leaks

Spills or leaks will be restricted to equipment fuel and associated fluids (e.g. hydraulic oil). Each piece of equipment will carry appropriate spill prevention supplies. Any spills or leaks will be reported to the RMC Project Manager. The RMC Project Manager shall notify the United Park Project Manager and any federal or state departments if necessary (e.g. UDEQ water quality division).

Best management practices such as silt fencing and berms will be used to contain stockpiles of soils and sediment.

10.9 Heat and Cold Stress

The potential for both heat and cold related disorders or conditions can occur in many common situations. Monitoring of heat and cold stress will include obtaining a baseline heart rate and oral temperature for all personnel, observation from the Health and Safety Manager, and personnel observation and communication. If numerous personnel begin to exhibit signs of heat or cold stress, monitoring will be expanded to all personnel on-site and precautionary reassures, such as decreased work cycles, will be put in place. Cold

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early morning temperatures can give way to warm daily temperatures, resulting in heavy perspiration within protective clothing. As temperatures cool again in the evening, the potential for cold related disorders or conditions can occur. Managers should be aware of the potential for this occurrence and should monitor workers accordingly. Dehydration and sunburn can occur in both hot and cold work environments. Workers at OU2 and OU3 should drink fluids and protect themselves with sunscreen on a year-round basis. Sunscreen should be applied regularly with washed hands prior to donning PPE to avoid contamination during sample collection.

10.9.1 Heat Stress

The potential for heat stress depends on the type of protective gear being worn, the ambient temperature and the worker's level of activity. Personnel will report any cases of dizziness, weakness, excessive sweating, lack of sweating, increased respiratory rate, or pulse and are to leave the work area immediately. Treatment for these symptoms is to remove the victim from the elements, administer extra fluids and apply a cold compress, and the heart rate and temperature of the victim will be recorded. Work cycle lengths and conditions will be based initially on subjective input from personnel. Work cycles will be reduced or adapted and a monitoring program will be initiated if the above conditions are encountered. Work cycles will also be reduced if a pulse rate of greater than 110 is noticed during rest. Personnel with elevated rates will not return to work until their pulse has lowered to their resting rate.

Workers exhibiting signs of heat stress will have their oral temperature measured at the beginning of a rest period before liquid intake. If oral temperature exceeds 99.6° F, the next work cycle will be shortened by one-third without changing the rest period. If the oral temperature still exceeds 99.6° F at the beginning of the next rest period, the next work cycle will be shortened by another one-third. If the oral temperature exceeds 100.6° F, the worker will not be allowed to wear semi-permeable or impermeable clothing. If an employee is overcome with heatstroke or becomes unconscious, the 9-1-1 service will be called. First-aid procedures will be used for heat related conditions, as necessary.

10.9.2 Cold Stress

During on-site activities, workers may be exposed to cold temperatures. Exposure to cold temperatures increases the likelihood and potential for disorders or conditions that could result in injury or illness. Factors leading to hypothermia and frostbite include ambient temperature, wind velocity, exposure time and insufficient cold-weather protective gear. Signs of excess cold exposure include uncontrollable fits of shivering, slurred speech, memory lapses, immobile hands, stumbling, drowsiness, and exhaustion. At the first sign of exposure, monitoring will begin and treatment will be administered if the personnel report any of the symptoms above or if the Health and Safety manager notices the above symptoms for any personnel. Treatments for these symptoms are to get the victim out of the wind and cold, remove wet clothing, supply a warm drink, and keep victim warm with blankets or clothing. If the victim's internal body temperature drops below 87°F, additional treatment at a medical facility is required.

Extreme low temperatures may not be required to create the potential for cold exposure problems; strong wind accompanied by cold temperatures can lead to these types of problems. The wind-chill factor is the cooling effect of any combination of temperature and wind velocity. The wind-chill factor should be considered when planning for exposure to low temperatures and wind.

The two primary forms of cold stress are described below:

Hypothermia

The first symptoms of this condition are uncontrollable shivering and the sensation of cold, irregular heartbeat, weakened pulse, and change in blood pressure. Severe shaking of rigid muscles may be caused by a burst of body energy and changes in the body's chemistry. Vague or slow slurred speech, memory lapses, incoherence, and drowsiness are some of the additional symptoms. Symptoms noticed before complete collapse are cool skin, slow and irregular breathing, low blood pressure, apparent exhaustion, and fatigue even after rest. As the core body temperature drops, the victim may become listless and confused, and may make little or no attempt to keep warm. Pain in the extremities can be the first warning of dangerous exposure to cold. If the body core temperature drops to about 85° F; a significant and dangerous drop in the blood pressure, pulse rate, and respiration can occur. In extreme cases, death will occur.

Frostbite

Frostbite occurs when the extremities do not receive sufficient heat from the central body and can happen in the absence of cold stress or hypothermia. This can occur because of inadequate circulation and/or insulation. Frostbite occurs when there is freezing of fluids around the cells of the body tissues due to extremely low temperatures. Damage may result, including loss of tissue around the areas of the nose, cheeks, ears, fingers, and toes. This damage can be serious enough to require amputation or result in permanent loss of movement. The first symptom of frostbite is an uncomfortable sensation of coldness, followed by numbness. Other symptoms of frostbite Include tingling, stinging, aching, or cramping. The skin changes color to white or grayish yellow, then to reddish-violet, and finally turns black as the tissue dies. Pain may be felt at first, but subsides. Blisters may appear. The affected part is cold and numb. When frostbite of the outer layer of skin occurs, the skin has a waxy or whitish look and is firm to the touch. In cases of deep frostbite, the tissues are cold, pale, and solid. Injury is severe.

10.10 Emergency Equipment/Facilities

The following emergency equipment will be maintained at all work areas:

- Cellular Telephone;
- First-aid kit;
- Fire extinguisher;

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- Sanitary station for washing hands; and
- Emergency eye wash solution.

10.11 Critique of Response and Follow-Up

Should an emergency response occur, following the conclusion of the response action the incident will be reviewed. Response to the incident will be critiqued to determine if the procedures in this HASP were followed appropriately and if current HASP procedures need to be amended to improve emergency response in potential future incidents.

11.0 CONFINED SPACE ENTRY PROCEDURES

11.1 Definitions

As per 29 CFR 1910.146 (b), "confined space" means a space that:

(1) Is large enough and so configured that an employee can bodily enter and perform assigned work; and

(2) Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and

(3) Is not designed for continuous employee occupancy.

Confined space at OU2/OU3 would be limited to soil test pit excavations.

11.2 General Provisions

Soil test pits that qualify as a confined space, as defined in Attachment D, will not be entered. Where possible, all soil samples will be collected by the equipment (e.g. trackhoe/backhoe) performing the excavation.

