UNIFORM FEDERAL POLICY
QUALITY ASSURANCE PROJECT PLAN

Keystone Corridor Groundwater Contamination Site Marion County, Indiana

Remedial Investigation

WA No. 192-RICO-B5VX/Contract No. EP-S5-06-01

Prepared for

November 2015

Contents

Acronyms and Abbreviations ..... **vii**

Worksheets #1 and #2—Title and Approval Page **1**

Worksheets #3 and #5—Project Organization and QAPP Distribution **5**

Worksheets #4, #7, and #8—Personnel Qualifications and Signoff Sheet **7**

Worksheet #6—Communication Pathways **11**

Worksheet #9—Project Planning Session Summary **13**

Worksheet #10—Conceptual Site Model **15**
- 10.1 The Problem to be Addressed by the Project 15
- 10.2 Site Description 16
- 10.3 Historical Investigations and Remedial History 16
- 10.4 Sampling Rational 20
- 10.5 Project Decision Conditions ("If..., then..." statements) 21

Worksheet #11—Project/Data Quality Objectives **25**
- Who will use the data? 28
- What will the data be used for? 28
- What types of data are needed? 29
- How "good" do the data need to be in order to support the environmental decision? 29
- How many data are needed? (Number of samples for each analytical group, matrix, and concentration) 30
- Where, when, and how should the data be collected/generated? 30
- Who will collect and generate the data? 30
- How will the data be reported? 31
- How will the data be archived? 31

Worksheet #12—Measurement Performance Criteria **33**

Worksheet #12-1—Measurement Performance Criteria Table **35**

Worksheet #12-2—Measurement Performance Criteria Table **36**

Worksheet #12-3—Measurement Performance Criteria Table **37**

Worksheet #12-4—Measurement Performance Criteria Table **38**

Worksheet #12-5—Measurement Performance Criteria Table **39**

Worksheet #12-6—Measurement Performance Criteria Table **40**

Worksheet #13—Secondary Data Uses and Limitations **41**

[a] (URS 2004) **41**

Worksheets #14 and #16—Project Tasks and Schedule **43**
- Field investigation Tasks 43
- Analysis Tasks 46
- Quality Control Tasks 46
- Secondary Data 46
- Data Management Tasks 47
- Assessment and Audit Tasks 49

Data Review and Usability 50
Documentation and Records 50

Worksheet #15-1—Project Action Limits and Laboratory-Specific Detection/Quantitation 53

Worksheet #15-2—Project Action Limits and Laboratory-Specific Detection/Quantitation 57

Worksheet #15-3—Project Action Limits and Laboratory-Specific Detection/Quantitation 61

Worksheet #15-4—Project Action Limits and Laboratory-Specific Detection/Quantitation 64

Worksheet #15-5—Project Action Limits and Laboratory-Specific Detection/Quantitation 65

Worksheet #15-6—Project Action Limits and Laboratory-Specific Detection/Quantitation 66

Worksheet #15-7—Project Action Limits and Laboratory-Specific Detection/Quantitation 67

Worksheet #17—Sampling Design and Rationale 69
Phase 1 69
Phase 2 72
Phase 3 74
Equipment Decontamination 75
Investigation-derived Waste Characterization and Disposal 75

Worksheet #18—Sampling Locations and Methods 76

Worksheets #19 and #30—Analytical SOP Requirements Table 79

Worksheet #20—Field Quality Control Summary 81
Field Duplicate Samples 81
Matrix Spike/Matrix Spike Duplicate Samples 81
Field Blanks 81
Equipment Blanks 81
Trip Blanks 81
Ambient Blanks 82

Worksheet #20—Field Quality Control Summary Table 83

Worksheet #21—Field Standard Operating Procedures 85

Worksheet #22—Field Equipment Calibration, Maintenance, Testing, and Inspection 87

Worksheet #23—Analytical SOPs 91

Worksheet #24—Analytical Instrument Calibration 93

Worksheet #25—Analytical Instrument and Equipment Maintenance, Testing, and Inspection 99

Worksheets #26 and #27—Sample Handling, Custody, and Disposal 101
Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory) 101
Laboratory Sample Custody Procedures (receipt of samples, archiving, and disposal) 102
Sample Identification Procedures 102
Examples 104
Chain-of-Custody Procedures 104

Worksheet #28-1—Analytical Quality Control and Corrective Action 105

Worksheet #28-2—Analytical Quality Control and Corrective Action 106

Worksheet #28-3—Analytical Quality Control and Corrective Action 107

Worksheet #28-4—Analytical Quality Control and Corrective Action 108

Worksheet #28-5—Analytical Quality Control and Corrective Action 109

Worksheet #28-6—Analytical Quality Control and Corrective Action 110

Worksheet #29—Project Documents and Records 111
Sample Tracking Program 111
Project-specific Deliverables 112

Worksheets #31, #32, and #33—Assessments and Correction Action 113

Worksheet #34—Data Verification and Validation Inputs 115

Worksheet #35—Data Verification Procedures 117

Worksheet #36—Data Validation Procedures 119
Data Verification/Validation Scope Overview 119
Field Data Review 119
Laboratory Data Review Requirements 119
Laboratory Data Evaluation 120
Data Review Guidelines 120
Data Verification/Validation Guidelines 120
Flagging Conventions 121

Worksheet #37—Data Usability Assessment 125
Summary of Usability Assessment Processes 125
Evaluation Procedures to Assess Project-specific Overall Measurement Error 125
Personnel Responsible for Performing Usability Assessment 125
Usability Assessment Documentation 125

References 129

Appendixes

A Field Standard Operating Procedures
B Laboratory Standard Operating Procedures
C Data Qualification Manager User Manual for EQuIS 6
D Project Schedule

Tables

11-1 Data Quality Objectives 25
36-1 Verification/Validation Data Qualifiers 121
36-2 Data Qualifying Conventions—General 121

Figures

1 Area Location Map
2 Potential Sampling Locations

Acronyms and Abbreviations

1,1,1-TCA	1,1,1-trichloroethane
AB	ambient blank
bgs	below ground surface
CC	continuing calibration
CCC	calibration check compounds
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CH2M	CH2M HILL, Inc.
cis-1,2 DCE	cis-1, 2-dichloroethene
CLP	Contract Laboratory Program
CPR	cardiopulmonary resuscitation
CRL	Central Regional Laboratory
CVAA	cold vapor atomic absorption
DNAPL	dense nonaqueous phase liquid
DO	dissolved oxygen
DPT	direct-push technology
DQI	data quality indicator
DQO	data quality objective
EB	equipment blank
EDD	electronic data deliverable
EDMAN	Electronic Data Management and Analysis Network
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ESL	ecological screening level
FB	field blank
FCWF	Fall Creek wellfield
FD	field duplicate
FS	feasibility study
GC/ECD	gas chromatograph/electron capture detector
GC/MS	gas chromatograph/mass spectrometry
GIS	geographic information system
GPS	global positioning system

HHRA	human health risk assessment
HI	hazard index
HRS	Hazard Ranking System
IC	initial calibration
ICAP	inductively coupled argon plasma
ICS	Interference check solutions
ICV	initial calibration verification
ID	identification
IDW	investigation-derived waste
IDEM	Indiana Department of Environmental Management
LCS	laboratory control sample
LD	laboratory duplicate
MB	method blank
MCL	maximum contaminant level
MDL	method detection limit
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mL	milliliter
MPC	measurement performance criteria
MNA	monitored natural attenuation
MS	matrix spike
MSD	matrix spike duplicate
MW	monitoring well
NA	not applicable
ORP	oxidation-reduction potential
PAL	project action limits
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
PCB	polychlorinated biphenyl
PCE	tetrachloroethylene
%R	percent recovery
PID	photoionization detector

ppb	parts per billion
ppm	parts per million
PRT	post run tubing
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QL	quantitation limit
RCRA	Resource Conservation and Recovery Act
RF	response factor
RI	remedial investigation
RL	reporting limit
RPD	relative percent difference
RRT	relative retention time
RSD	relative standard deviation
RSL	Regional Screening Level
SG	soil gas
SLHHRA	screening-level human health risk assessment
SOP	standard operating procedure
SpC	specific conductance
SPCC	system performance check compounds
SSC	site safety coordinator
SSPA	S. S. Papadopulos and Associates, Inc.
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TAT	turnaround time
TB	trip blank
TBD	to be determined
TCE	trichloroethylene
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TOC	total organic carbon
UFP	Uniform Federal Policy
VC	vinyl chloride

VI	vapor intrusion
VISL	vapor intrusion screening level
VOC	volatile organic compound
WAM	work assignment manager

Worksheets #1 and #2—Title and Approval Page

Site Name/Project Name: Keystone Corridor Groundwater Contamination Site

Revision Number: 0

Site Location: Indianapolis, Marion County, Indiana **Site Number/Code:** INN000510399

Operable Unit: OU0

Document Title: *Uniform Federal Policy Quality Assurance Project Plan— Keystone Corridor Groundwater Contamination Site*

Lead Organization: U.S. Environmental Protection Agency (EPA)

Contractor Name: CH2M HILL (CH2M) **Contractor Number:** EP-S5-06-01

Contract Title: Remedial Action Contract 2 **Work Assignment Number:** 192-RICO-B5VX

Preparers' Name and Organizational Affiliation: Heather Hodach/CH2M**,** Dave Reamer/CH2M, Jamie Sutton/CH2M, and Hope Mauer/CH2M

Preparer's Address, Telephone Number, and E-mail Address: Heather Hodach, CH2M, 135 South 84th Street, Suite 400

Milwaukee, WI 53214; 414-272-2426

Preparation Date: 09/09/2015

1. Identify regulatory program:

   The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly known as Superfund

2. Identify approval entity: EPA Region 5

3. The quality assurance project plan (QAPP) is (select one): ☐Generic ☒Project-Specific

4. List dates of scoping sessions that were held:

   – Meeting between EPA, CH2M, and S. S. Papadopulos and Associates, Inc. (SSPA) was held on June 16, 2015, at the EPA Region 5 headquarters in Chicago, Illinois, to gain team endorsement on the overall strategy and activities to be completed.

5. List dates and titles of QAPP documents written for previous site work, if applicable: Not applicable.

6. List organizational partners (stakeholders) and connection with lead organization:

   EPA Region 5 (lead organization)
   Indiana Department of Environmental Management (IDEM) (State Agency)

   CH2M (contractor)

   SSPA (EPA's contractor)

7. List data users:

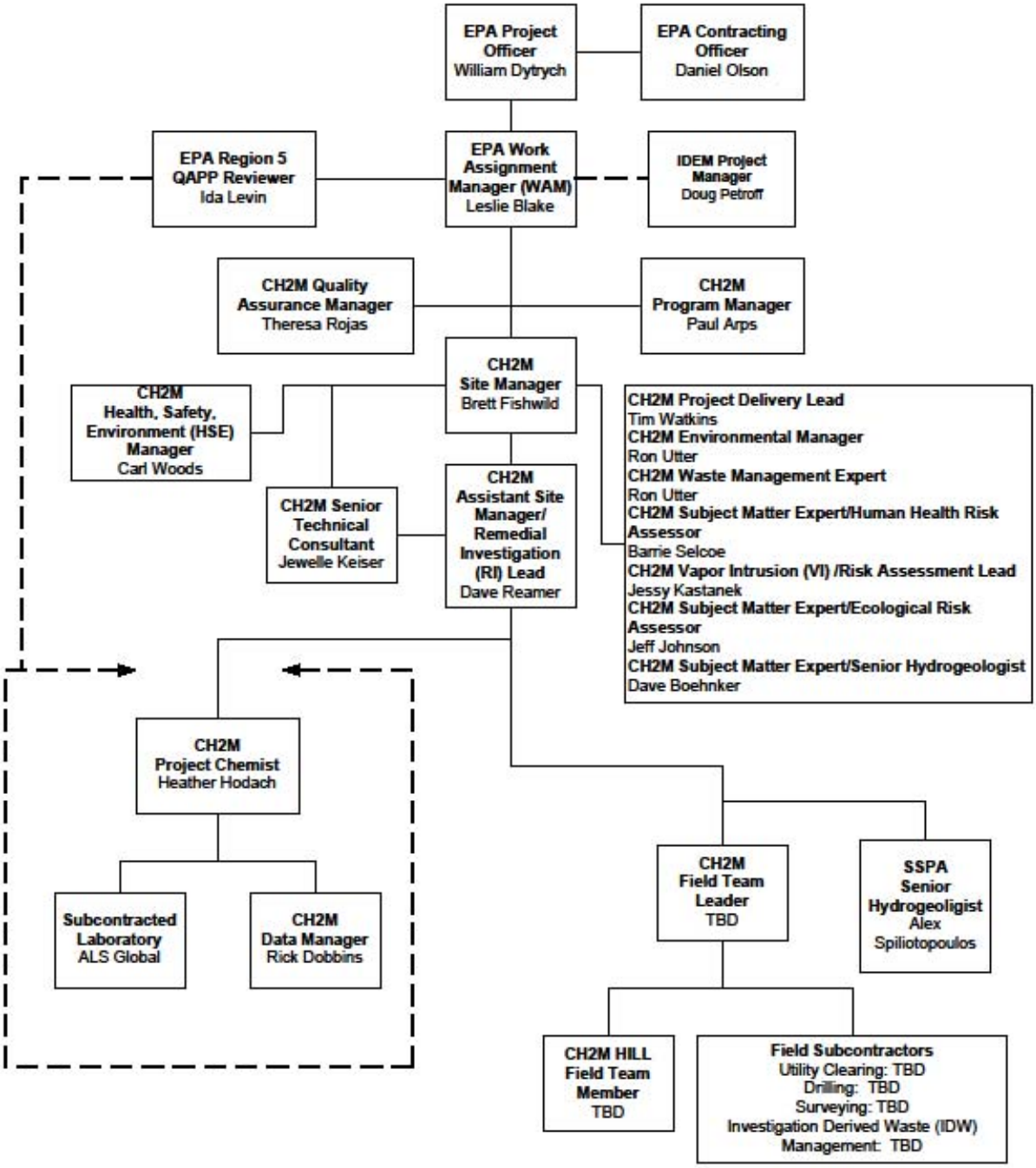
   EPA, IDEM, CH2M, SSPA

QUALITY ASSURANCE PROJECT PLAN
Remedial Investigation
KEYSTONE CORRIDOR GROUNDWATER CONTAMINATION SITE
BARTHOLOMEW COUNTY, INDIANA
WA No. 192-RICO-B5VX/Contract EP-S5-06-01

Lead Organization: United States Environmental Protection Agency
Prepared by: CH2M
Date: November 2015
Approved by:

Investigative Organization's Site Manager	Brett Fishwild/CH2M	11/13/2015 Date
Investigative Organization's Site Program Quality Assurance (QA) Manager	Theresa Rojas/CH2M	11/18/2015 Date
Lead Organization's Project Manager	Leslie Blake/EPA	2/17/16 Date
EPA Region 5 QAPP Reviewer	Ida Levin/EPA	2/17/16 Date
Laboratory Director	Jeff Glaser/ALS Global	11/19/2015
Laboratory QA Manager	Chad Stoike/ALS Global	11/19/2015