11.3 Procedure for Confined Space Entry

Soil test pits that do not qualify as a confined space will only be entered under the supervision of a "Competent Person" which is defined by OSHA Technical Manual (OTM) Section V: Chapter 2 (http://www.osha.gov/dts/osta/otm/otm_v/otm_v_2.html, Presented in Attachment D as *"an individual who is capable of identifying existing and predictable hazards or working conditions that are hazardous, unsanitary, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate or control these hazards and conditions"*.

Due to the diversity of excavation and necessary depths of test pits on-site, the RMC Health and Safety Manager will discuss benching and shoring regulations that will be

required for the necessary depth of the test pit in the field and prior to excavation of test pits.

Trenching and pit safety is presented in Attachment D.

11.4 Confined Space Observer (Stand-by Person)

Anyone working in the immediate vicinity of a confined space (e.g. soil test pit) will only do so in the presence of an observer. The equipment operator may act as the observer.

12.0 HAZARD COMMUNICATION

Hazard Communication will include informing all personnel about the hazards of contaminants which include but are not limited to:

Arsenic	Toxic on inhalation and ingestion; skin irritant. Known human carcinogen.
Cadmium	Toxic on inhalation and ingestion. Probable human carcinogen
Lead	Toxic on inhalation and ingestion. Probable human carcinogen
Mercury	Toxic on inhalation and ingestion; skin irritant. Known human carcinogen.
Zinc	Zinc is considered to be relatively nontoxic, particularly if taken orally. However, manifestations of overt toxicity symptoms (nausea, vomiting, epigastric pain, lethargy, and fatigue) will occur with extremely high zinc intakes.

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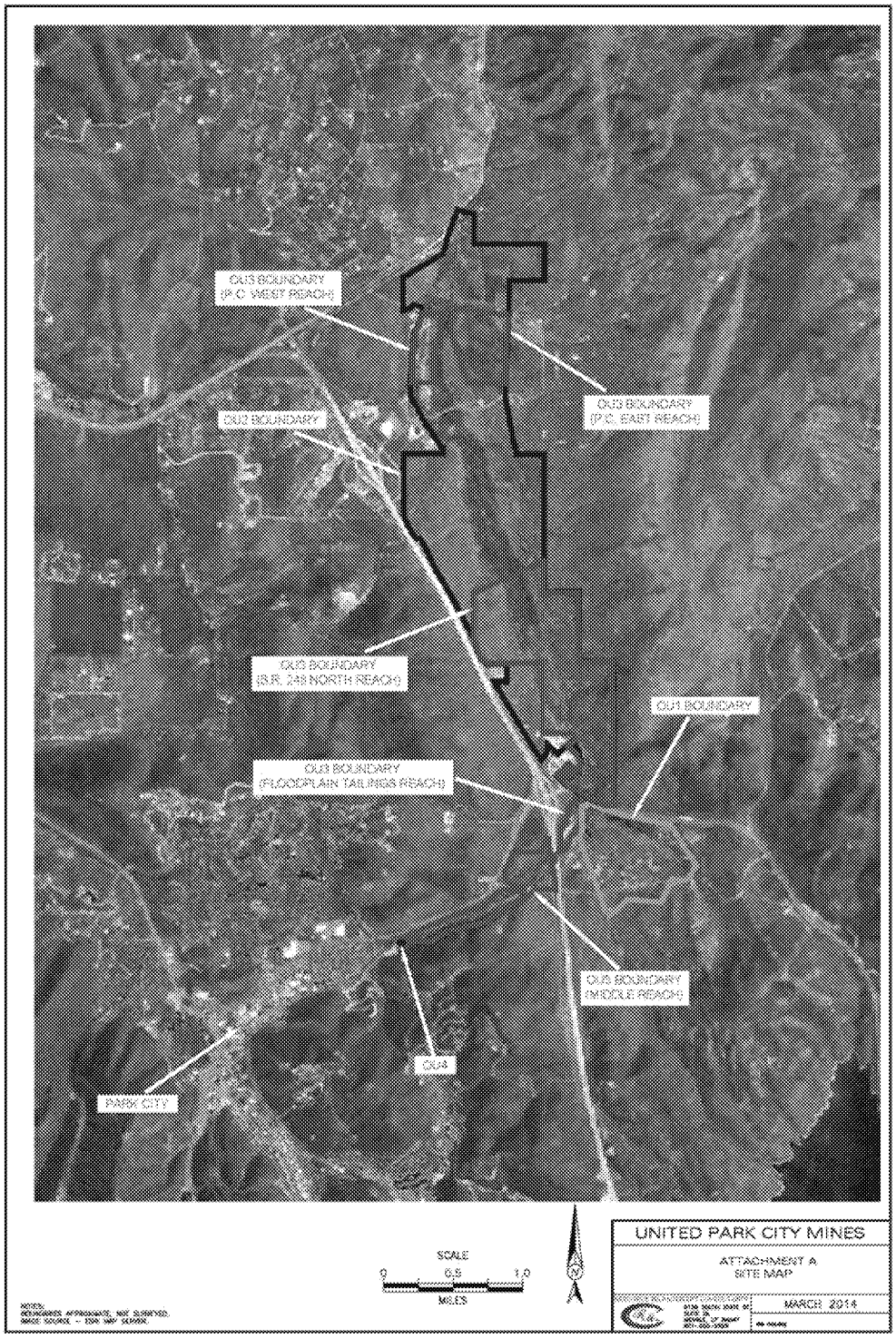
Attachment A – Site Map



Attachment B – Emergency Contact Phone Numbers

Organization	Telephone
Any Emergency	**911**
Ambulance:	911
Local Police (Summit County Sherriff)	435-615-3600
Fire:	911
State Police:	801-576-8606
Hospital (Primary)	435-658-7000
Hospital (Secondary)	800-544-2885
Poison Control Center:	801-581-2151
Regional EPA:	800-227-8917
EPA Emergency Response Team:	800-227-8914
National Response Center:	800-424-8802
Center for Disease Control:	404-639-3311
Chemtrec:	800-262-8200
Spill Center:	978-897-6461
United Park Emergency Operations Center:	801-355-2350
DOE Emergency Operations Center (National Center):	202-586-5000

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Attachment C – Emergency Route to Hospital

Driving directions to Park City Medical Center from OU3 (Source: Google Maps)