Worksheets #3 and #5—Project Organization and QAPP Distribution



QAPP Recipients	Title	Organization	Telephone Number	Fax Number	E-mail Address
Leslie Blake	Region 5 Work Assignment Manager (WAM)	EPA	312-353-7921	312-385-5428	Blake.Leslie@epa.gov
Ida Levin	Region 5 QAPP Reviewer	EPA	312-886-6254	312-692-2929	Levin.Ida@epa.gov
Theresa Rojas	QA Manager	CH2M	678-530-4297	770-604-9282	Theresa.Rojas@ch2m.com
Brett Fishwild	Site Manager	CH2M	937-220-2955		Brett.Fishwild@ch2m.com
Dave Reamer	Assistant Site Manager /Remedial Investigation (RI) Lead	CH2M	973-316-3547		Dave.Reamer@ch2m.com
Jewelle Keiser	Senior Technical Consultant	CH2M	414-847-0469	414-454-8767	Jewelle.Keiser@ch2m.com
Barrie Selcoe	Subject Matter Expert/Human Health Risk Assessor	CH2M	281-246-4322	281-721-8401	Barrie.Selcoe@ch2m.com
Jeff Johnson	Subject Matter Expert/Ecological Risk Assessor	CH2M	937-220-2931		Jeffery.Johnson@ch2m.com
Jessy Kastanek	Vapor Intrusion (VI) and Risk Assessment Lead	CH2M	720-286-5778		Jessica.Kastanek@ch2m.com
Heather Hodach	Project Chemist	CH2M	414-847-0428		Heather.Hodach@ch2m.com
TBD	Field Team Lead	CH2M	TBD	TBD	TBD
Rick Dobbins	Database manager	CH2M	352-384-7049		Rick.Dobbins@ch2m.com
Chad Whelton	Laboratory Project Manager	ALS Global	616-582-5201		Chad.Whelton@alsglobal.com

Worksheets #4, #7, and #8—Personnel Qualifications and Signoff Sheet

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications
Leslie Blake	Region 5 WAM	EPA	Overall responsibility for all phases of work, review, and approval.	
Ida Levin	Region 5 QAPP Reviewer	EPA	QAPP review and approval.	
Paul Arps	Program Manager	CH2M	Principal point of contact for the EPA contracting officer and project officer. Directs the creation and/or implementation of program policies. Selects the program QA manager with endorsement by the business group federal sector quality manager. Reviews budget, schedule, and performance reports. Reviews corrective actions and lessons learned to assess the effectiveness of resolutions. Allocates resources for quality management.	B.S., Chemistry, 13 years of experience
Theresa Rojas	QA Manager	CH2M	Accountable for the overall QA of the program. Approves and charters project quality manager. Evaluates project quality requirements and supports implementation to meet quality requirements. Resolves disputes concerning quality through discussion and negotiation.	B.S., Chemistry 29 years of experience
Brett Fishwild	Site Manager	CH2M	Responsible for executing the phases of the work assignment and for efficiently applying the full resources of the project team. Responsible for the technical, financial, administrative, and client-related aspects of the project and the project team. Plans the execution of the work assignment and identifies necessary staff. Organizes, directs, and manages personnel and resources. Communicates with the EPA WAM. Responds to and implements corrective actions.	M.S., Geological Sciences, B.S., Geological Sciences, 17 years of experience
Dave Boehnker	Subject Matter Expert/Senior Hydrogeologist	CH2M	Provides technical expertise, develops site-specific goals for the site, and provides input on investigation strategy.	B.S., Geology, 35 years of experience
Dave Reamer	Assistant Site Manager/ RI Leader	CH2M	Coordinates, directs, and reports site activities; ensures adherence to the QAPP; communicates issues to site manager and field team; assists with contractor oversight.	B.S., Geology, 10 years of experience

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications
TBD	Field Team Leader/Field Quality Manager/ Site Safety Coordinator	CH2M	Documents and conveys progress of field activities, including adherence and any deviations from the QAPP; communication with task lead and project chemist, and others as directed by them; directs CH2M field support staff and contractors; provides daily safety briefings and directs onsite safety activities.	
Barrie Selcoe	Subject Matter Expert/Human Health Risk Assessor	CH2M	Provides technical human health risk assessment expertise and develops site-specific goals for the site, including VI.	M.P.H., Risk Assessment, B.S., Environmental Health, 25 years of experience
Jeff Johnson	Subject Matter Expert/Ecological Risk Assessor	CH2M	Provides technical ecological risk assessment expertise and develops site-specific goals for the site.	B.A., Biology, 13 years of experience
Jessy Kastanek	VI and Risk Assessment Lead	CH2M	Provides technical human health risk assessment expertise and develops site-specific goals for the site, including VI.	M.S. Engineering, B.S. Engineering, 13 years of experience
Jewelle Keiser	Senior Technical Consultant	CH2M	Provides technical expertise and develops site-specific goals for the site.	M.S. Geology and Geophysics/Hydrogeology, 31 years of experience
Carl Woods	Health, Safety, and Environment Manager	CH2M	Provides support and assistance for health and safety requirements and management.	M.S., Environmental Safety Management, B.A., General Studies, 18 years of experience
Heather Hodach	Project Chemist	CH2M	Assists in QAPP preparation, coordinates laboratory subcontractors, performs oversight of laboratory and data validation, and performs data evaluation.	B.S. Chemistry, 15 years of experience
Rick Dobbins	Database Manager	CH2M	Sets up the project data management system, performs data conversion, quality control (QC), and database maintenance, and prepares data exports (tables, electronic data deliverables [EDDs]).	B.S., Chemistry, 25 years of experience
Chad Whelton	Laboratory Project Manager	ALS Global	Coordinates laboratory analysis and reporting, and maintains communication with the project chemist.	

Special Training Requirements

Project Function	Specialized Training Title or Description of Course	Training Provider	Training Date	Personnel/Groups Receiving Training	Personnel Titles/ Organizational Affiliation	Location of Training Records/Certificates
Field Activities	Occupational Safety and Health Administration Hazardous Waste Operations and Emergency Response Standard 40-hour training and annual 8-hour refresher	Registered training organization	Annually	All staff, including subcontracted personnel who enter the site	Field team staff, Site Manager (SM), and support staff who enter the site	CH2M Human Resources Department
Field Activities	Cardiopulmonary resuscitation (CPR) and first-aid	Registered training organization	Every 3 years	Site safety coordinator (SSC)	Field team staff	CH2M Human Resources Department
Field Activities	SSC–Hazardous Waste	Registered training organization	Every 3 years	SSC	SSC from CH2M	CH2M Human Resources Department
Health and Safety	Health and Safety Plan	CH2M	Various, project specific	All field staff, including subcontracted personnel working in the field	All field personnel from CH2M and subcontracted personnel	Signoff sheet at the end of the health and safety plan

Signoff Sheet

Organization: EPA

Project Personnel	Title	Telephone Number	Signature	Date
Leslie Blake	Region 5 WAM	312-353-7921		
Ida Levin	Region 5 QAPP Reviewer	312-886-7185		

Organization: CH2M—To be signed once Uniform Federal Policy (UFP)-QAPP is approved by lead organization.

Project Personnel	Title	Telephone Number	Signature	Date
Theresa Rojas	QA Manager	678-530-4297		
Brett Fishwild	Site Manager	937-220-2955		
Dave Reamer	Assistant Site Manager/RI Lead	973-316-3547		
Jewelle Keiser	Senior Technical Consultant	414-847-0469		
Barrie Selcoe	Subject Matter Expert/Human Health Risk Assessor	281-721-8527		
Jeff Johnson	Subject Matter Expert/Ecological Risk Assessor	937-220-2931		
Jessy Kastanek	VI and Risk Assessment Lead	720-286-5778		
TBD	Field Team Lead			
Heather Hodach	Project Chemist	(414) 847-0428		

Worksheet #6—Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Communication with CH2M program manager	EPA program officer	William Dytrych	312-886-0755	Provides administrative direction to CH2M program manager and project team, authorizes changes to plan, and can stop work, if needed.
Communication with CH2M contract manager	EPA contracting officer	Daniel Olsson	312-353-3187	Provides administrative direction to CH2M contracts manager.
Communication with CH2M site manager	EPA WAM	Leslie Blake	312-353-7921	Serves as primary point of contact for EPA, and provides approval of technical direction to CH2M site manager.
Point of contact with IDEM Environmental Manager	IDEM environmental manager	Doug Petroff	317-234-7179	Serves as primary point of contact for IDEM, assists with technical direction to CH2M site manager and EPA WAM.
Communication with EPA program officer and Contracting Officer	CH2M program manager	Paul Arps	262-349-4180	Receives contractual direction from EPA program officer and contracting officer, and notifies EPA of contractual deviations (changes in scope of work, budget, or schedule) by e-mail or letter.
Point of contact with EPA WAM	CH2M site manager	Brett Fishwild	937-220-2955	Materials and information about the project will be forwarded to EPA WAM by Brett Fishwild.
Manage technical project phases	CH2M task management/RI leader	Dave Reamer	973-316-3547	Notifies Brett Fishwild of RI-related problems by next business day. Serious issues will also be reported to program quality manager, Theresa Rojas.
Field staff discussion and inquiry	CH2M field team leader	TBD	TBD	Serve as a primary point of contact for field team before, during, and after the investigation; communicates back to the site manager, quality manager, and project chemist, as needed. Communication by phone as needed with field staff during field sampling events, followup with e-mail to document decisions and actions.
QAPP deviations in the field	CH2M field team leaders/field team member	TBD	TBD	The field team leader will immediately notify the site manager by phone and e-mail of deviations from the QAPP made in the field and the reasons. Documentation of deviations from the work plan will be kept in the field logbook; deviations will be made only with the approval of the site manager. The site manager will advise EPA WAM of deviations from the QAPP. Significant changes will be reviewed and approved by the same personnel that approved the final QAPP document.
Daily field progress reports	CH2M field team leader	TBD	TBD	E-mail or fax daily field progress reports to the site manager.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Field corrective actions	CH2M field quality manager	TBD	TBD	The need for corrective action for field issues will be determined by the field quality manager. The site manager and RI leader will ensure QAPP requirements are met by field staff. The field quality manager will notify the site manager immediately of needed field corrective actions.
Reporting laboratory data quality issues	Laboratory project manager	Chad Whelton	616-582-5201	QA/QC issues with field samples will be reported to the project chemist immediately.
Analytical corrective actions	Project chemist	Heather Hodach	414-847-0428	The need for corrective action by the analytical laboratory will be determined by the project chemist. The project chemist will ensure QAPP requirements are met by the laboratory. No analytical data can be released until data are reviewed for completeness and conformance to analytical guidelines by the project chemist. The project chemist will review data as soon as possible upon receipt from the validator.
Release of analytical data	Laboratory project manager	Chad Whelton	616-582-5201	No analytical data can be released to CH2M and EPA until it has been reviewed by the laboratory. No final data can be released to CH2M until validation is completed and the laboratory has approved release of the data.
QAPP amendments	Region 5 WAM and QAPP reviewer	Leslie Blake Ida Levin	312-353-7921 312-886-7185	Major changes to the QAPP must be reviewed and approved by the same personnel that reviewed and approved the final QAPP before the changes can be implemented.

Worksheet #9—Project Planning Session Summary

Site Name:	Keystone Corridor Groundwater Contamination Site
Project Name and Site Location:	Keystone Corridor Groundwater Contamination Site, Indianapolis, Marion County, Indiana
Projected Date(s) of Sampling:	October 2015 through December 2015
Site Manager:	Brett Fishwild

Date of Session: June 16, 2015

Scoping Session Purpose: Develop and obtain team endorsement on the overall strategy and activities to be completed during the RI.

Name	Title/Role	Affiliation	Phone #	E-mail Address
Leslie Blake	Remedial project manager/WAM	EPA	(312) 353-7921	Blake.Leslie@ch2m.com
Doug Petroff	Project manager	IDEM	(317) 234-7179	dpetroff@idem.in.gov
Brett Fishwild	Site manager	CH2M	(937) 220-2955	Brett.Fishwild@ch2m.com
Dave Boehnker	Subject matter expert/senior hydrogeologist	CH2M	(937) 220-2971	David.Boehnker@ch2m.com
Alex Spiliotopoulos	Senior hydrogeologist	SSPA	(301) 718-8900	alexs@sspa.com
Matt Tonkin	President	SSPA	(301) 500-2287	matt@sspa.com

Decisions/Discussion Items

- EPA presented the remedial history of the site and the expectations of the project.
- The team agreed to the following items:
  - **Site boundaries**. Though the Hazard Ranking System (HRS) report identified a multitude of potential sources within the 1-year and 5-year time of travel capture zones for Indianapolis' two municipal well fields, the team agreed to constrain the investigation area to the current EPA-defined boundaries of the site. The center of the site is designated as the intersection of Keystone Avenue and East Fall Creek Parkway North Drive, and the site is approximately bounded on the north by 45th Street, on the west by Norwaldo Avenue, on the south by 38th Street, and on the east by Eastern Avenue (Figure 1).
  - **Potential contaminants of concern**. The investigation will focus on tetrachloroethylene (PCE) and trichloroethylene (TCE) releases identified in the HRS report and their degradation products. Therefore, the full analytical suite of volatile organic compounds (VOCs) will be analyzed. Additionally, due to the potential use of 1,4-dioxane as preservative of 1,1,1-trichloroethane

(1,1,1-TCA), one semivolatile organic compound (SVOC), 1,4-dioxane, will also be analyzed, though in a more limited fashion than VOCs.

- **Potential source properties**. The following seven properties are identified in the HRS report as having historical releases located within the defined investigation area and will be investigated: Tuchman Cleaners, Thomas Caterers of Distinction, Vantage Point Cleaners, Purtee Plating, Lumberman's Wholesale Supply, Imperial Cleaners, and S&K Laundry.
- **Limited soil gas investigation**. Due to the limited investigation time, the team agreed to one soil gas sampling event, with the assumption that additional work could be completed under a separate investigation and possibly as a separate (to be created) operable unit. Additionally, CH2M proposes a phased approach to field data collection. This will allow data from one phase to directly impact how data is collected in the subsequent phase, which will increase cost efficiencies and reduce the time needed to collect and analyze data.
- **Analytical methods**. Due to the time constraints on the investigation, EPA agreed that laboratory analysis should be completed with expedited turnaround times (TATs) (3- and 7-day results) and that a subcontracted laboratory should complete the analyses instead of using either the Contract Laboratory Program (CLP) or Central Regional Laboratory (CRL).

Due to the age and discontinuous nature of historical information regarding the potential source of the groundwater contamination and the current period of performance of CH2M's prime contract ending on March 14, 2016, the proposed project approach is designed to complete field sampling in an expedited and phased manner.

After completion of the field activities and data collection, a draft RI report will be submitted to EPA. Based on the current prime contract end date and the anticipated schedule to complete project-related activities, the efforts to prepare the final RI report and the feasibility study (FS) report and conduct post-RI/FS activities were not to be included in the work plan.