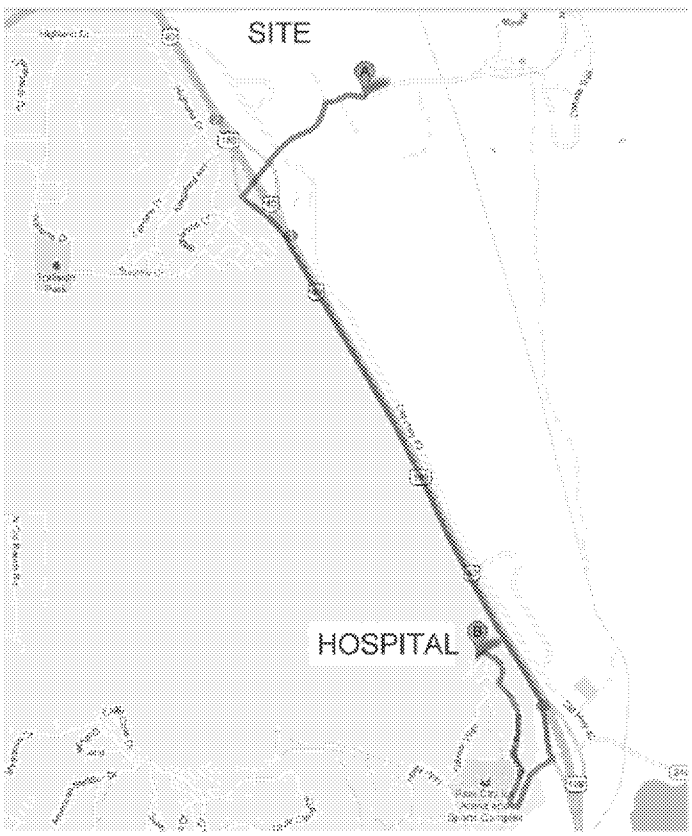
Park City Medical Center
900 Round Valley Dr #200
Park City, UT 84060

Old Hwy 40

1. Head southeast on Old Hwy 40 2.1 mi
2. Turn right onto UT-248 W 0.4 mi
3. Take the 1st right onto Round Valley Dr 0.6 mi
4. At the traffic circle, continue straight to stay on Round Valley Dr
   Destination will be on the right 0.2 mi

Driving directions to Park City Medical Center from OU2:

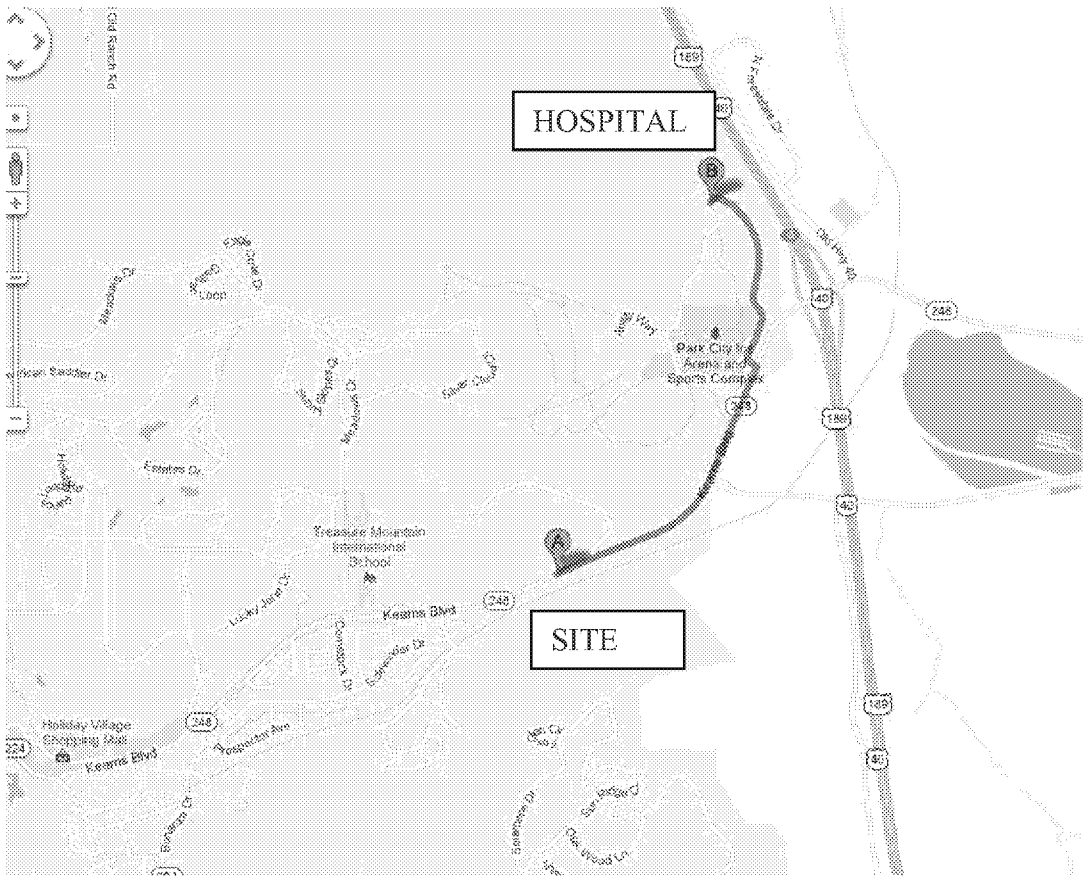
1. Head west toward Justice Center Rd 0.2 mi
2. Turn left onto Silver Creek Dr 0.4 mi
3. Continue onto Silver Summit Pkwy 0.1 mi
4. Turn left to merge onto US-40 E 2.5 mi
5. Take exit 4 toward Park City/Kamas 0.2 mi
6. Turn right onto Kearns Blvd 0.3 mi
7. Take the 1st right onto Round Valley Dr 0.6 mi
8. At the traffic circle, continue straight to stay on Round Valley Dr
   Destination will be on the right 0.2 mi



Driving directions to Park City Medical Center from the southern portion of OU3:

1. Head northeast on UT-248 E/Kearns Blvd toward Richardson Flat Rd 1.0 mi
2. Turn left onto Round Valley Drive 0.6 mi
3. At the traffic circle, continue straight to stay on Round Valley Drive
Destination will be on the right 0.1 mi

Park City Medical Center
900 Round Valley Dr, Park City, UT 84060



Attachment D – OSHA Technical Manual (OTM), Section V: Chapter 2

(http://www.osha.gov/dts/osta/otm/otm_v/otm_v_2.html)

EXCAVATIONS: HAZARD RECOGNITION IN TRENCHING AND SHORING

I. Introduction
II. Definitions
III. Overview: Soil Mechanics
IV. Determination of Soil Type
V. Test Equipment and Methods for Evaluating Soil Type
VI. Shoring Types
VII. Shielding Types
VIII. Sloping and Benching
IX. Spoil
X. Special Health and Safety Considerations
XI. Bibliography
Appendix V:2-1. Site Assessment Questions

For problems with accessibility in using figures and illustrations in this document, please contact the Office of Science and Technology Assessment at (202) 693-2095.

I. INTRODUCTION

Excavating is recognized as one of the most hazardous construction operations. OSHA recently revised Subpart P, *Excavations,* of 29 CFR 1926.650, 1926.651, and 1926.652 to make the standard easier to understand, permit the use of performance criteria where possible, and provide construction employers with options when classifying soil and selecting employee protection methods.

This chapter is intended to assist *OSHA Technical Manual* users, safety and health consultants, OSHA field staff, and others in the recognition of trenching and shoring hazards and their prevention.

II. DEFINITIONS

A. **Accepted Engineering Practices** are procedures compatible with the standards of practice required of a registered professional engineer.

B. **Adjacent Structures Stability** refers to the stability of the foundation(s) of adjacent structures whose location may create surcharges, changes in soil conditions, or other disruptions that have the potential to extend into the failure zone of the excavation or trench.

C. **Competent Person** is an individual who is capable of identifying existing and predictable hazards or working conditions that are hazardous, unsanitary, or dangerous to employees, and who *has authorization to take*

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prompt corrective measures to eliminate or control these hazards and conditions.

D. **Confined Space** is a space that, by design and/or configuration, has limited openings for entry and exit, unfavorable natural ventilation, may contain or produce hazardous substances, and is not intended for continuous employee occupancy.

E. **Excavation**. An **Excavation** is any man-made cut, cavity, trench, or depression in an earth surface that is formed by earth removal. A **Trench** is a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth of a trench is greater than its width, and the width (measured at the bottom) is not greater than 15 ft (4.6 m). If a form or other structure installed or constructed in an excavation reduces the distance between the form and the side of the excavation to 15 ft (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

F. **Hazardous Atmosphere** is an atmosphere that by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen-deficient, toxic, or otherwise harmful may cause death, illness, or injury to persons exposed to it.

G. **Ingress and Egress** mean "entry" and "exit," respectively. In trenching and excavation operations, they refer to the provision of safe means for employees to enter or exit an excavation or trench.

H. **Protective System** refers to a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, and from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

I. **Registered Professional Engineer** is a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer who is registered in any state is deemed to be a "registered professional engineer" within the meaning of Subpart P when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

J. **Support System** refers to structures such as underpinning, bracing, and shoring that provide support to an adjacent structure or underground installation or to the sides of an excavation or trench.

K. **Subsurface Encumbrances** include underground utilities, foundations, streams, water tables, transformer vaults, and geological anomalies.

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L. **Surcharge** means an excessive vertical load or weight caused by spoil, overburden, vehicles, equipment, or activities that may affect trench stability.

M. **Tabulated Data** are tables and charts approved by a registered professional engineer and used to design and construct a protective system.

N. **Underground Installations** include, but are not limited to, utilities (sewer, telephone, fuel, electric, water, and other product lines), tunnels, shafts, vaults, foundations, and other underground fixtures or equipment that may be encountered during excavation or trenching work.

O. **Unconfined Compressive Strength** is the load per unit area at which soil will fail in compression. This measure can be determined by laboratory testing, or it can be estimated in the field using a pocket penetrometer, by thumb penetration tests, or by other methods.

P. **Definitions That Are No Longer Applicable**. For a variety of reasons, several terms commonly used in the past are no longer used in revised Subpart P. These include the following:

1. **Angle of Repose.** Conflicting and inconsistent definitions have led to confusion as to the meaning of this phrase. This term has been replaced by **Maximum Allowable Slope.**

2. **Bank, Sheet Pile, and Walls.** Previous definitions were unclear or were used inconsistently in the former standard.

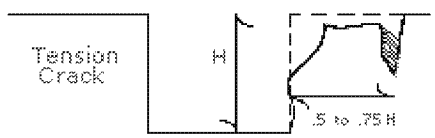
3. **Hard Compact Soil** and **Unstable Soil.** The new soil classification system in revised Subpart P uses different terms for these soil types.

III. 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.

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

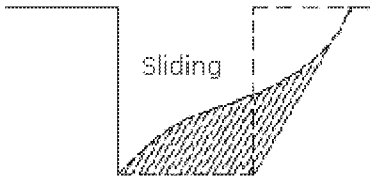
FIGURE 5:2-1. TENSION CRACK.



accompanying drawing for additional details.

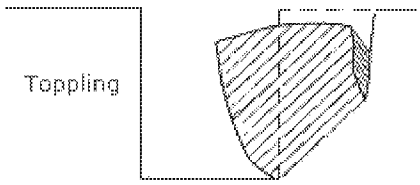
B. **Sliding** or sluffing may occur as a result of tension cracks, as illustrated below.

FIGURE 5:2-2. SLIDING.



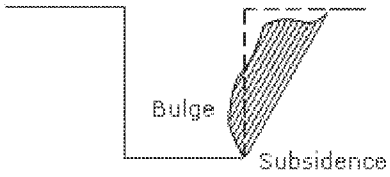
C. **Toppling**. In addition to sliding, tension cracks can cause toppling. Toppling occurs when the trench's vertical face shears along the tension crack line and topples into the excavation.

FIGURE 5:2-3. TOPPLING.



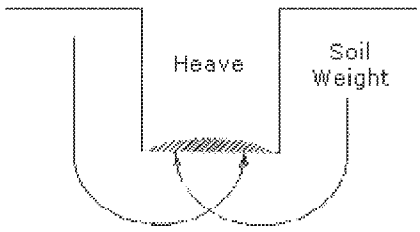
D. **Subsidence and Bulging**. An unsupported excavation can create an unbalanced stress in the soil, which, in turn, causes subsidence at the surface and bulging of the vertical face of the trench. If uncorrected, this condition can cause face failure and entrapment of workers in the trench.

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

FIGURE 5:2-6. BOILING.

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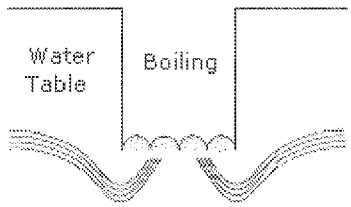
table is one of the causes of boiling. Boiling produces a "quick" condition in the bottom of the cut, and can occur even when shoring or trench boxes are used.



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.

IV. DETERMINATION OF SOIL TYPE

OSHA categorizes soil and rock deposits into four types, A through D, as follows:

G. **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.

H. **Type of 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.

I. **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).

J. **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.

K. **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

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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.

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). However, Penetrometers have error rates in the range of ± 20-40%.

1. **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).
2. **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.
3. **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.

A. **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.

B. **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,

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it is considered granular. The evaluator also checks for any signs of vibration.