The accelerated schedule to complete RI activities and the associated report with risk assessments within the period of performance was emphasized. It was also clarified that additional potential sources, at this time, are not to be investigated unless the RI data indicate otherwise.

SSPA will support CH2M throughout the course of the project in two main ways: (1) providing geographic information system (GIS)-based services to render all analytical and geospatial data in graphical and tabular form, and (2) providing groundwater modeling to EPA directly as needed.

Follow-up Task

CH2M will submit a work plan to EPA to define the activities, schedule, and budget for completing the field sampling and reporting at the site. This QAPP will be prepared in parallel with EPA's review of the work plan to expedite the completion of the site investigations.

Worksheet #10—Conceptual Site Model

10.1 The Problem to be Addressed by the Project

Chlorinated VOCs have been detected in groundwater and soil samples collected from the former Tuchman Facility in 1989. Additional investigations, conducted to identify the source of VOCs in groundwater, observed elevated levels of VOCs on the Thomas Caterers of Distinction property and the former Vantage Point Cleaners, Purtee Plating, Lumberman's Wholesale Supply, and Imperial 1-Hour Cleaners properties.

The Fall Creek wellfield (FCWF) located near the site consists of 9 operating municipal wells that supply water to approximately 15 percent of total water to the Indianapolis distribution system, which includes an estimated population of 123,000 residents. Six municipal wells have had historical detections of various VOCs, notably chlorinated solvents, during several of the most recent quarters of sampling, with vinyl chloride (VC) detected above the maximum contaminant level (MCL) at one well. Results of the EPA HRS evaluation concluded that the 9 operating municipal wells have the potential to become contaminated from the groundwater VOC plume.

The depicted plume, based on the HRS Documentation Record for the site, measures approximately 4,500 feet long (north to south) and approximately 1,500 feet wide (east to west). The plume consists of chlorinated solvents, including PCE, TCE, VC, and cis-1,2-dichloroethene (cis-1,2-DCE). The VOC groundwater plume will be investigated in the outwash aquifer, which extends down to the top of the karst carbonate bedrock, approximately 80 feet below ground surface (bgs). Due to the time constraints of the investigation, the karst bedrock aquifer will not be investigated during this RI. Over 40 known users or handlers of solvents have been identified as possible sources in the HRS documentation record. Due to the complex geology and high number of known and potential sources of chlorinated VOCs in the project area, the HRS determined that it is not feasible to directly link any source to the contaminants encountered in the plume. This RI will investigate the presence of VOCs in soil and groundwater at 6 properties known to have historical VOC contamination in soil in the vicinity of the FCWF. The RI will also delineate the horizontal and vertical extent of the VOC plume in the outwash aquifer throughout the study area.

The purpose of the RI is to support selection of a remedy for the site. The RI will evaluate the nature and extent of hazardous substances, pollutants, or contaminants related to PCE, TCE, and associated VOCs in source materials (if found) and within potentially impacted soils, soil gas, air, groundwater, pore water, and surface water at the site. The results of the RI will be presented in a draft RI report, which will also assess the potential risks that the hazardous substances, pollutants, or contaminants present to human health and the environment. The following are the potential human exposure pathways associated with the site:

- Migration of VOCs through groundwater to drinking water supply wells (which are monitored)
- Migration of VOCs through groundwater, which can offgas VOCs, which can, in turn, be transported diffusively and advectively through soil gas into the indoor air within structures (conventional vapor intrusion)
- Migration of VOCs from vadose zone soils near the point of disposal through the vadose zone as soil gas into the indoor air within structures (also part of conventional vapor intrusion)
- Migration of VOCs through sewer or other utility corridors. This can include VOCs discharged into the sewer lines directly, or VOCs that enter sewers or utility backfill from soil gas or impacted shallow groundwater. These VOCs can then directly enter structures or be reintroduced into the vadose zone at a considerable distance from the point of release (preferential pathway or utility corridor vapor intrusion).
- Migration of VOCs into Fall Creek.

10.2 Site Description

The site consists of an area of VOC groundwater and soil contamination located within a mixed commercial, residential, and industrial area in Indianapolis, Marion County, Indiana. Based on EPA's HRS evaluation, the center of the site is designated as the intersection of Keystone Avenue and East Fall Creek Parkway North Drive, and the site is approximately bounded on the north by 45th Street, on the west by Norwaldo Avenue, on the south by 38th Street, and on the east by Eastern Avenue (Figure 1). The site can be found in Sections 17 and 18, Township 16 North, and Range 4 East.

Groundwater at the site is present within the approximately 80-foot-thick unconsolidated silty sand and gravel outwash, as well as in the underlying carbonate bedrock containing the karst aquifer. The site is in an urban setting with impervious cover from buildings and roadways prevalent. Within the outwash aquifer, previous investigations completed at the Tuchman property have indicated an upper layer of sands, silty sands, and clayey sands extending from ground surface to approximately 25 feet bgs. Underlying the upper sands is an approximately 35-foot till layer consisting of sandy clays with interbedded sand lenses. Beneath the clay layer is generally silty sand extending to carbonate bedrock encountered at approximately 80 feet bgs.

Accordingly, the upper outwash aquifer will be studied in three general intervals: the shallow aquifer zone between approximately 0 and 25 feet bgs, the intermediate discontinuous clay and sand zone between approximately 25 and 60 feet bgs, and the deep aquifer between 60 and 80 feet bgs.

Regional static water levels are generally 20 to 50 feet bgs (in highland areas), with the outwash aquifer groundwater generally flowing towards Fall Creek. Static water levels within the site are approximately 20 feet bgs. Groundwater to the north of Fall Creek generally flows to the south-southwest, and groundwater south of Fall Creek flows towards the west. Previous investigations determined that the hydraulic conductivity of the outwash aquifer is between 1.7×10^{-4} and 5.1×10^{-4} centimeters per second (EPA 2013).

The outwash and carbonate bedrock (karst) aquifer have been evaluated as a combined aquifer. No continuous layer of clay or sandy/gravelly clay has been observed above the carbonate bedrock within 2 miles of the center of the groundwater plume; therefore, interconnected sand and gravel units act as a single, unified aquifer system where the karst aquifer is recharged through the outwash. Municipal wells are installed throughout the combined aquifer in both the outwash and karst aquifers.

The bedrock consists of the Devonian-aged Muscatatuck Group of limestone and dolomite, which dips slightly to the southwest. The bedrock consists of typical karst topography including sinkholes, small caves, and other solution features. The carbonate bedrock extends more than 200 feet deep and is present throughout the entire site. The hydraulic conductivity of the karst aquifer is estimated to be 10^{-2} centimeters per second (EPA 2013).

10.3 Historical Investigations and Remedial History

Over 40 known users or handlers of solvents have been identified as possible sources in the HRS documentation. The following section summarizes VOC contamination from seven properties that are suspected of contributing VOCs to the groundwater plume and will be investigated during this RI. This section also summarizes previous investigations and remedial efforts that were performed at the seven properties to date. Each of the potential source area properties described in the following subsections have had multiple owners with various activities occurring at the properties. The properties listed below are referred to their names as listed in the IDEM Environmental Site Investigation (ESI) and EPA HRS study for

consistency. Use of each former or current site owner's company name in this UFP-QAPP does not imply that potential contamination of the property occurred during their ownership.

Tuchman Cleaners Facility

The former Tuchman Cleaners was located at 4401 Keystone Avenue, Indianapolis, Indiana. The facility used PCE, generated PCE waste, and had several PCE spills onsite. In May 1989, elevated levels of VOCs were detected in samples from two soil borings that were collected near an underground tank as part of a subsurface investigation. Later in 1989, a soil gas survey was conducted on the property to determine the extent of subsurface contamination at the facility. The investigation concluded that it was possible that the majority of the plume had migrated with the groundwater to the south/southeast and had traveled off of the property. Exploratory borings performed in 1989, as part of a Phase II Investigation, indicated that the subsurface soils and groundwater on the property were contaminated with VOCs (EPA 2013).

Four monitoring wells were subsequently installed on the property, which contained elevated levels of TCE (1,330 micrograms per liter [µg/L]), VC (21,900 µg/L), and PCE (6,500 µg/L) in the groundwater. Another Phase II investigation/remediation report was completed in January of 1996 to evaluate the nature of the potential source area and to evaluate how best to remediate the VOCs. Elevated levels of VC, TCE, PCE, and other breakdown products were detected in the groundwater. Water samples were also collected from the washwater containment pits of the drycleaner's operations in 1999 to pinpoint any potential sources of contamination, and analysis revealed elevated levels of PCE in the pits. An additional Stage I investigation in July and August of 2000, which collected soil and groundwater grab samples, also detected elevated levels of PCE in soils and groundwater (EPA 2013).

A soil vapor extraction (SVE) system and a pump-and-treat system were installed in October 1990. Approximately 162 to 217 kilograms of VOCs have been removed from the shallow groundwater zone during 82 months of pumping. According to a groundwater monitoring report dated April 11, 2000, the remediation system was effective at blocking impacted groundwater from flowing off of the property site, but did not mention if any contaminated groundwater left the facility prior to the installation of the remediation system. VOC concentrations decreased during the remediation activities, but data from upgradient monitoring well MW6 indicated that PCE had likely migrated onto the property from an offsite source. It was noted that this monitoring well was located immediately downgradient of the former Vantage Point Cleaners on Allisonville Road that included dry-cleaning operations that may have resulted in releases to the subsurface. In general, groundwater flow was documented in a southwesterly direction, although localized variations in groundwater flow direction have been documented (EPA 2013).

An onsite dense nonaqueous phase liquid (DNAPL) recovery well was installed in November of 2003. Approximately 2,000 pounds of DNAPL were recovered from 2003 to 2006 (IDEM 2010).

Monitoring of the wells on the property from 2002 and 2003 and 2005 to 2008 revealed continuous detections of PCE, although VOC concentrations fluctuated in some of the wells. An RI report prepared for the owners of the property indicated that PCE and its associated degradation products have migrated off of the Tuchman Property.

On July 7, 2008, National Drycleaners, Inc., the parent company of Tuchman and Tuchman Cleaners, Inc., declared Chapter 11 Bankruptcy. As of that date, all remedial efforts ceased pursuant to the bankruptcy proceedings at the Tuchman Cleaners Site (EPA 2013).

Lumberman's Wholesale Supply

The property at 4024 Millersville Road, referred to as Lumberman's Wholesale Supply, formerly housed glass manufacturing, a lumberyard, and dry-cleaning and laundry facilities. During the mid-1990s, dry cleaning and laundry operations were primarily conducted to clean industrial-use towels that were contaminated

with metals, SVOCs, VOCs, and other chemicals. In 1996, the Indiana Attorney General's office halted operations at the facility due to Resource Conservation and Recovery Act (RCRA) waste-handling violations (BCA Consultants 2005).

In 1996, water samples taken from a 5,000-gallon tank fed by a 246-foot-deep onsite well showed concentrations of PCE at 20 parts per billion (ppb). However, no PCE was found in water sampled from the well, suggesting that PCE may have been absorbed by the water in the unventilated facility (IDEM 2002).

Between 1997 and 2002, preliminary site assessments were completed at the site, which included the installation of monitoring wells, and the collection of subsurface soil and groundwater samples. Soil beneath the potential source area had up to 1,900 parts per million (ppm) of PCE in 1997, and PCE was found at up to 300 ppb in groundwater (SESCO Group [SESCO] 2009).

In 2004, a Voluntary Remediation Agreement was approved and adopted. In 2009, remediation at the site was initiated by implementing enhanced bioremediation in the subsurface by injecting Hydrogen Release Compound Advanced 3D Microemulsion. Subsequent sampling at the site revealed chlorinated solvent impacts in groundwater at two location on the western edge of the site and soil impacts above the IDEM criteria in the potential source area. IDEM required an additional soil and VI investigation and the development of a remediation work plan (SESCO 2012).

In 2012, a subslab depressurization vapor mitigation system was installed in order to address VI impacts inside the site building (SESCO 2012).

Vantage Point Cleaners

Former Vantage Point Cleaners operated from approximately 1979 until 1997 as a dry cleaner, using and disposing of PCE waste. In 1996, an environmental consultant was contracted to conduct a Phase I Environmental Assessment at the former location of Vantage Point Cleaners, located at 4405 Allisonville Road, Indianapolis, Indiana, northeast of Tuchman. Elevated levels of PCE were detected in the groundwater from two of three monitoring wells that were installed on the property (EPA 2013).

T&N Partnership, the owner of the vacant lot where Vantage Point Cleaners formerly operated, filed a lawsuit against Tuchman Cleaners and Vantage Point Cleaners. According to the Summary Judgment, it was determined that the contamination found on the vacant lot migrated from both Vantage Point Cleaners and Tuchman Cleaners.

A Phase II Environmental Investigation was conducted on the Vantage Point property and four additional monitoring wells were installed. Naphthalene was the only compound detected in the groundwater at the Vantage Point Cleaners. In 2007, a Phase II Site Investigation was conducted to determine if there was any contribution to PCE groundwater impacts to a vacant lot located between Vantage Point Cleaners and Tuchman Cleaners. The investigation found that elevated levels of PCE were detected on the Vantage Point Cleaners property (EPA 2013).

In 2010, IDEM issued a Special Notice of Liability letter to the registered agent of the former Vantage Point Cleaners, stating that a release of hazardous substances was documented from the former Vantage Point Cleaners property and that the facility was responsible to perform a response action that was deemed necessary by IDEM. In January 2011, a consultant for the registered agent prepared a work plan to investigate the VI pathway at a nearby church at the request of IDEM. On February 16, 2012, IDEM issued a Commissioners Order to Vantage Point Cleaners' responsible parties to conduct necessary response actions in order to address the groundwater contamination. According to an investigation on an adjacent property located at 4405 Keystone, Vantage Point Cleaners was listed as a potential source of contamination (EPA 2013).

No documented remedial actions have been performed at this property to date.

Thomas Caterers of Distinction

The property located northwest of Tuchman Cleaners contained a former rug cleaner and dry cleaner prior to 1970 and currently operates as a catering facility. The facility is located at 4440 North Keystone Avenue, Indianapolis. In January 2010, Thomas Caterers of Distinction contracted an environmental consultant to conduct a Phase II Environmental Investigation on its property. Analysis of the groundwater collected from all monitoring wells indicated elevated levels of PCE and TCE in the wells, and all soil samples contained PCE. Soil samples that were obtained on the property during the IDEM site investigation revealed elevated levels of PCE as high as 0.160 milligrams per kilogram (mg/kg) (EPA 2013).

No documented remedial actions have been performed at this property to date.

Purtee Plating

Purtee Plating has historically operated as both metal plating and automotive repair/restoration businesses. The property is located northwest of the groundwater plume at 2300-2306 East 44th Street, Indianapolis, Indiana. On March 24, 2006, IDEM staff conducted an inspection at the facility in response to a complaint alleging that nine drums of nickel plating wastes were abandoned at the property. The inspection revealed that the drums were present, and the owner was required to dispose of them. A series of investigations were conducted on the property showing elevated levels of PCE, cis-1,2 DCE, and various metals in the soils. The concentrations of PCE and TCE detected in the groundwater indicated that the groundwater on the property was being impacted by upgradient sources since concentrations were higher in wells upgradient of the property and downgradient of a potential source of PCE and TCE (Tuchman Cleaners) (EPA 2013).