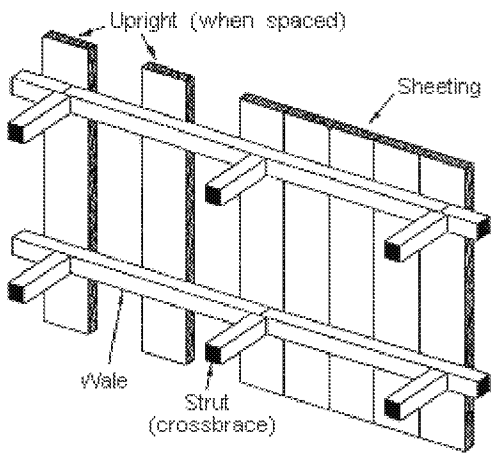
During a visual test, the evaluator should check for crack-line openings along the failure zone that would indicate tension cracks, look for existing utilities that indicate that the soil has previously been disturbed, and observe the open side of the excavation for indications of layered geologic structuring.

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 (see Paragraph III. F. in this chapter). 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.

SHORING TYPES

Shoring is the provision of a support system for trench faces used to prevent movement of soil, underground utilities, roadways, and foundations. Shoring or shielding is used when the location or depth of the cut makes sloping back to the maximum allowable slope impractical. Shoring systems consist of posts, wales, struts, and sheeting. There are two basic types of shoring, timber and aluminum hydraulic.

FIGURE V:2-7. TIMBER SHORING.



. **Hydraulic Shoring**. The trend today is toward the use of hydraulic shoring, a prefabricated strut and/or wale system manufactured of aluminum or steel. Hydraulic shoring provides a critical safety advantage over timber shoring because workers do not have to enter the trench to install or remove hydraulic shoring. Other advantages of most hydraulic systems are that they:

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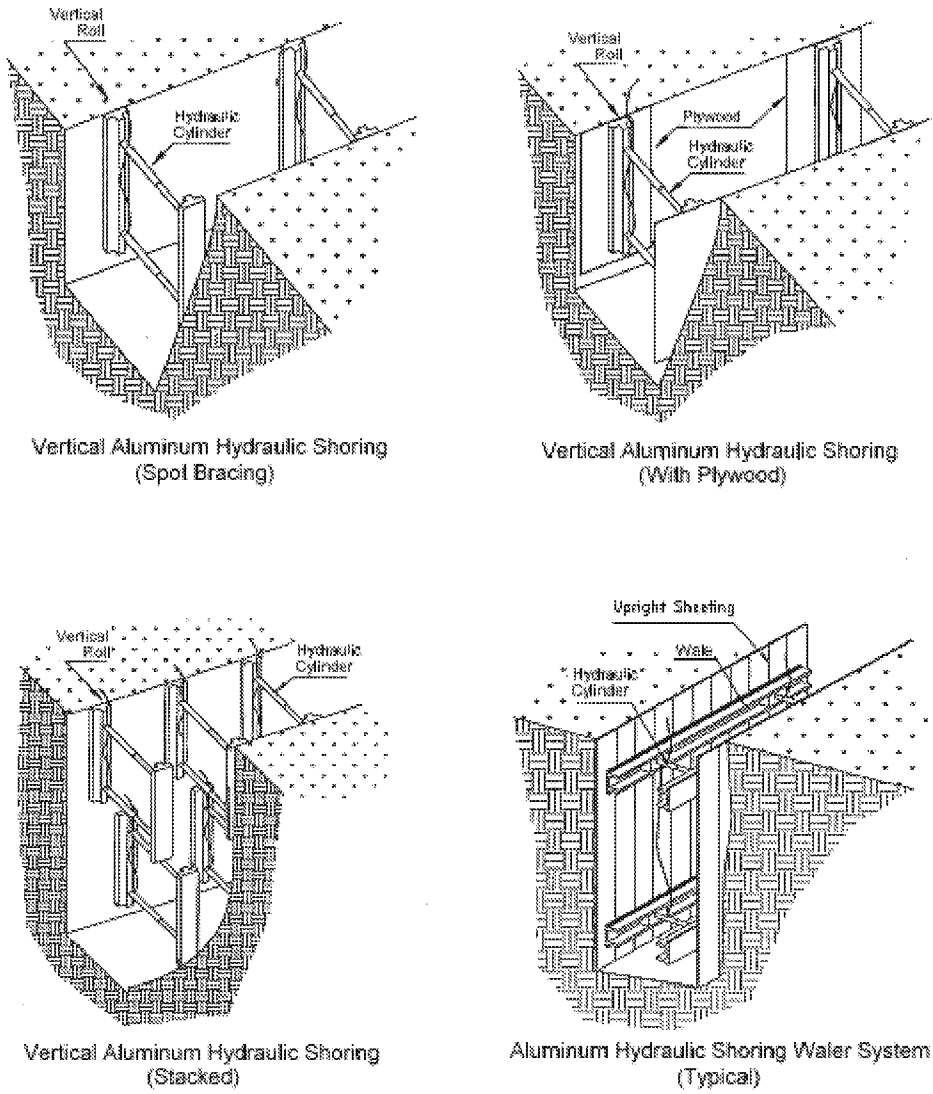
- Are light enough to be installed by one worker;
- Are gauge-regulated to ensure even distribution of pressure along the trench line;
- Can have their trench faces "preloaded" to use the soil's natural cohesion to prevent movement; and
- Can be adapted easily to various trench depths and widths.

All shoring should be installed from the top down and removed from the bottom up. Hydraulic shoring should be checked at least once per shift for leaking hoses and/or cylinders, broken connections, cracked nipples, bent bases, and any other damaged or defective parts.

FIGURE V:2-8. SHORING VARIATIONS: TYPICAL ALUMINUM HYDRAULIC SHORING INSTALLATIONS.



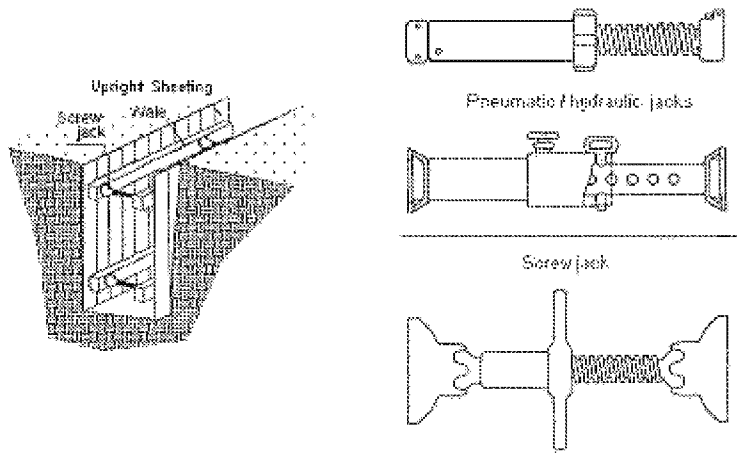
A. **Pneumatic Shoring** works in a manner similar to hydraulic shoring. The primary difference is that pneumatic shoring uses air pressure in place of hydraulic pressure. A disadvantage to the use of pneumatic shoring is that an air compressor must be on site.