No documented remedial actions have been performed at this property to date.

Imperial 1-Hour Cleaners

In 2011, IDEM collected subsurface soil and groundwater samples from the property located at 2248 East 38th Street. A historical records search revealed that Imperial 1-Hour Cleaners operated at this address from approximately 1972 to 1982. The building in which the former laundry operated on the western side is still standing and is currently a mosque. Soil and groundwater samples were collected from two borings placed on the east side of the building, downgradient of former laundry operations. This property is approximately 1,170 feet southeast of municipal well FC2, the most severely impacted municipal well in the FCWF (IDEM 2012).

PCE and TCE were detected in groundwater samples collected. In subsurface soils, no contaminants were detected at levels greater than three times background or, if not detected in background samples, greater than the quantitation limit (IDEM 2012).

No documented remedial actions have been performed at this property to date.

S & K Laundry

S & K Laundry operated a laundromat and dry cleaning facility at 2321 East 38th Street from approximately 1963 to 1999. In 2011, IDEM collected subsurface soil and groundwater samples from the property along the east side of the building. The placement of the samples collected were assumed to be on the downgradient side of the building in regards to groundwater flow direction. This property is approximately 1,760 feet southeast of municipal well FC2 (IDEM 2012). The building in which the former laundry operated is still standing and is currently a check cashing business.

PCE, TCE, and cis-1,2-DCE were detected in each of the three groundwater samples collected. PCE, TCE, and cis-1,2-DCE were detected at concentrations as high as 23 µg/L, 1.5 µg/L, and 2.1 µg/L, respectfully. PCE, TCE and cis-1,2-DCE were detected in subsurface soils at concentrations as high as 810 micrograms per kilogram (µg/kg), 22 µg/kg, and 78 µg/kg, respectfully (IDEM 2012).

No documented remedial actions have been performed at this property to date.

10.4 Sampling Rational

Based on the current understanding of the site history, geology, and hydrogeology, a phased investigative sampling approach has been developed for the RI. A brief description of each phase and its objectives is presented in the following paragraphs, and a more detailed description of site activities is presented in Worksheet #17. Current potential Phase 1 sample locations are shown in Figure 2. No samples are currently planned to be collected at the former S & K laundry property due to its distance from the known center of the VOC plume in groundwater and because it is hydraulically upgradient of the Lumberman location. However, soil and groundwater samples may be collected at this property if results of the RI indicate impacts from this location.

Phase 1

The purposes of Phase 1 are two-fold: (1) collect soil and groundwater samples in the area where the releases are suspected in an effort to identify specific source locations; and (2) expeditiously collect groundwater grab samples across the area historically modeled as the Keystone Corridor plume in an effort to identify the gross extent of the current plume.

During Phase 1, soil borings will be completed at six of the seven potential source properties, along with properties downgradient for the purpose of collecting soil samples for source characterization, lithology information, field screening with a photoionization detector (PID), and groundwater grab sampling. A total of 18 sample locations will be installed throughout the potential source properties, and 20 additional sample locations will be installed in downgradient areas.

Existing monitoring wells throughout the area will be located and evaluated for use during the RI. Existing monitoring wells included in the RI will be resurveyed, and wells will be redeveloped, as needed, in preparation for sampling these wells in Phase 2.

Phase 2

Phase 2 has two main objectives: (1) install and sample new and existing permanent groundwater monitoring wells in an effort to define the extent of the groundwater plume, and (2) collect samples to assess ecological and human health risk. The information collected in this phase will become the basis for the RI report.

Up to 20 new paired monitoring wells (10 wells in the shallow portion of the outwash aquifer and 10 in the deep outwash aquifer) will be installed to delineate the extent of the groundwater plume based on the results of Phase 1. One synoptic water level gauging event will be completed using approximately 60 wells (up to 20 newly installed wells and 40 existing monitoring wells) to characterize the hydrogeology of the site (groundwater flow direction and gradient). Additionaly, in situ aquifer (“slug”) tests will be performed in 5 monitoring wells to evaluate the transmissivity and hydraulic conductivity of the outwash aquifer. Groundwater samples from up to 60 monitoring wells and 12 private water supply wells will be collected during Phase 2 to assess the extent of the VOC groundwater plume.

Up to 10 pore water samples and 10 surface water samples will be collected from Fall Creek. The samples collected will be used to assess the potential risk associated with groundwater VOCs that may be migrating into Fall Creek.

Phase 3

Phase 3 has one main objective, the collection of data to support the human health risk assessment. Activities in Phase 3 will focus on the collection of soil gas data and soil samples at potential source areas.

The results of Phases 1 and 2 will be used to plan and execute Phase 3. Phase 3 will include the advancement of soil borings at potential source properties, and the collecion of soil gas samples for rapid assessment of six VOCs through use of HAPSITE gas chromatograph (GC)/mass spectrometer (MS) technology.

Soil gas will be analyzed at up to 80 locations to determine the extent of areas within the site exhibiting potential VI risk. An additional 8 soil gas samples (one additional sample from 8 locations) will also be collected to evaluate the vertical soil gas profile; up to 8 (10 percent of the lcoations) confirmatory soil gas samples will be collected for fixed laboratory analysis using Summa canisters. Biodegradation parameters (oxygen, carbon dioxide, and methane) will be measured in soil gas at each location in the field after performing the helium leak test.

Up to 5 borings will be installed at 6 of the 7 potential source areas to collect soil samples for the primary purpose of assessing potential human health risk. Soil borings will be installed in the vadose zone and samples will be collected generally from 0 to 2 feet bgs (current scenarios) and 2 to 10 feet bgs (future scenario).

10.5 Project Decision Conditions (“If…, then…” statements)

Field data collection activities will be completed in phases with each subsequent phase relying on the data results from the previous phase. As the current degree of VOC contamination at the potential source areas and the extent of the groundwater plume are not completely known, the initial phase will investigate six of the seven potential source areas and expand to areas crossgradient and downgradient of the properties. The results of Phase 1 will be used to install monitoring wells focusing on delineation of the groundwater plume during Phase 2, and data needed to complete focused risk assessments during Phases 2 and 3.

Phase 1

At six of the seven properties and at locations downgradient of the potential source areas, initial soil borings will be installed with a sonic drill rig to a depth immediately above bedrock, approximately 80 feet bgs. Continuous cores will be logged and screened with a PID by the project geologist to develop a better understanding of the subsurface lithology, identify the depth of the intermediate clay layer and interbedded sand lenses, and evaluate possible VOC impacts of soil to be sampled.

Following the installation of initial soil borings installed for the purpose of obtaining lithological information and screening of soils for VOCs, additional soil borings will be installed at six of the seven properties studied in this RI and in downgradient areas for the purpose of collecting soil and groundwater grab samples. Soil and groundwater grab samples will be collected for laboratory analysis of target compound list (TCL) VOCs. Figure 2 shows the approximate location of subsurface drilling and sampling locations; however, the final location of Phase 1 borings may change due to access constraints.

Soil logging will be completed from the ground surface to the bottom of the outwash aquifer (approximately 80 feet bgs). Soil samples will be collected from the shallow (0 to 25 feet bgs) and deep (60 to 80 feet bgs)

portions of the soil column at select locations spaced across the extent of the potential source area and immediately downgradient of the potential source area. If soil screening indicates a visual impact, olfactory impact, or an elevated PID reading within a specific depth interval, then a collected soil sample will be biased to that depth. If soil screening does not indicate a potential depth interval of VOC-impacted soil, a soil sample will be collected from approximately the midpoint of the portion of the soil column to be sampled (for example 12 feet bgs for the shallow and 70 feet bgs for the deep). If soil screening indicates potentially impacted soils in the clay and interbedded sand units of the intermediate portion of the soil column, up to 2 samples may be collected from each selected boring location from potentially impacted soils.

Groundwater grab samples will be collected at potential source areas and locations cross- and downgradient. The groundwater grab sampling will include a vertical component by collecting samples in the shallow and deep portions of the aquifer at each location. In addition, a groundwater grab sample will be collected from the interbedded sand and clay units of the intermediate zone at approximately 11 locations. If soil screening indicates a potentially impacted interval, a groundwater grab sample will be collected from that interval. If evidence of potentially impacted soils is not observed in a soil boring, groundwater grab samples will be collected from an approximate 2-foot interval near the midpoint of each portion of the aquifer to be sampled. The sample interval may be increased based on conditions of the formation (that is, silt- and clay-rich soils).

A search of existing monitoring wells will be completed, and if existing wells are found and access is obtained for these wells, each well will be sounded and the integrity of the well will be evaluated. If monitoring wells are located and found to be useable at locations and depths suitable to support the goals of the RI, the monitoring wells will be incorporated in the Phase 2 groundwater elevation synoptic and groundwater sampling events. If the well is found to be in useable condition, but the depth to bottom is shallower than what is reported in well construction logs, the well will be redeveloped to remove possible sediment at the bottom of the well.

Phase 2

The results from the soil and groundwater grab sampling in Phase 1 will be used to identify locations to install monitoring wells in Phase 2. Groundwater samples will be collected from newly installed monitoring wells along with existing monitoring wells for laboratory analysis of TCL VOCs. A subset of samples will be analyzed for 1,4-dioxane, a preservative of 1,1,1-TCA. Samples will also be collected from select monitoring wells for analysis of monitored natural attenuation (MNA) parameters, which will include sulfate, chloride, nitrate/nitrite, total iron and ferrous iron, sulfide, total organic carbon (TOC), and alkalinity.

Pore water and surface water samples will be collected from within Fall Creek to support the human health risk assessment (HHRA)[1] and ecological risk assessment (ERA). Pore water and surface water samples will be sent for laboratory analysis of TCL VOCs, as follows:

- Monitoring wells will be installed to delineate the extent of the VOC groundwater plume. Monitoring wells will be installed at locations based on the results of the Phase 1 groundwater grab samples. Ten monitoring wells are planned to be installed in the shallow portion of the outwash aquifer and 10 wells in the deep portion of the outwash aquifer. If results of the groundwater grab samples suggest that the plume is primarily in one portion of the aquifer, then a greater proportion of monitoring wells may be installed in that portion of the aquifer. If substantial sand layers are identified in the

[1] Pore water samples will not be used in the HHRA.

intermediate portion and contain elevated VOCs based on the Phase 1 results, monitoring wells may be installed within the intermediate portion of the aquifer.

- If existing wells are in areas that would support the investigation and are in sound condition, these monitoring wells will be incorporated into the RI.
- If the groundwater plume is observed to intersect Fall Creek, then pore water and surface water samples will be collected from areas of the river that are shown to be intersected based on the results of the Phase 2 groundwater grab sampling event.

Phase 3

Phase 3 has one main objective, the collection of data to support the HHRA.

Activities in Phase 3 will focus on the collection of soil gas data and soil samples at potential source areas. Soil samples will be sent for laboratory analysis of TCL VOCs. Soil gas samples will be analyzed for VOCs in the field through use of a HAPSITE GC/MS, and a subset of soil gas samples will be sent for fixed laboratory analysis of VOCs, as follows:

- Results of the Phase 1 soil samples and Phase 1 and 2 groundwater samples will be used to determine if the six potential source areas have definable VOC-impacted soils and may be characterized as source areas. At each of the six properties that are suspected of being a potential source area, five soil borings will be installed for the purpose of collecting surface (0 to 2 feet bgs) and subsurface soil (2 to 10 feet bgs) samples. At the potential source area(s), soil logging will be completed from the ground surface to 10 feet bgs. If results of the Phase 1 soil sampling activities indicate areas of potentially impacted soil, soil borings installed during Phase 3 and sample intervals will be biased towards those locations and depths.
- If historical documents indicate areas of suspected storage, usage, or release of chlorinated VOCs, soil borings will be biased to those areas. If results of the Phase 1 soil sampling activities do not indicate potentially impacted soils, and historical documents do not suggest potential sources of chlorinated VOCs, then soil borings at these properties will be installed in a random grid across the property.
- If soil screening indicates a visual impact, olfactory impact, or a sustained PID reading of greater than 10 ppb volume, then a soil sample will be collected at that depth. If soil screening does not indicate a potential depth interval of VOC-impacted soil, then a soil sample will be collected from approximately the midpoint of the interval to be sampled.
- A soil gas investigation will be performed at the site to delineate site-related VOC concentrations in soil gas within the potential source areas, primarily to the north of the site. Available site information such as the location of potential VOC source areas, historical groundwater and soil VOC concentrations, utility corridor maps, residential and commercial land uses, and previous VI sampling data will be used to identify the areas of interest with the greatest potential for VI. Soil gas sampling will be performed in these areas initially, and if elevated soil gas concentrations are detected above VI screening levels, then step out locations will continue until the extent of the area(s) where soil gas is below VI screening levels is determined. Up to 80 sample locations are planned. If the soil gas plume is smaller than anticipated, then fewer locations may be completed.

Worksheet #11—Project/Data Quality Objectives

Table 11-1. Data Quality Objectives

DQO #	Step 1: Statement of Problem	Step 2: Identify Goals of the Study	Step 3: Identify Information Inputs	Step 4: Define Boundary Studies	Step 5: Develop Analytical Approach	Step 6: Specify Performance or Acceptance Criteria	Step 7: Develop Plan for Obtaining Data
1	Chlorinated VOCs have been detected in groundwater at concentrations exceeding the EPA MCLs. In addition, VOCs have been been detected in six municipal water supply wells downgradient of the site.The nature and extent of the groundwater plume has not been defined. Seven commercial properties have had documented VOC-impacted soils. An HHRA is required to estimate the potential level of risk to human health associated with these areas.	Characterize the nature and delineate the extent of the current VOC plume in groundwater. Identify if each of the six potential source area properties are a source of the VOCs in groundwater. Collect soil samples at each property identified as a potential source area to support a HHRA.	Collect groundwater grab samples, groundwater samples from monitoring wells, and residential water supply wells, for VOC analyses. Collect soil samples from each potential source area for VOC analyses. Review existing data from samples previously collected from water supply wells and existing monitoring wells. Stratigraphic logs/cross-sections and well construction diagrams.	The depicted plume, based on the HRS Documentation Record for the site, currently measures approximately 4,500 feet long (north to south) and approximately 1,500 feet wide (east to west). The study area encompasses an urban area with a mix of residential, commercial, and industrial properties. The center of the Keystone Site is designated as the intersection of Keystone Avenue and East Fall Creek Parkway North Drive, and the site is approximately bounded on the north by 45th Street, on the west by Norwaldo Avenue, on the south by 38th Street, and on the east by Eastern Avenue The vertical extent of the study will extend from ground surface to the top of the carbonate bedrock (approximately 80 feet bgs).	Install soil borings for lithological descriptions and to determine sample intervals. Forty-seven groundwater grab and 26 soil samples will be analyzed for TCL VOCs. Sixty groundwater samples from monitoring wells and 12 samples from private water supply wells will be analyzed for TCL VOCs. Ten groundwater samples will be analyzed for 1,4-dioxane, a chemical used to preserve 1,1,1-TCA. Twenty groundwater samples will be analyzed for MNA parameters to assess MNA as a remedial option. MNA parameters will also be used to assess the influence of incomplete biodegradation of the chlorinated hydrocarbons. The parameters include sulfate, chloride, nitrate/nitrite, total iron and ferrous iron, sulfide, TOC, and alkalinity. Water quality parameters (temperature, pH, dissolved oxygen [DO], specific conductance [SpC], oxidation-reduction potential [ORP], and turbidity) will be measured in the field from the wells. A PID will be used to screen soils for VOCs. Refer to Worksheet #17.	Refer to Worksheets #24, #28, and #36 for acceptance and performance criteria. Laboratory data are considered usable if data validation criteria are met (refer to Worksheet #37 for data usability criteria).	Phased investigation approach, including the installation of monitoring wells and soil borings for the purpose of collecting groundwater and soil samples for TCL VOC analyses. **Phase 1** Collection of groundwater grab and soil samples from up to three depth intervals at 38 locations. **Phase 2** Installation of 20 monitoring wells and sampling of approximately 60 groundwater monitoring wells and 12 private wells across the groundwater plume area. **Phase 3** up to 5 soil borings installed at 6 of the 7 potential source areas. Soil samples to be collected from the 0- to 2- and 2- to 10-foot intervals to support the HHRA.

DQO #	Step 1: Statement of Problem	Step 2: Identify Goals of the Study	Step 3: Identify Information Inputs	Step 4: Define Boundary Studies	Step 5: Develop Analytical Approach	Step 6: Specify Performance or Acceptance Criteria	Step 7: Develop Plan for Obtaining Data
2	Previous investigations have identified chlorinated VOCs in the groundwater underlying the commercial areas. The commercial area has not been completely evaluated for VI risk. It is unknown if the VOCs in groundwater extend to the adjacent residential areas. VI issues have been identified in residential areas adjacent to the site but have not been connected to the site.	The goal is to identify areas where VOCs in soil gas or utility corridors may result in potential VI risk.	Historical groundwater and soil VOC concentrations, previous vapor intrusion sampling data, and groundwater results from Phases 1 and 2. Soil gas VOC concentrations from up to 80 locations. Vertical profile soil gas sampling. Land use/zoning maps that provide information about commercial vs. residential building uses. Aerial photographs, etc., that provide information about the location of buildings.	The depicted groundwater plume, based on the HRS Documentation Record for the site, currently measures approximately 4,500 feet long (north to south) and approximately 1,500 feet wide (east to west). The study area encompasses an urban area with a mix of residential, commercial, and industrial properties. Standard practice is to consider an inclusion zone at least 100 feet laterally or vertically from the boundary of subsurface vapor concentrations of potential concern, with longer distances potentially in utility corridors. The center of the Keystone Site is a designated as the intersection of Keystone Avenue and East Fall Creek Parkway North Drive and the site is approximately bounded on the north by 45th Street, on the west by Norwaldo Avenue, on the south by 38th Street, and on the east by Eastern Avenue The vertical extent of the study will extend to the top of the capillary fringe, approximately 17 feet bgs, as well as considering groundwater information collected from at or near the water table.	The soil gas samples field analyzed for VOCs using HAPSITE GC/MS to analyze 6 constituents (PCE, TCE, 1,1,1-TCA, cis-1,2-DCE, trans-1,2-dichloroethene, vinyl chloride) Confirmatory soil gas samples collected at a frequency of 10 percent and analyzed for VOCs by method TO-15. Field measurements of biodegradation parameters (oxygen, methane, and carbon dioxide) will be collected from each probe. Vapor Intrusion concerns will be analyzed based on a multiple lines of evidence approach consistent with EPA 2015 guidance. Refer to Worksheet #17.	Refer to Worksheets #24, #28, and #36 for acceptance and performance criteria. Laboratory data are considered usable if data validation criteria are met (refer to Worksheet #37 for data usability criteria).	Historical groundwater and soil VOC concentrations, previous VI sampling data, utility maps, land use/zoning maps, aerial photographs, and groundwater results from Phases 1 and 2 will be used to determine soil gas sample locations. Soil gas sampling will be performed in suspected areas of elevated soil gas concentrations and will continue stepping out from them until the extent of the area(s) where soil gas VOC concentrations exceed screening levels are identified or available time/funding is exhausted. Temporary soil gas probes will be installed during Phase 3 at a depth below 5 feet, preferably below 8 feet but above the capillary fringe at up to 80 locations. Soil gas probes will be installed vertically above the capillary fringe. Eight locations will be sampled at 2 depths in offset borings to evaluate the vertical soil gas profile. Shallow depths will be at least 5 feet and preferably 8 feet to represent basement depths. Deeper location should be just above the water table and capillary fringe. Up to 88 soil gas samples will be analyzed for 6 VOCs through HAPSITE GC/MS field analysis. Confirmatory soil gas samples will be collected at a frequency of 10 percent for laboratory analysis by Method TO-15. Refer to Worksheet #17 for details on the sample collection design and rationale.

DQO #	Step 1: Statement of Problem	Step 2: Identify Goals of the Study	Step 3: Identify Information Inputs	Step 4: Define Boundary Studies	Step 5: Develop Analytical Approach	Step 6: Specify Performance or Acceptance Criteria	Step 7: Develop Plan for Obtaining Data
3	VOCs in the groundwater could potentially discharge to Fall Creek at concentrations that may pose a risk to ecological and human receptors.	The goal is to complete a groundwater to surface water evaluation to support the development of an ERA and HHRA.	Data from Phase 1 will be evaluated to identify up to 10 pore water/surface water sample locations from Fall Creek.	The extent of the river intersected by the VOC groundwater plume. The vertical extent of the study will extend to approximately 1 foot below the top of the creek bed.	Pore water and surface water samples will be analyzed for TCL VOCs. Water quality parameters (temperature, pH, DO, total dissolved solids, SpC, ORP, and turbidity) will be measured in the field from each well point and surface water directly adjacent to well point. Refer to Worksheet #17.	Refer to Worksheets #24, #28, and #36 for acceptance and performance criteria. Laboratory data are considered usable if data validation criteria are met (refer to Worksheet #37 for data usability criteria).	Data from Phase 1 will be evaluated to identify up to 10 pore water sample locations and 10 surface water sample locations within Fall Creek. Locations will be selected in areas where Fall Creek intersects the VOC groundwater plume. Refer to Worksheet #17 for details on the sample collection design and rationale.

DQO = data quality objective

Who will use the data?

The data will be used by CH2M, EPA, IDEM, and SSPA.

What will the data be used for?

Groundwater, soil, pore water, surface water and soil gas sample collection and field analysis, and other associated RI activities will be conducted to evaluate the nature and extent of VOC contaminants, fill data gaps necessary to complete the physical site conceptual model, and assess potential impacts on human health and ecological receptors.

Phase 1 Subsurface Soil and Groundwater Grab Sampling

Phase 1 will entail the collection of lithology information, groundwater grab samples, and soil samples from subsurface soil borings. Soil borings will be installed at six of the seven potential source area properties and at locations downgradient of the potential source areas. Continuous cores will be logged and screened with a PID by the project geologist to develop a better understanding of the site geology and VOC impacts to be sampled.

Soil borings will be advanced through the aquifer and samples will be collected from three general intervals from ground surface to the top of bedrock (approximately 80 feet bgs). Data collected during Phase 1 will be used to evaluate whether the potential source areas contain impacted soils and groundwater that may warrant further sample collection during Phases 2 and 3. Further sampling at these properties will be conducted if elevated VOCs are detected to evaluate risk and to determine extent of contamination at these properties. Groundwater grab samples collected from both the potential source areas and downgradient locations will be used to determine the approximate extent of the VOC groundwater plume.

Phase 2 Groundwater and Pore Water / Surface Water Sampling

Phase 2 primarily involves installing groundwater monitoring wells, collecting samples from Fall Creek, and completing a hydrogeologic study.

Monitoring well pairs (shallow and deep) will be installed and groundwater samples will be collected from newly installed monitoring wells, existing monitoring wells, and private water supply wells. Groundwater samples will be collected to provide a horizontal and vertical profile of the overall groundwater plume in the outwash aquifer.

Collocated pore water and surface water samples will be collected from within Fall Creek. The results of these samples will be used to assess the level of risk to potential receptors and will be the basis of the ERA and will support the HHRA.[2]

Water levels collected from surveyed monitoring wells will be used to characterize the hydrogeology of the site (groundwater flow direction and magnitude). Slug tests will be performed at five monitoring wells to evaluate the transmissivity and hydraulic conductivity of the outwash aquifer. Results of the hydrogeologic study will be used evaluate site hydrogeology and contaminant migration in the RI report and to evaluate remedial alternatives.

[2] Pore water samples will not be used in the HHRA.

Phase 3 Soil Gas and Soil Sampling

Soil gas samples will be collected from temporary soil gas probes installed within areas where the potential for elevated VOC levels in soils exists, primarily focused near the northern potential source area properties, and extend away from these areas to delineate to the extent possible the lateral extent of areas exceeding vapor intrusion screening levels (VISLs). Soil gas samples will be collected from temporary probes and analyzed in the field using a HAPSITE GC/MS. Two samples will be collected from within offset boreholes at different depths at eight locations to create a vertical profile of soil gas. Soil gas results will be used in conjunction with groundwater, stratigraphic, and other lines of evidence to assess whether additional VI studies are warranted. Confirmatory soil gas samples will be sent for fixed laboratory analysis at a frequency of 10 percent.

Soil samples will be collected from within potential source areas as identified based on the Phase 1 sampling event. Soil borings will be installed at six of seven potential source areas for the purpose of collecting soil samples. Soil data will be used to evaluate VOC concentrations in soils at the potential source area and to evaluate potential human health and ecological risk (bulk soil samples are not generally considered an important line of evidence for VI, but they are used for the evaluation of other pathways such as direct contract).

What types of data are needed?

Task	Sampling Activity/Objective	Sampling Frequency/ Duration	Matrix	Parameters
Groundwater VOC Plume Characterization	Groundwater Sampling (Refer to DQO #1)	Phases 1 and 2	Groundwater	TCL VOCs, 1,4-dioxane, sulfate, chloride, nitrate/nitrite, total iron, sulfide, TOC, alkalinity (analytical laboratory), pH, temperature, ferrous iron, DO, specific conductance, ORP, and turbidity (field screening)
Groundwater Flow Characterization	Characterize the hydrogeology of the site	Phase 2	Groundwater	Measure groundwater water levels to calculate flow direction and gradient. Complete slug tests to determine aquifer transmissivity and conductivity
Pore and Surface Water	Pore and surface water sampling (Refer to DQO #3)	Phase 2	Sediment Pore and Surface Water	TCL VOCs (analytical laboratory), temperature, pH, DO, total dissolved solids, SpC, ORP, and turbidity (field screening)
Soil Gas	Soil gas sampling (Refer to DQO #2)	Phase 3	Soil Gas	VOCs (analytical laboratory), VOCs, methane, oxygen, and carbon dioxide (field screening); helium leak check
Soil	Soil sampling(Refer to DQO #1)	Phases 1 and 3	Soil	TCL VOCs (analytical laboratory)/field screening of soils with a PID

How “good” do the data need to be in order to support the environmental decision?

The data should meet the project criteria as specified in QAPP Worksheets #15-1 through #15-8 and the QC requirements that are explained in QAPP Worksheet #37.

Worksheet #15 presents analytical methodology and limits. In addition to listing the particular analytes, screening levels, and limits, the table identifies where quantitation limits (QLs) or MDLs are greater than project action limits (PALs). Although the information was taken into consideration when planning analytical protocol for the site and could lead to some uncertainty, it does not prevent conclusions from being drawn with respect to the project objectives for the following reasons:

- Even though some QLs are greater than the respective screening levels, MDLs are closer to and could be less than the applicable PALs. The laboratory instrumentation would likely detect a constituent if present at a concentration greater than its MDL, and such a result would be reported as estimated because it is less than the QL.
- If a particular analyte has a QL or MDL greater than a screening level and there are sufficient other analytes in the same constituent group that would likely be detected with a QL or MDL less than the screening values, then determinations for further action at the site can be made with sufficient confidence.
- Standard EPA methods are proposed, which often have PALs below QLs due to the low target risk levels incorporated into the PALs.
- The analytes with PALs below the QLs are not expected to be related to releases from the site.

Definitive data are defined as data that are suitable for final decision making. They are generated using rigorous analytical methods such as approved EPA CLP methods. Definitive data are not restricted in their use unless quality problems require data qualification, resulting in unusable data. For this project, screening level data quality will be defined as definitive data methods where field related QA/QC will not be collected to support the results; therefore, the data will not be as rigorous as definitive data requirements.

Analytical field data such as turbidity, redox potential, and other water quality readings and air biodegradation readings collected during soil gas sample collection will be screening level data only. In addition, MNA parameters will be collected to assess the general groundwater reductive conditions and will not require additional QA/QC analysis.

How many data are needed? (Number of samples for each analytical group, matrix, and concentration)

Worksheet #17 (Sampling Design and Rationale) describes the field investigation activities. Worksheet #18 (Sampling Locations and Methods) summarizes the number of samples and the analytical parameters.

Where, when, and how should the data be collected/generated?

Detailed information on where, when, and how the data will be collected is provided in Worksheets #17 and #18.

Who will collect and generate the data?

For soil gas, pore water, surface water, groundwater, and soil sampling, CH2M will collect environmental samples. Soil gas samples will be analyzed in the field by CH2M through use of a HAPSITE GC/MS and confirmatory samples will be sent to a fixed laboratory at a frequency of 10 percent. The subcontracted analytical laboratory will generate the data results for all samples except for field analysis of soil gas, groundwater quality parameters (pH, temperature, DO, specific conductance, ORP and turbidity), ferrous iron, and biodegradation parameters (oxygen, carbon dioxide, and methane). The laboratory standard operating procedures (SOPs) will be provided in Appendix B of the final version of this QAPP.

How will the data be reported?

The data will be reported to EPA in accordance with procedures outlined in Worksheet #36. Electronic (such as database management system) data will be stored by CH2M for 10 years after contract completion. CH2M's scope does not include community relations, risk communication, or communicating results to property owners. CH2M will refer property owner and community inquiries to EPA.

How will the data be archived?

The final evidence file will be the central repository for documents that constitute evidence relevant to sampling and analysis activities. CH2M will be the custodian of the evidence file and will maintain the contents of the evidence files for the project, including relevant records, reports, logs, field notebooks, sketches, pictures, contractor reports, and data reviews, in a secured area with limited access. CH2M will keep records for 10 years after contract completion. As necessary, records may be transferred to an offsite records storage facility. The records storage facility must provide secure, controlled access records storage.