0. **Screw Jacks**. Screw jack systems differ from hydraulic and pneumatic systems in that the struts of a screw jack system must be adjusted manually. This creates a hazard because the worker is required to be in the trench in order to adjust the strut. In addition, uniform "preloading" cannot be achieved with screw jacks, and their weight creates handling difficulties.

1. **Single-Cylinder Hydraulic Shores**. Shores of this type are generally used in a water system, as an assist to timber shoring systems, and in shallow trenches where face stability is required.

2. **Underpinning**. This process involves stabilizing adjacent structures, foundations, and other intrusions that may have an impact on the excavation. As the term indicates, underpinning is a procedure in which the foundation is physically reinforced. Underpinning should be conducted only under the direction and with the approval of a registered professional engineer.

FIGURE V:2-9. SHORING VARIATIONS.



SHIELDING TYPES

. **Trench Boxes** are different from shoring because, instead of shoring up or otherwise supporting the trench face, they are intended primarily to protect workers from cave-ins and similar incidents. The excavated area between the outside of the trench box and the face of the trench should be as small as possible. The space between the trench boxes and the excavation side are backfilled to prevent lateral movement of the box. Shields may not be

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subjected to loads exceeding those which the system was designed to withstand.

FIGURE V:2-10. TRENCH SHIELD.

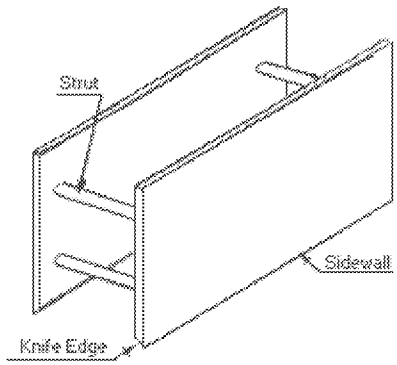
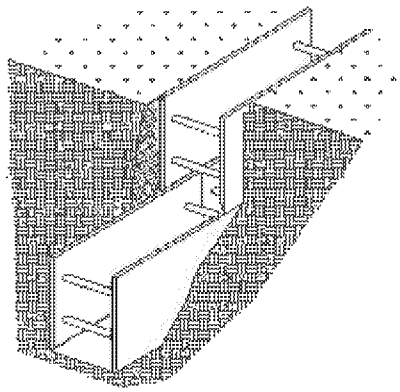


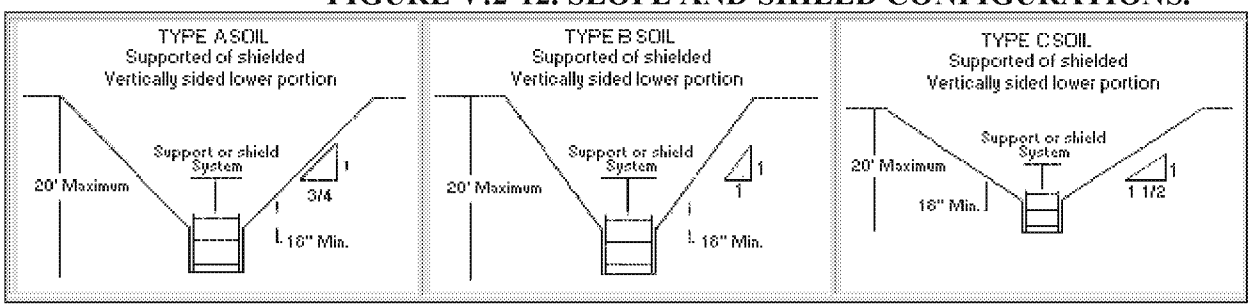
FIGURE V:2-11. TRENCH SHIELD, STACKED.



. **Combined Use**. Trench boxes are generally used in open areas, but they also may be used in combination with sloping and benching. The box should extend at least 18 in (0.45 m) above the surrounding area if there is sloping toward excavation. This can be accomplished by providing a benched area adjacent to the box.

Earth excavation to a depth of 2 ft (0.61 m) below the shield is permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench and there are no indications while the trench is open of possible loss of soil from behind or below the bottom of the support system. Conditions of this type require observation on the effects of bulging, heaving, and boiling as well as surcharging, vibration, adjacent structures, etc., on excavating below the bottom of a shield. Careful visual inspection of the conditions mentioned above is the primary and most prudent approach to hazard identification and control.

FIGURE V:2-12. SLOPE AND SHIELD CONFIGURATIONS.



SLOPING AND BENCHING

. **Sloping**. Maximum allowable slopes for excavations less than 20 ft (6.09 m) based on soil type and angle to the horizontal are as follows:

TABLE V:2-1. ALLOWABLE SLOPES.

Soil type	height/Depth ratio	Slope angle
Stable Rock	Vertical	90°
Type A	¾:1	53°
Type B	1:1	45°
Type C	1½:1	34°
Type A (short-term)	½:1	63°
(For a maximum excavation depth of 12 ft)		

FIGURE V:2-13. SLOPE CONFIGURATIONS: EXCAVATIONS IN LAYERED SOILS.

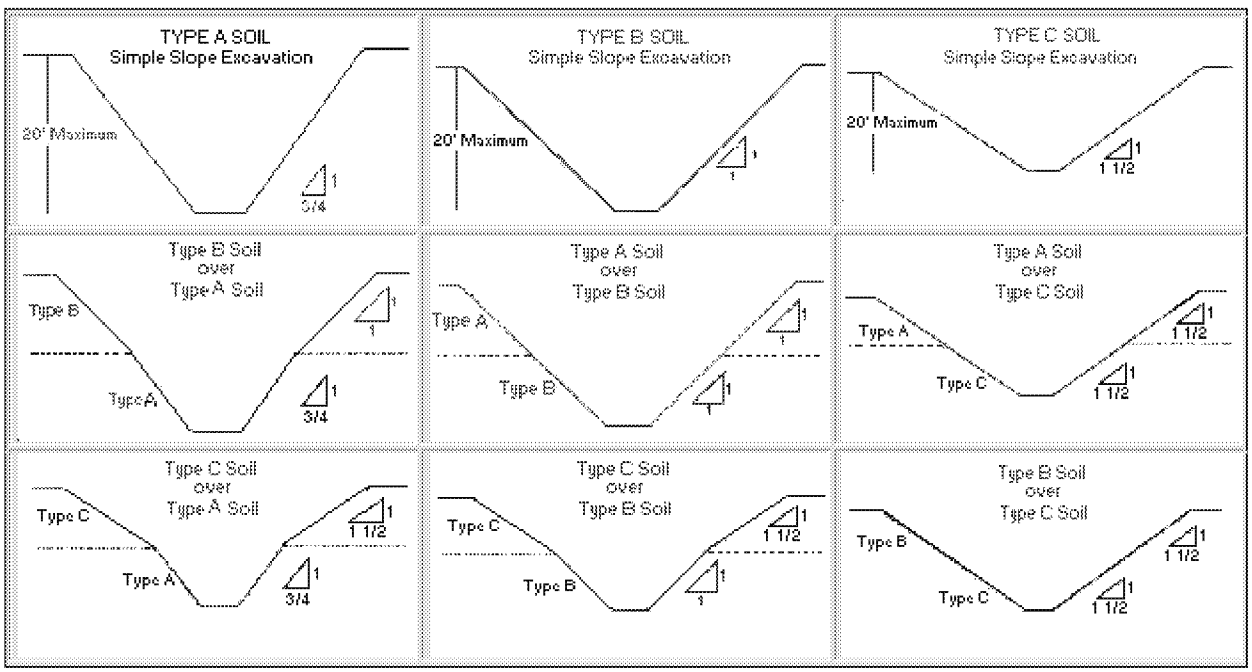
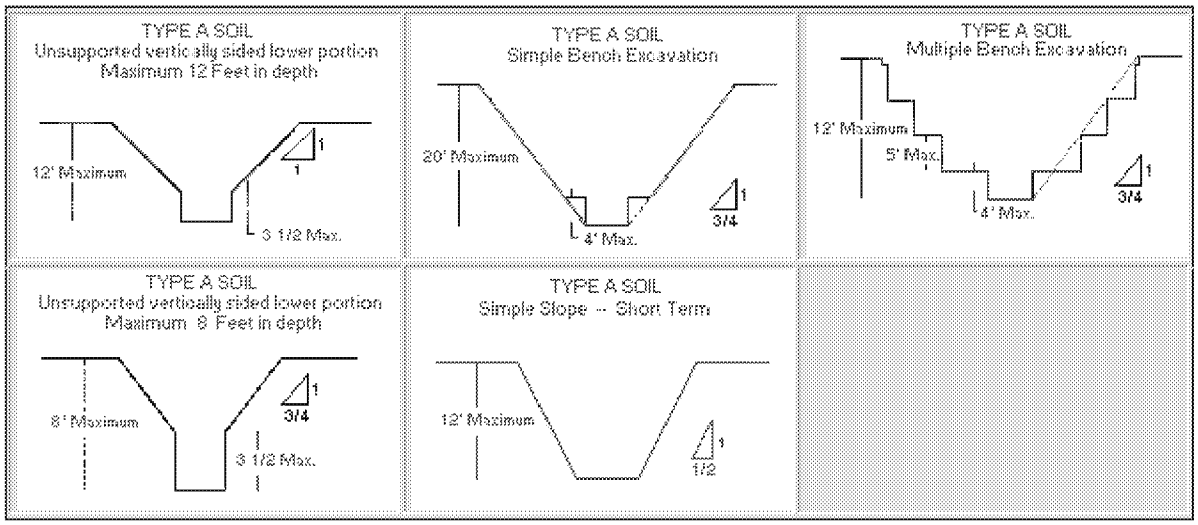


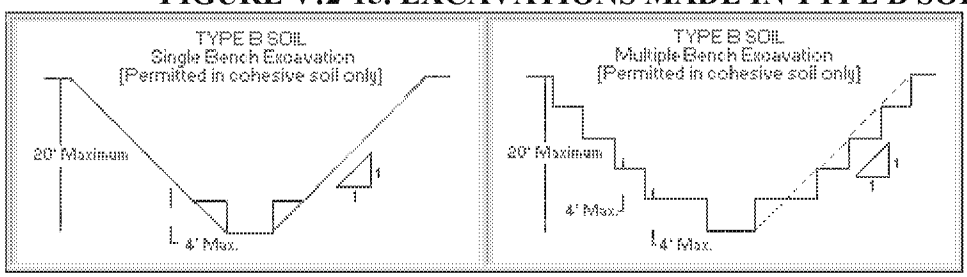
FIGURE V:2-14. EXCAVATIONS MADE IN TYPE A SOIL.



. **Benching.** There are two basic types of benching, simple and multiple. The type of soil determines the horizontal to vertical ratio of the benched side.

As a general rule, the bottom vertical height of the trench must not exceed 4 ft (1.2 m) for the first bench. Subsequent benches may be up to a maximum of 5 ft (1.5 m) vertical in Type A soil and 4 ft (1.2 m) in Type B soil to a total trench depth of 20 ft (6.0 m). All subsequent benches must be below the maximum allowable slope for that soil type. For Type B soil the trench excavation is permitted in cohesive soil only.

FIGURE V:2-15. EXCAVATIONS MADE IN TYPE B SOIL.



SPOIL

. **Temporary Spoil**. Temporary spoil must be placed no closer than 2 ft (0.61 m) from the surface edge of the excavation, measured from the nearest base of the spoil to the cut. This distance should not be measured from the crown of the spoil deposit. This distance requirement ensures that loose rock or soil from the temporary spoil will not fall on employees in the trench.

Spoil should be placed so that it channels rainwater and other run-off

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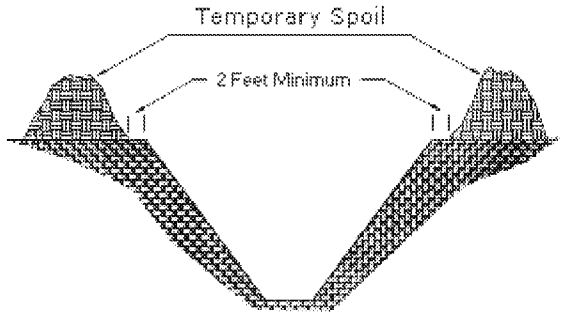
water away from the excavation. Spoil should be placed so that it cannot accidentally run, slide, or fall back into the excavation.

FIGURE V:2-16. TEMPORARY SPOIL.



A. **Permanent Spoil**. Permanent spoil should be placed at some distance from the excavation. Permanent spoil is often created where underpasses are built or utilities are buried. The improper placement of permanent spoil, i.e. insufficient distance from the working excavation, can cause an excavation to be out of compliance with the horizontal-to-vertical ratio requirement for a particular excavation. This can usually be determined through visual observation. Permanent spoil can change undisturbed soil to disturbed soil and dramatically alter slope requirements.

SPECIAL HEALTH AND SAFETY CONSIDERATIONS

. **Competent Person**. The designated competent person should have and 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.