Worksheet #12—Measurement Performance Criteria

The measurement performance criteria (MPC) for chemical analyses being performed for each matrix and analytical parameter are summarized in Table 12-1 on the following page. The MPCs follow those defined in the referenced EPA method or laboratory SOPs. The quality of the data to be collected for this project will be verified through appropriate MPCs established for both sampling procedures and analytical methods.
The criteria relate to data quality indicators (DQIs), consisting of precision, accuracy, representativeness, comparability, completeness, and sensitivity, commonly referred to as PARCCS parameters. The DQIs are defined as follows:

- **Precision** refers to the reproducibility of measurements. Precision is usually expressed as standard deviation, variance, percent difference, or range, in either absolute or relative terms.
- **Accuracy** refers to the degree of agreement between an observed value (such as sample results) and an accepted reference value. A measurement is considered accurate when the reported value agrees with the true value or known concentration of the spike or standard within acceptable limits.
- **Representativeness** describes the extent to which a sampling design adequately reflects the environmental conditions of a site. Representativeness is determined by appropriate program design, with consideration of elements such as proper well locations, drilling and installation procedures, operations process locations, and sampling locations.
- **Comparability** addresses the degree to which different methods or data agree or can be represented as similar. Comparability is achieved by using standard methods for sampling and analysis, reporting data in standard units, normalizing results to standard conditions, and using standard and comprehensive reporting formats.
- **Completeness** is a measure of the amount of valid data collected using a measurement system. Completeness is expressed as a percentage of the number of measurements that are specified in this UFP QAPP.
- **Sensitivity** is the ability of a method or instrument to detect the target analytes at the level of interest. Sensitivity can be measured by calculating the percent recovery of the analytes at the detection limit, which is the minimum concentration of an analyte that can be routinely identified and quantified above the MDL by a laboratory.

The quality of the sampling procedures and laboratory results will be evaluated for compliance with project DQOs through a review of overall PARCCs (EPA 2009), in accordance with procedures described in Worksheet #37 (Data Usability Assessment). The results will be summarized in an overall data usability report.

Worksheet #12-1—Measurement Performance Criteria Table

Matrix	Aqueous
Analytical Group	TCL VOCs
Concentration Level	Trace

Sampling Procedure[a]	Analytical Method/SOP[b]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S & A)
SOP #7 and #14	Laboratory SOP #1	Precision	RPD ± 20%	MS/MSD	A
			RPD ± 30%	FD	S & A
		Accuracy/Bias	± % Recovery	LCS, MS	A
		Completeness	> 90% Laboratory Analysis	Percent Completeness	S & A
		Representativeness	Contamination of sample	MB, TB, EB	S & A
		Comparability	Qualitative measure for field sampling procedures	LCS, MS	A

[a] Reference number from QAPP Worksheet #21
[b] Reference number from QAPP Worksheet #23
FD = field duplicate, LCS = laboratory control sample, MB = method blank, TB = trip blank, EB = equipment blank, RPD = relative percent difference, MS = matrix spike, MSD = matrix spike duplicate

Worksheet #12-2—Measurement Performance Criteria Table

Matrix Soil

Analytical Group TCL VOCs

Concentration Level Low

Sampling Procedure[a]	Analytical Method/SOP[b]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S & A)
SOP #2, and #3	Laboratory SOP #1	Precision	RPD ± 20%	MS/MSD	A
			RPD ± 50%	FD	S & A
		Accuracy/Bias	± % Recovery	LCS, MS	A
		Completeness	> 90% Laboratory analysis	Percent Completeness	S & A
		Representativeness	Contamination of sample	MB, TB, EB	S & A
		Comparability	Qualitative measure for field sampling procedures or extract with a constituent of concern	LCS, MS	A

[a] Reference number from QAPP Worksheet #21
[b] Reference number from QAPP Worksheet #23
FD = field duplicate, LCS = laboratory control sample, MB = method blank, TB = trip blank, EB = equipment blank, RPD = relative percent difference, MS = matrix spike, MSD = matrix spike duplicate

Worksheet #12-3—Measurement Performance Criteria Table

Matrix Soil Gas

Analytical Group VOCs

Concentration Level Low

Sampling Procedure[a]	Analytical Method/SOP[b]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S & A)
SOP #8	Laboratory SOP #2	Precision	RPD ± 25% if both samples are > 5xRL	FD	S & A
			RPD ± 25% if both samples are > 5xRL	LD	A
		Accuracy/bias	± % Recovery	LCS, Surrogates	A
		Completeness	> 90% Laboratory Analysis	Percent Completeness	S & A
		Representativeness	Contamination of sample	MB, AB	A
		Comparability	Qualitative measure for field sampling procedures	LCS	A

[a] Reference number from QAPP Worksheet #21
[b] Reference number from QAPP Worksheet #23
FD = field duplicate, LD = laboratory duplicate, LCS = laboratory control sample, MB = method blank, AB = ambient blank, RPD = relative percent difference

Worksheet #12-4—Measurement Performance Criteria Table

Matrix	Aqueous (1,4-Dioxane)
Analytical Group	SVOCs
Concentration Level	Trace

Sampling Procedure[a]	Analytical Method/SOP[b]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S & A)
SOP #7 and #14	Laboratory SOP #1	Precision	RPD ± 20%	MS/MSD	A
			RPD ± 30%	FD	S & A
		Accuracy/Bias	± % Recovery	LCS, MS	A
		Completeness	> 90% Laboratory Analysis	Percent Completeness	S & A
		Representativeness	Contamination of sample	MB, EB	S & A
		Comparability	Qualitative measure for field sampling procedures	LCS, MS	A

[a] Reference number from QAPP Worksheet #21
[b] Reference number from QAPP Worksheet #23
FD = field duplicate, LCS = laboratory control sample, MB = method blank, EB = equipment blank, RPD = relative percent difference, MS = matrix spike, MSD = matrix spike duplicate

Worksheet #12-5—Measurement Performance Criteria Table

Matrix Aqueous

Analytical Group Total Iron

Concentration Level Low

Sampling Procedure[a]	Analytical Method/SOP[b]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S & A)
SOP #8	Laboratory SOP #3	Precision	RPD ± 25%	LD	S & A
		Accuracy/Bias	± % Recovery	LCS	A
		Completeness	> 90% Laboratory analysis	Percent Completeness	S & A
		Representativeness	Contamination of sample	MB,	S & A
		Comparability	Qualitative measure for field sampling procedures	LCS	A

[a] Reference number from QAPP Worksheet #21
[b] Reference number from QAPP Worksheet #23
LD = laboratory duplicate, LCS = laboratory control sample, MB = method blank, RPD = relative percent difference,

Worksheet #12-6—Measurement Performance Criteria Table

Matrix	Aqueous
Analytical Group	General Chemistry[c]
Concentration Level	Low

Sampling Procedure[a]	Analytical Method/SOP[b]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S & A)
SOP #8	Laboratory SOP #4, #5, #6, #7	Precision	RPD ± 30%	LD	S & A
		Accuracy/bias	± % Recovery	LCS	A
		Completeness	> 90% Laboratory analysis	Percent Completeness	S & A
		Representativeness	Contamination of sample	MB,	S & A
		Comparability	Qualitative measure for field sampling procedures	LCS	A
		Sensitivity	Evidence of shift in instrument response or zero setting MDLs	LCS	A

[a] Reference number from QAPP Worksheet #21
[b] Reference number from QAPP Worksheet #23
[c] General Chemistry for groundwater samples includes the following parameters: alkalinity, chloride, nitrate, nitrite, sulfate, sulfide, and total organic carbon.
LCS = laboratory control sample, MB = method blank, RPD = relative percent difference, MDL = method detection limit

Worksheet #13—Secondary Data Uses and Limitations

Secondary Data	Data Source	Data Generator(s)	How Data Will Be Used	Limitations on Data Use
Site Inspection	Site Inspection Report for the Keystone Corridor Groundwater Contamination Site	IDEM.	Well and soil data, potential for VI risk, groundwater contaminant concentrations.	None
Expanded Site Inspection	Expanded Site Inspection Report for the Keystone Corridor Groundwater Contamination Site	IDEM	Well and soil data, potential for VI risk, groundwater contaminant concentrations.	None
Results of the Phase II RI	Phase II RI Report completed at the former Tuchman Cleaners property	URS[a]	Geologic cross-section, soil descriptions to initially plan sampling locations and depths.	Qualitative data use only
Zoning and Land Use Maps, Aerial Photos	Private and government databases.	Various	Identify building location and uses to support VI evaluation.	Qualitative data use only
Historic Site Investigations and Sample Results	Various historical site investigation and remediation reports from local property owners as made available.	Various	Well and soil data, potential for VI risk, groundwater contaminant concentrations, well construction diagrams for existing wells, municipal groundwater monitoring data.	Qualitative data use only

[a] (URS 2004)

Worksheets #14 and #16—Project Tasks and Schedule

Field investigation Tasks

Mobilization

Prior to field data collection activities, a field office will be setup at the Citizen's Water facility located within the site study boundaries. The EPA Scribe program will be set up for the site and used for field documentation of samples collected and for the generation of chains of custodies throughout the RI.

An investigation-derived waste (IDW) staging area will also be established at the Citizen's Water Facility for both a frac tank to contain and store liquid IDW and soil roll-off boxes and/or sludge-boxes for soil cuttings and debris.

Utility Locates

Prior to any intrusive field activities, locations will be cleared for subsurface utilities by both contacting the Indiana 811 utility locate service and through the use of a private, third-party locating firm. Utilities at each soil boring location will be identified and marked within a 20-foot radius with paint and or flags. To expedite the soil gas delineation event by reducing the number of access agreements needed, soil gas delineation will be performed primarily in city right of ways. Utilities will be cleared in large expanses of the right-of-ways as delineation efforts proceed in each direct to reduce the potential for delays. The Indiana 811 utility locate service will be called at least 2 full business days in advance, and all notified utilities will be documented as to their clearance. If utilities are found within 5 feet of a proposed drilling location, then the location will be moved at least 5 feet outside of the marked utilities. Utility clearance activities will be completed following SOP #10.

Soil Sampling

Soil borings will be installed within the potential source areas and at downgradient properties using rotosonic drilling technologies. Borings in the suspected source areas and north of Fall Creek will be cased across the thickness of the upper aquifer and approximately 10 feet into the intermediate clay with a 7-inch-diameter temporary casing to prevent vertical migration of contaminants.

Soils will be continuously cored and logged, field screened using a PID, and collected for laboratory analysis during Phases 1 and 3. Soil samples will be collected during Phase 1 to determine if potential source areas are impacted with VOCs. Soil samples will be will be collected from six of the seven potential source areas to evaluate risk to human health in the HHRA. Phase 3 soil borings will be installed in the vadose zone and samples will be collected generally from 0 to 2 feet bgs (direct contact) and 2 to 10 feet bgs (construction-worker scenario). Soil samples will be sent for laboratory analysis under chain of custody. Boreholes will be abandoned by pressure grouting with a tremie pipe following Indiana requirements. Each soil sampling location will be surveyed by the field team using a survey-grade (submeter accuracy) handheld global positioning system (GPS) unit. Soil samples will be analyzed for TCL VOCs by EPA Method 8260B. Soil sampling activities will be completed following SOPs #1 and #2.

Groundwater Grab Sampling

Concurrent with the collection of soil sampling in Phase 1, groundwater grab samples will be collected from each of the soil borings installed for the purpose of collecting samples. Discrete groundwater grab samples

will be collected using a submersible pump from a reusable stainless-steel screen isolated from the upper and lower portions of the borehole/casing. Dedicated polyethylene tubing will be connected to the pump to facilitate the collection of samples. The slotted lead steel rod and other downhole equipment including the sampling pump will be decontaminated between each sample. Samples will then be collected and kept in a cooler with ice until they are shipped under a chain of custody to the subcontracted laboratory for TCL VOC analysis. Groundwater grab sampling activities will be completed following SOP #14.

Monitoring Well Installations

Conventional monitoring wells will be installed using rotosonic drilling technologies. Monitoring wells will be constructed using 2-inch-diameter schedule 40 polyvinyl chloride (PVC) casing, with 5 feet of 10-slot (0.01-inch) machine-slotted PVC well screen, and sand pack material will be compatibly sized to the well screen. Actual screen lengths will be determined based on field observations and may be greater than 5 feet. Design and construction of the monitoring wells will be in accordance with IDEM well construction requirements.

Borings in the suspected source areas and north of Fall Creek where a significant clay layer in the outwash aquifer is suspected, as evident in historical soil boring logs and from initial lithological soil borings installed in this RI, will be dual-cased across the thickness of the upper aquifer and approximately 10 feet into the intermediate clay to prevent vertical migration of contaminants. Seven-inch-diameter temporary casing will be installed at each 6-inch-diameter boring in areas where a significant clay layer is observed. Once the temporary 7-inch casing is set into the clay layer, the drill rods will be decontaminated, and a 6-inch boring will be completed to the desired depth. The temporary casing will be removed as the annular space between the well and the borehole are filled with grout.

General construction details include installation of sand pack 1 to 2 feet above the well screen, a 2-foot layer of fine filter pack sand, a 1- to 2-foot layer of hydrated bentonite pellets, and pressure grouting of the remaining annular space using the tremie pipe method. The grout will consist of neat cement, a bentonite slurry or as pelletized, medium-grade, or coarse-grade crushed bentonite.

Monitoring wells will be finished with either a flush mount manhole surface or a protective steel locking stickup, depending on conditions at each drilling area. Wells installed will include a concrete pad, locking compression cap J-plug, and keyed alike padlocks. The stickup well completions will also include three concrete-filled protective bollards. Following installation of the monitoring wells, the wells will be developed using a combination of a surge block and purging to over-pump the entire well-screen interval and the wells. Well locations and top-of-casing elevation for wells sampled will be surveyed by an Indiana-licensed surveyor. Monitoring well installation activities will be completed following SOP #4.

Groundwater Sampling

Groundwater monitoring wells will be sampled using the low-flow methodology. Each well will be inspected upon arrival and checked for damage, missing parts, subsidence, or flooding. Static water levels will be measured from the permanent mark on the PVC casing. The wells will be purged with a submersible sampling pump, and stabilization parameters will be collected and recorded by a water quality meter and water flow-through cell. Samples will then be collected and kept in a cooler with ice until they are shipped under a chain of custody.

The groundwater samples will be analyzed for TCL VOCs, and a subset of samples will be analyzed for MNA parameters, including sulfate, chloride, nitrate/nitrite, total iron and ferrous iron, sulfide, TOC, and alkalinity. Ferrous iron will be analyzed in the field through use of a field HACH colorimeter. A subset of monitoring wells will also be analyzed for 1,4-dioxane. Groundwater sampling activities will be completed following SOP #7.

Residential Private Water Supply Well Sampling

Groundwater samples will also be collected from private water supply wells on residential properties and possible municipal water supply wells. The Indiana GIS databases will be searched for records of water supply wells. In addition, historical reports and information obtained by EPA will be searched to identify residential properties with documented water supply wells that may be sampled to help determine the extent of the VOC groundwater plume. EPA will contact each property owner and obtain a signed access agreement prior to entering each property. Each landowner will be interviewed to confirm well and plumbing construction details and the location of any water treatment systems. After confirming pipe dimensions from the well pump to the sampling location, the well will be run enough to purge the calculated volume. Water samples will be collected with the owner of the property present, and samples will be collected from a sampling point upstream of water treatment, filters, or water softeners when possible. Samples collected from private wells will be completed following SOP #15. Samples will then be collected and kept in a cooler with ice until they are shipped under a chain of custody and shipped for laboratory analysis of TCL VOCs.