A. **Surface Crossing of Trenches**. Surface crossing of trenches should be discouraged; however, if trenches must be crossed, such crossings are permitted only under the following conditions:

- Vehicle crossings must be designed by and installed under the supervision of a registered professional engineer.
- Walkways or bridges must be provided for foot traffic. These structures shall:
  - have a safety factor of 4;

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- have a minimum clear width of 20 in (0.51 m);
- be fitted with standard rails; and
- extend a minimum of 24 in (.61 m) past the surface edge of the trench.

B. **Ingress and Egress**. Access to and exit from the trench require the following conditions:
   - Trenches 4 ft or more in depth should be provided with a fixed means of egress.
   - Spacing between ladders or other means of egress must be such that a worker will not have to travel more than 25 ft laterally to the nearest means of egress.
   - Ladders must be secured and extend a minimum of 36 in (0.9 m) above the landing.
   - Metal ladders should be used with caution, particularly when electric utilities are present.

C. **Exposure to Vehicles**. Procedures to protect employees from being injured or killed by vehicle traffic include:
   - Providing employees with and requiring them to wear warning vests or other suitable garments marked with or made of reflectorized or high-visibility materials.
   - Requiring a designated, trained flagperson along with signs, signals, and barricades when necessary.

D. **Exposure to Falling Loads**. Employees must be protected from loads or objects falling from lifting or digging equipment. Procedures designed to ensure their protection include:
   - Employees are not permitted to work under raised loads.
   - Employees are required to stand away from equipment that is being loaded or unloaded.
   - Equipment operators or truck drivers may stay in their equipment during loading and unloading if the equipment is properly equipped with a cab shield or adequate canopy.

E. **Warning Systems for Mobile Equipment**. The following steps should be taken to prevent vehicles from accidentally falling into the trench:
   - Barricades must be installed where necessary.
   - Hand or mechanical signals must be used as required.
   - Stop logs must be installed if there is a danger of vehicles falling into the trench.
   - Soil should be graded away from the excavation; this will assist in vehicle control and channeling of run-off water.

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F. **Hazardous Atmospheres and Confined Spaces**. Employees shall not be permitted to work in hazardous and/or toxic atmospheres. Such atmospheres include those with:
   - Less than 19.5% or more than 23.5% oxygen;
   - A combustible gas concentration greater than 20% of the lower flammable limit; and
   - Concentrations of hazardous substances that exceed those specified in the *Threshold Limit Values for Airborne Contaminants* established by the ACGIH (American Conference of Governmental Industrial Hygienists).

   All operations involving such atmospheres must be conducted in accordance with OSHA requirements for occupational health and environmental controls (see Subpart D of 29 CPR 1926) for personal protective equipment and for lifesaving equipment (see Subpart E of 29 CFR 1926). Engineering controls (e.g., ventilation) and respiratory protection may be required.

   When testing for atmospheric contaminants, the following should be considered:
   - Testing should be conducted before employees enter the trench and should be done regularly to ensure that the trench remains safe.
   - The frequency of testing should be increased if equipment is operating in the trench.
   - Testing frequency should also be increased if welding, cutting, or burning is done in the trench.

   Employees required to wear respiratory protection must be trained, fit-tested, and enrolled in a respiratory protection program. Some trenches qualify as confined spaces. When this occurs, compliance with the Confined Space Standard is also required.

G. **Emergency Rescue Equipment**. Emergency rescue equipment is required when a hazardous atmosphere exists or can reasonably be expected to exist. Requirements are as follows:
   - Respirators must be of the type suitable for the exposure. Employees must be trained in their use and a respirator program must be instituted.
   - Attended (at all times) lifelines must be provided when employees enter bell-bottom pier holes, deep confined spaces, or other similar hazards.
   - Employees who enter confined spaces must be trained.

H. **Standing Water and Water Accumulation**. Methods for controlling standing water and water accumulation must be provided and should consist of the following if employees are permitted to work in the excavation:

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- Use of special support or shield systems approved by a registered professional engineer.
- Water removal equipment, i.e. well pointing, used and monitored by a competent person.
- Safety harnesses and lifelines used in conformance with 29 CFR 1926.104.
- Surface water diverted away from the trench.
- Employees removed from the trench during rainstorms.
- Trenches carefully inspected by a competent person after each rain and before employees are permitted to re-enter the trench.

I. **Inspections**. Inspections shall be made by a competent person and should be documented. The following guide specifies the frequency and conditions requiring inspections:
   - Daily and before the start of each shift;
   - As dictated by the work being done in the trench;
   - After every rainstorm;
   - After other events that could increase hazards, e.g. snowstorm, windstorm, thaw, earthquake, etc.;
   - When fissures, tension cracks, sloughing, undercutting, water seepage, bulging at the bottom, or other similar 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.

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APPENDIX V: 2-1. SITE ASSESSMENT QUESTIONS

During first and subsequent visits to a construction or facility maintenance location, the compliance officer (or the site's safety officer or other competent person) may find the following questions useful.

1. Is the cut, cavity, or depression a *trench* or an *excavation*?

2. Is the cut, cavity, or depression more than 4 ft (1.2 m) in *depth*?

3. Is there *water* in the cut, cavity, or depression?

4. Are there adequate means of *access* and *egress*?

5. Are there any *surface encumbrances*?

6. Is there exposure to *vehicular traffic*?

7. Are *adjacent structures stabilized*?

8. Does *mobile equipment* have a *warning system*?

9. Is a *competent person in charge* of the operation?

10. Is *equipment operating* in or around the cut, cavity, or depression?

11. Are procedures required to monitor, test, and *control hazardous atmospheres*?

12. Does a competent person *determine soil type*?

13. Was a *soil testing device* used to determine soil type?

14. Is the *spoil* placed 2 ft (0.6 m) or *more from the edge* of the cut, cavity, or depression?

15. Is the *depth* 20 ft (6.1 m) *or more* for the cut, cavity, or depression?

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16. Has a *registered professional engineer* approved the procedure if the depth is more than 20 ft (6.1 m)?

17. Does the procedure require *benching* or *multiple benching*? *Shoring*? *Shielding*?

18. If provided, *do shields extend at least 18 in (0.5 m) above* the surrounding area if it is sloped toward the excavation?

19. If shields are used, is the depth of the cut *more than 2 ft (0.6 m) below the bottom of the shield*?

20. Are any required *surface crossings* of the cut, cavity, or depression the *proper width and fitted with hand rails*?

21. Are means of *egress* from the cut, cavity, or depression *no more than 25 ft (7.6m) from the work*?

22. Is *emergency rescue equipment* required?

23. Is there *documentation of the minimum daily excavation inspection*?

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