Pore Water and Surface Water Sampling

Up to 10 well points manufactured by ECT Manufacturing will be installed within Fall Creek to support the ERA. Each well point incorporates an outer and inner screen and riser. The outer screen is constructed of 2-inch-diameter PVC piping with a 12-inch machine-slotted screen (0.01-inch slot size). A pointed well cap is attached to the bottom of the outer screened segment, and risers are attached to the screen segment to achieve enough overall well point length so the top riser segment extends above the surface water line.

A 1-inch-diameter inner screen and riser is installed within the outer screen. This inner screen consists of a 12-inch machine-slotted area (0.010-inch slot size) covered by a pre-packed filter that consists of a metal mesh covering filled with coarse sand.

Each well point will be hammered to depth so that the top of the screens are at least 1 to 2 inches below the sediment surface. The outer and inner screens will be purged with a peristaltic pump to remove debris prior to collecting a sample. Surface water quality parameters will be measured in the water directly adjacent to the pore water sampling locations. Initial (pre-sampling) water quality parameters will be collected from the well point. Water quality parameters are expected to differ in the pore water and the surface water environments. This comparison will be used to verify that pore water samples do not consist of surface water drawn down through the shallow sediment during pumping. Water quality parameters will include temperature, pH, DO, total dissolved solids, SpC, ORP, and turbidity.

Each sample will be collected by using a peristaltic pump and polyethylene tubing to pull water from the sediment layer to the surface. A pore water sample will be collected from each well point for laboratory analysis of TCL VOCs. In addition, pre- and post-sampling water quality parameters will be collected.

A collocated surface water sample will be collected adjacent to each well point 6 inches beneath the top of the water level. Surface water samples will be collected from a decontaminated Widco Alpha water sampling device or equivalent. Surface water samples will also be sent for laboratory analysis of TCL VOCs. Pore water and surface water samples will be collected following SOP #17.

Each well point will be surveyed by the field team using a survey-grade handheld GPS unit.

Soil Gas Probe Installation and Sampling

Temporary soil gas probes will be installed by a direct-push technology (DPT) drill rig using the Geoprobe™ post-run tubing (PRT) method. Each temporary soil gas probe will be constructed with an expendable drive point, PRT point holder and adapter, and 1.25-inch-outer-diameter drive rods. Quarter-inch outer-diameter

Teflon tubing is connected to the PRT system to facilitate sample collection from the ground surface. The PRT system will be pushed by the DPT rig to an area just above the capillary fringe, approximately 17 feet bgs, and the probe will be retracted approximately 6 to 12 inches to create an annular space. Eight locations will be sampled at 2 depths in the same borehole to evaluate vertical soil gas profile. The sampling probe will be pushed initially to a shallow depth, a sample will be collected, and the probe will be pushed down to the deeper depth for sample collection in the same borehole. If an obstruction prevents the collection of the deeper sample, then an additional borehole will be offset approximately 5 feet and reattempted.

Each soil gas probe will be surveyed by the field team using a survey-grade handheld GPS unit.

Following installation of the temporary soil gas probes, each soil gas probe will be helium-leak checked and purged prior to sample collection. Soil gas samples will be collected in Tedlar bags and analyzed in the field with a HAPSITE GS/MS for six primary chlorinated VOC constituents. Confirmatory samples will be collected in Summa canisters equipped with flow controllers set at 200 milliliters per minute at 10 percent of the soil gas probe locations (8 samples). Soil gas samples will be sent for laboratory analysis under a chain of custody. Soil gas samples will be collected following the procedures in SOP #8.

Demobilization

Equipment and facilities will be demobilized from the site at the end of Phase 3. Efforts will be made to remove facilities and disconnect services concurrently. The project files will be removed from the field trailer, brought to the CH2M office in Dayton, Ohio, and organized.

IDW samples will be collected from the soil cuttings and combined purge, decontamination, and development water in order to characterize the waste for disposal. The samples will be sent to a subcontracted laboratory for analysis. Once the analytical results are received a waste characterization determination will be made and a waste profile will be created for client approval and signature. All IDW will be transported off-site and disposed of at an EPA Off-Site Rule-approved facility upon the waste profile approval. All IDW transportation will be performed with a uniform hazardous or non-hazardous waste manifest.

Analysis Tasks

CH2M's subcontracted laboratory, ALS Laboratories (ALS) will analyze the groundwater, pore water, surface water and soil samples for VOCs at their Holland, MI laboratory. A subset of groundwater samples for nitrate/nitrite, sulfate and chloride, total iron, sulfide, TOC, and alkalinity will also be analyzed at the ALS – Holland, MI facility. 1,4-dioxane in groundwater will be analyzed at the ALS - Kelso, WA facility and soil gas samples for VOCs will be analyzed at the ALS - Cincinnati, OH facility. ALS will also analyze

CH2M will operate a HAPSITE GC/MS in the field for the analysis of 6 VOC compounds.

The specific methods for the analyses are found in Worksheet #23.

Quality Control Tasks

SOPs will be implemented according to Worksheets #11, #12, #15, #22, #24, #25, #27, and #28 for items related to QC. QC samples are described in Worksheet #28.

Secondary Data

See QAPP Worksheet #13.

Data Management Tasks

The data will be tracked, stored, handled, and managed. Field activities will be recorded in project logbooks and on applicable field forms. Site maps will be maintained and sample locations will be updated on the maps as necessary. Field and analytical data will be consolidated and maintained within an electronic database management system. The database management system will be used to perform sample tracking, storage of electronic data, validation of data, querying data for analysis, and preparation of final data tables.

The following are the team members and their responsibilities for the data management process:

- **Project Chemist—**Responsible for reviewing the chain-of-custody and laboratory login forms daily and establishing the sample tracking system. Oversees proper use of EPA's sample management system (Scribe) and accuracy of the information entered. Reviews laboratory data for accuracy and quality and compares electronic outputs for accuracy to laboratory electronic copies. Conducts tracking of samples, forwards tracking information and received data to the database manager, and identifies the data inputs (for example, sample numbers) to use in generating tables and plots.
- **Database Manager—**Responsible for setting up the data management system in consultation with the project chemist at the beginning of the data evaluation task. Also oversees the data management process, including data conversion/manual entry into the data management system, QC of the entered data, preparation of the required tables and plots of the data, and prepares the Electronic Data Management and Analysis Network (EDMAN) EDDs. Coordinates with the person responsible for reviewing the entered data for QC purposes. Forwards deliverables to the site manager.

  Upon completion of the data validation, an EDMAN EDD shall be prepared and submitted to EPA by the CH2M Region 5 sample coordinator. Preparation and submittal of the EDMAN EDD shall include the population of the EDMAN tables, running the data checker, correcting deviations and data integrity conflicts, creating the site map in ".dxf" format, and preparation for transmittal.
- **GIS Manager—**Responsible for coordinating with the site manager to set up the geodatabase prior to sampling. Maintains spatial layers and overall geodatabase integrity and accuracy. Provides GIS-related outputs for reports.

Sample and Data Tracking

The project chemist is responsible for tracking samples in the sample-tracking database to ensure that the analytical results for samples sent for analysis are received. Copies of chains of custody from the field team are used to enter in sample identifications (IDs), collect data, and analyses. Upon receipt of a sample receipt notice from the laboratory, the date received by the laboratory, and a date the electronic copy is due will be entered. Likewise, upon receipt of the electronic copy and EDD, the date they were received will also be entered. The EDDs will be uploaded to the project database when received from the laboratory and will be tracked in the sample-tracking table. Validation qualifiers will be added to the database, and the results will be qualified accordingly.

Data Types

The data will be added to the project database as they become available. The data will include new data collected in the laboratory and validated by CH2M. Additionally, groundwater level data, relevant field data, soil gas data analyzed through HAPSITE GC/MS, and geospatial information will be included. Data sources will be noted in the database.

Survey data will be incorporated into the GIS database and maintained by SSPA.

Hard/Electronic Copy

Measurements made during field data collection activities will be recorded in field logbooks and sample processing logs. Field data will be reduced and summarized, tabulated, and stored along with the field logbooks and sample processing logs.

The raw analytical laboratory data are stored electronically.

Data Input Procedures

Sampling information, analytical results, applicable QA/QC data, data validation qualifiers, and other field-related information will be entered into the project database for storage and retrieval during data evaluation and report development. The analytical data will be loaded into the database using EDD files received from the analytical laboratory. Validation qualifiers will be applied to the dataset either electronically or manually. Other available field-related data collected will be manually entered onto standard EDD templates for loading into the database. Historical data, either in hard copy or electronic form, will be manually entered on or formatted to standard EDD templates for database loading.

Project Database

Sampling information, analytical results, applicable QA/QC data, data validation qualifiers, field-related information, and historical data will be entered into the project database for storage and retrieval during data evaluation and report development.

The data will be managed using EQuIS 6, a third-party database system by EarthSoft, Inc., that is used in EPA Region 5 to store and analyze project data submissions.

The database will be protected from unauthorized access, tampering, accidental deletions or additions, and data or program loss that can result from power outages or hardware failure. The following procedures will be adopted to ensure protection:

- The master database will be hosted by EarthSoft, Inc., on a network file server with Web access from a local server to the installation of the EQuIS data management system and access by EQuIS Enterprise Web interface. Members of the data management team involved in loading, modifying, or querying the database will be given access through EQuIS user accounts and passwords, as well as the appropriate network server permissions.
- EQuIS Enterprise provides users with a Web-based interface that allows for data reporting in standard formats. Where required, data exports from copies of the master database will be stored on the local area network for access by project staff through custom reporting tools developed to minimize possible database corruption by users. Whenever the master database is updated or modified, the data will be recopied exported to the local area network to ensure that the current copy data set is available to users.
- Daily backups of the master database and its copies will be made to ensure that the data will not be lost due to problems with the network. Each night, a daily differential backup will be performed by EarthSoft, Inc. Then, each week, a full backup will be completed by EarthSoft, Inc. The backups are stored on a SAN device located in Utah, and are then transferred to an offsite data center.

GIS Description

A project geodatabase will be setup prior to sampling and maintained by SSPA. An ArcView project or extension will be used providing the following functionality: load and display project site base maps, and display sampling station locations and associated sampling data (date, media, and results). Results will be shown as stations highlighted on the map.

The GIS manager will use Esri ArcGIS Desktop software to manage all project spatial data and for the production of figure deliverables. Standard File Geodatabase format will be used and configured based on client specifications and needs. A project coordinate system will be assigned accordingly as directed by the client.

Documentation and Records

Documentation of data management activities is critical because it provides the following:

- An electronic copy record of project data management activities
- Reference information critical for database users
- Evidence that the activities have been properly planned, executed, and verified
- Continuity of data management operations when personnel changes occur

The data management plan will serve as the initial general documentation of the project data management efforts. Additional documentation will be maintained to document specific issues such as database structure definitions, database inventories, database maintenance, user requests, database issues and problems, and client contact.

The final evidence file will be the central repository for documents that constitute evidence relevant to sampling and analysis activities. CH2M is the custodian of the evidence file and maintains the contents for the project. Project-related data, including field logs, field forms, chain-of-custody forms, correspondence, the final QAPP, and project reports will be maintained in hard copy and/or electronic format (PDF) at the CH2M Dayton, Ohio, office.

CH2M will keep records until project completion and closeout. As necessary, records may be transferred to an offsite records storage facility. The records storage facility must provide secure, controlled-access records storage. Records of raw analytical laboratory data, QA data, and reports will be kept by the laboratory for at least 5 years.

Records and field measurements of all samples will be collected in field books and scanned electronically. Chains of custody, air bills, and sample logs will be prepared and retained for each sample. Monitoring well location surveys will be obtained from the subcontractor and retained electronically. A copy of the final QAPP will be kept at the CH2M Milwaukee and Dayton offices.

Presentation of Study Data

Depending on data user needs, data presentation may consist of the following formats:

- Tabulated results of data summaries or raw data
- Figures showing groundwater elevations or concentration isopleths or location-specific concentrations
- Tables providing statistical evaluation
- Presentation tools, such as ARCINFO or similar analysis/presentation aids

In addition to laboratory data, other physical data will be collected during field efforts. The information will be stored in the project database. Other types of data elements may be added as the field investigation needs and activities evolve.

Assessment and Audit Tasks

See Worksheets #31, #32, and #33.

Data Review and Usability

The laboratory will make sure that the data are complete for all samples received. The data will be validated by CH2M using the National Functional Guidelines, laboratory SOPs, and this QAPP. A three-step data review process (consisting of verification, validation, and usability assessment) will be employed to examine the collected data so that only scientifically sound data of known and documented quality are used to make environmental decisions. Worksheets #34 (Data Verification and Validation Input) through #37 (Data Usability Assessment) describe the process and criteria in detail.

Analytical data obtained during the project will be validated by a qualified CH2M chemist according to the specifications provided in Worksheet #36 (Data Validation Procedures). Full documentation of the data validation process and the results will be provided in an attachment to the technical memorandum presenting the investigation results. Validated data and field logs will be reviewed to assess total measurement error and determine overall usability of the data for project purposes. Final data are placed in the database with qualifiers.

An electronic deliverable report of validated data will be provided to the EPA in the EDMAN format at the end of the project.

Documentation and Records

Records and field measurements of all samples will be collected in the field books and scanned electronically. Chains of custody, air bills, and sample logs will be prepared and retained for each sample. Survey information obtained from the subcontractor will be retained electronically. A copy of the final QAPP will be kept at the CH2M Milwaukee and Dayton offices.

A technical memorandum will be prepared to present the results following each phase of the RI. The technical memorandums will summarize the field investigation activities, analytical results, and deviations to the proposed field investigation. Preliminary results will be provided to EPA after each phase of the RI.

Depending on data user needs, data presentation may consist of the following formats:

- Tabulated results of data summaries or raw data
- Figures showing concentration isopleths or location-specific concentrations
- Draft field logs consisting of soil boring logs, well construction logs, and groundwater sampling logs.

Project Schedule

A detailed project schedule in Project format is provided in Attachment D. A list of major dates is provided below.

Activities	Organization	Dates		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
Site-specific Plans	CH2M	August 10, 2015	October 9, 2015	Site-specific plans	September 9, 2015
Field Investigation Phase 1	CH2M	March 7, 2016	March 30, 2016	Samples to laboratory	TBD
Data Validation	CH2M	Upon receipt of Phase 1 analytical data reports	21 days after receipt of final data	Data quality evaluation report	TBD
Field Investigation Phase 2	CH2M	April 11, 2016	April 25, 2016	Samples to laboratory	TBD
Data Validation		Upon receipt of Phase 2 analytical data reports	21 days after receipt of final data	Data quality evaluation report	TBD
Field Investigation Phase 3	CH2M	May 13, 2016	May 29, 2016	Samples to laboratory	TBD
Data Validation	CH2M	Upon receipt of Phase 3 analytical data reports	21 days after receipt of final data	Data quality evaluation report	TBD
Screening Level Human Health Risk Assessment (SLHHRA)/Screening Level Ecological Risk Assessment	CH2M	May 13, 2016	July 1, 2016	Final SLHHRA and Screening Level Ecological Risk Assessment	June 24, 2016
HHRA/ERA		July 1, 2016	August 5, 2016	Final HHRA and ERA	August 5, 2016
Draft RI Report	CH2M	March 21, 2016	August 5, 2016	Draft RI Report	August 5, 2016

TBD = to be determined

Worksheet #15-1—Project Action Limits and Laboratory-Specific Detection/Quantitation

Matrix: Aqueous

Analytical Group: TCL VOCs

Concentration Level: Trace

Analyte	CAS Number	Ecological Screening Level (µg/L)[a]	Ecological Screening Level Source	Human Health Screening Level[b] (µg/L)	Human Health Screening Level Source	Achievable Laboratory Limits	
						MDLs[h] (µg/L)	QLs (µg/L)
1,1,1-Trichloroethane	71-55-6	76	REG 5 ESLs	200	MCL	0.193	1.0
1,1,2,2-Tetrachloroethane	79-34-5	380	REG 5 ESLs	0.076	RSL	0.337	1.0
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	-	-	1,500	VISL	0.467	1.0
1,1,2-Trichloroethane	79-00-5	500	REG 5 ESLs	5	MCL	0.254	1.0
1,1-Dichloroethane	75-34-3	47	REG 5 ESLs	2.7	RSL	0.214	1.0
1,1-Dichloroethene	75-35-4	65	REG 5 ESLs	7	MCL	0.237	1.0
1,2,3-Trichlorobenzene	87-61-6	8	REG 3 FSBs	7	RSL	0.295	1.0
1,2,4-Trichlorobenzene	120-82-1	30	REG 5 ESLs	70	MCL	0.193	1.0
1,2-Dibromo-3-chloropropane	96-12-8	-	-	0.2	MCL	0.425	1.0
1,2-Dibromoethane	106-93-4	-	-	0.05	MCL	0.335	1.0
1,2-Dichlorobenzene	95-50-1	14	REG 5 ESLs	600	MCL	0.221	1.0
1,2-Dichloroethane	107-06-2	910	REG 5 ESLs	5	MCL	0.265	1.0
1,2-Dichloropropane	78-87-5	360	REG 5 ESLs	5	MCL	0.265	1.0
1,3-Dichlorobenzene[c]	541-73-1	38	REG 5 ESLs	75	MCL	0.210	1.0
1,4-Dichlorobenzene	106-46-7	9.4	REG 5 ESLs	75	MCL	0.204	1.0
2-Butanone	78-93-3	2,200	REG 5 ESLs	5,600	RSL	0.866	5.0
2-Hexanone	591-78-6	99	REG 5 ESLs	38	RSL	0.153	5.0
4-Methyl-2-pentanone	108-10-1	170	REG 5 ESLs	1,200	RSL	0.149	1.0
Acetone	67-64-1	1,700	REG 5 ESLs	14,000	RSL	3.112	10.0
Benzene	71-43-2	114	REG 5 ESLs	5	MCL	0.251	1.0
Bromochloromethane	74-97-5	-	-	83	RSL	0.245	1.0
Bromodichloromethane[d]	75-27-4	-	-	20	MCL	0.160	1.0
Bromoform[d]	75-25-2	230	REG 5 ESLs	20	MCL	0.099	1.0
Bromomethane	74-83-9	16	REG 5 ESLs	7.5	RSL	0.998	1.0
Carbon Disulfide	75-15-0	15	REG 5 ESLs	810	RSL	0.258	1.0
Carbon Tetrachloride	56-23-5	240	REG 5 ESLs	5	MCL	0.138	1.0

Matrix: Aqueous

Analytical Group: TCL VOCs

Concentration Level: Trace

Analyte	CAS Number	Ecological Screening Level (µg/L)[a]	Ecological Screening Level Source	Human Health Screening Level[b] (µg/L)	Human Health Screening Level Source	Achievable Laboratory Limits	
						MDLs[h] (µg/L)	QLs (µg/L)
Chlorobenzene	108-90-7	47	REG 5 ESLs	100	MCL	0.187	1.0
Chloroethane	75-00-3	-	-	21,000	RSL	0.211	1.0
Chloroform[d]	67-66-3	140	REG 5 ESLs	20	RSL	0.247	1.0
Chloromethane	74-87-3	-	-	190	RSL	0.254	1.0
cis-1,2-Dichloroethene	156-59-2	-	-	70	MCL	0.250	1.0
cis-1,3-Dichloropropene[e]	10061-01-5	-	-	0.47	RSL	0.238	1.0
Cyclohexane	110-82-7	-	-	1,000	VISL	0.308	1.0
Dibromochloromethane[d]	124-48-1	-	-	20	MCL	0.166	1.0
Dichlorodifluoromethane	75-71-8	-	-	7.4	VISL	0.407	1.0
Ethylbenzene	100-41-4	14	REG 5 ESLs	700	MCL	0.221	1.0
Isopropylbenzene	98-82-8	2.6	REG 3 FSBs	450	RSL	0.253	1.0
Methyl Acetate	79-20-9	-	-	20,000	RSL	0.623	2.0
Methyl tert-Butyl Ether	1634-04-4	11,070	REG 3 FSBs	14	RSL	0.118	1.0
Methylcyclohexane[f]	108-87-2	-	-	1,000	VISL	0.315	1.0
Methylene Chloride	75-09-2	940	REG 5 ESLs	5	MCL	0.636	5.0
Styrene	100-42-5	32	REG 5 ESLs	100	MCL	0.177	1.0
Tetrachloroethene	127-18-4	45	REG 5 ESLs	5	MCL	0.246	1.0
Toluene	108-88-3	253	REG 5 ESLs	1,000	MCL	0.197	1.0
trans-1,2-Dichloroethene	156-60-5	970	REG 5 ESLs	100	MCL	0.289	1.0
trans-1,3-Dichloropropene[g]	10061-02-6	-	-	0.47	RSL	0.189	1.0
Trichloroethene	79-01-6	47	REG 5 ESLs	5	MCL	0.345	1.0
Trichlorofluoromethane	75-69-4	-	-	184	VISL	0.386	1.0
Vinyl Chloride	75-01-4	930	REG 5 ESLs	2	MCL	0.190	1.0
Xylenes (Total)	1330-20-7	27	REG 5 ESLs	10,000	MCL	0.617	3.0

[a] Indiana water quality standards for aquatic life (CACs) were used; if not available, then EPA Region 5 ecological screening levels (REG 5 ESLs) were used. If REG 5 ESLs were not available, then EPA Region 3 freshwater screening benchmarks (REG 3 FSBs) were used.

[b] Screening Levels are the maximum contaminant level (MCL), where available, or the minimum value between the EPA Tap Water Regional Screening Level (RSL), and the EPA Vapor Intrusion Screening Level (VISL). Tap water RSLs are June 2015 values based on a target Excess Lifetime Cancer Risk (ELCR) = $1x10^{-6}$ and Hazard Index (HI) = 1; VISLs are June 2015 values based on EPA calculator, Version 3.4, a residential exposure scenario, a target ELCR = 1×10^{-6}, a target HI = 1, and a default groundwater temperature = 25 degrees Celsius. RSL values as referenced by (EPA 2015).

Matrix: Aqueous

Analytical Group: TCL VOCs

Concentration Level: Trace

Analyte	CAS Number	Ecological Screening Level (µg/L)[a]	Ecological Screening Level Source	Human Health Screening Level[b] (µg/L)	Human Health Screening Level Source	Achievable Laboratory Limits	
						MDLs[h] (µg/L)	QLs (µg/L)

[c] The RSL for 1,4-Dichlorobenzene was used as a surrogate for 1,3-Dichlorobenzene.

[d] The RSL for 1,3-Dichloropropene was used as a surrogate for cis-1,3-Dichloropropene.

[e] The MCL for total trihalomethanes (80 µg/l) was divided by the total number of trihalomethanes, thereby providing a screening level of 20 µg/l for each of the four related analytes.[f] The RSL for Cyclohexane was used as a surrogate for Methylcyclohexane.

[g] The RSL for 1,3-Dichloropropene was used as a surrogate for trans-1,3-Dichloropropene.

[h] The estimated MDLs are updated annually and are subject to change.

Indiana water quality standards for aquatic life, July 1996 (http://www.in.gov/legislative/iac/T03270/A00020.PDF)

REG 5 ESLs = EPA Region 5 ecological screening levels, August 2003 (http://epa.gov/region5/waste/cars/pdfs/ecological-screening-levels-200308.pdf)

REG 3 FSBs = EPA Region 3 freshwater screening benchmarks, December 2014 (http://www.epa.gov/reg3hscd/risk/eco/btag/sbv/fw/screenbench.htm)

µg/L = micrograms per liter; QL = quantitation limit; MDL = method detection limit

Shading represents cases where the screening levels are lower than the estimated laboratory method detection limit and/or quantitation limit. Refer to Worksheet #11, Section 11.4 for a discussion.

Worksheet #15-2—Project Action Limits and Laboratory-Specific Detection/Quantitation

Matrix: Soil

Analytical Group: TCL VOCs

Concentration Level: Low

Analyte	CAS Number	Ecological Screening Level (µg/kg)[a]	Human Health Screening Level[b] (µg/kg)	Human Health Screening Level Source	Achievable Laboratory Limits	
					MDLs[g] (µg/kg)	QLs (µg/kg)
1,1,1-Trichloroethane	71-55-6	29,800	70	MCL-SSL	0.153	5.0
1,1,2,2-Tetrachloroethane	79-34-5	127	0.03	RSL-SSL	0.115	5.0
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	-	140,000	RSL-SSL	0.181	5.0
1,1,2-Trichloroethane	79-00-5	28,600	1.6	MCL-SSL	0.616	5.0
1,1-Dichloroethane	75-34-3	20,100	0.78	RSL-SSL	0.132	5.0
1,1-Dichloroethene	75-35-4	8,280	2.5	MCL-SSL	0.172	5.0
1,2,3-Trichlorobenzene	87-61-6	-	21	RSL-SSL	0.251	5.0
1,2,4-Trichlorobenzene	120-82-1	11,100	200	MCL-SSL	0.136	5.0
1,2-Dibromo-3-chloropropane	96-12-8	35.2	0.086	MCL-SSL	0.521	5.0
1,2-Dibromoethane	106-93-4	1,230	0.014	MCL-SSL	0.154	5.0
1,2-Dichlorobenzene	95-50-1	2,960	580	MCL-SSL	0.088	5.0
1,2-Dichloroethane	107-06-2	21,200	1.4	MCL-SSL	0.154	5.0
1,2-Dichloropropane	78-87-5	32,700	1.7	MCL-SSL	0.356	5.0
1,3-Dichlorobenzene[c]	541-73-1	37,700	72	MCL-SSL	0.083	5.0
1,4-Dichlorobenzene	106-46-7	546	72	MCL-SSL	0.172	5.0
2-Butanone	78-93-3	89,600	1,200	RSL-SSL	0.848	10.0
2-Hexanone	591-78-6	12,600	8.8	RSL-SSL	0.667	5.0
4-Methyl-2-pentanone	108-10-1	443,000	280	RSL-SSL	0.185	5.0
Acetone	67-64-1	2,500	2,900	RSL-SSL	1.52	10.0
Benzene	71-43-2	255	2.6	RSL-SSL	0.097	5.0
Bromochloromethane	74-97-5	-	21	RSL-SSL	0.143	5.0
Bromodichloromethane	75-27-4	540	22	MCL-SSL	0.108	5.0
Bromoform	75-25-2	15,900	21	MCL-SSL	0.146	5.0
Bromomethane	74-83-9	235	1.9	RSL-SSL	0.307	10.0
Carbon Disulfide	75-15-0	94.1	240	RSL-SSL	0.190	5.0
Carbon Tetrachloride	56-23-5	2,980	1.9	MCL-SSL	0.239	5.0

Matrix: Soil

Analytical Group: TCL VOCs

Concentration Level: Low

Analyte	CAS Number	Ecological Screening Level (µg/kg)[a]	Human Health Screening Level[b] (µg/kg)	Human Health Screening Level Source	Achievable Laboratory Limits	
					MDLs[g] (µg/kg)	QLs (µg/kg)
Chlorobenzene	108-90-7	13,100	68	MCL-SSL	0.160	5.0
Chloroethane	75-00-3	-	5,900	RSL-SSL	0.524	5.0
Chloroform	67-66-3	1,190	22	MCL-SSL	0.201	5.0
Chloromethane	74-87-3	10,400	49	RSL-SSL	0.260	10.0
cis-1,2-Dichloroethene	156-59-2	-	21	MCL-SSL	0.120	5.0
cis-1,3-Dichloropropene[d]	10061-01-5	398	0.17	RSL-SSL	0.115	5.0
Cyclohexane	110-82-7	-	13,000	RSL-SSL	0.171	5.0
Dibromochloromethane	124-48-1	2,050	21	MCL-SSL	0.147	5.0
Dichlorodifluoromethane	75-71-8	39,500	300	RSL-SSL	0.252	10.0
Ethylbenzene	100-41-4	5,160	780	MCL-SSL	0.116	5.0
Isopropylbenzene	98-82-8	-	740	RSL-SSL	0.146	5.0
Methyl Acetate	79-20-9	-	4,100	RSL-SSL	0.451	10.0
Methyl tert-Butyl Ether	1634-04-4	-	3.2	RSL-SSL	0.185	5.0
Methylcyclohexane[e]	108-87-2	-	13,000	RSL-SSL	0.217	10.0
Methylene Chloride	75-09-2	4,050	1.3	MCL-SSL	0.137	5.0
Styrene	100-42-5	4,690	110	MCL-SSL	0.298	5.0
Tetrachloroethene	127-18-4	9,920	2.3	MCL-SSL	0.220	5.0
Toluene	108-88-3	5,450	690	MCL-SSL	0.125	5.0
trans-1,2-Dichloroethene	156-60-5	784	31	MCL-SSL	0.233	5.0
trans-1,3-Dichloropropene[f]	10061-02-6	398	0.17	RSL-SSL	0.163	10.0
Trichloroethene	79-01-6	12,400	1.8	MCL-SSL	0.191	5.0
Trichlorofluoromethane	75-69-4	16,400	730	RSL-SSL	0.271	5.0
Vinyl Chloride	75-01-4	646	0.69	MCL-SSL	0.166	5.0
Xylenes (Total)	1330-20-7	10,000	9,800	MCL-SSL	0.540	5.0

[a] EPA Region 5 ecological screening levels, August 2003 (http://epa.gov/region5/waste/cars/pdfs/ecological-screening-levels-200308.pdf)

[b] Screening Levels are the Maximum Contaminant Level-based Soil Screening Level (SSL) for the Protection of Groundwater (MCL-SSL), where available, or the minimum value between the Residential Soil Regional Screening Level (RSL) and the Tap Water RSL-based SSL for the Protection of Groundwater (RSL-SSL). RSLs are June 2015 values, based on a target ELCR = 1 x 10^{-6} and HI = 1.

[c] The RSL for 1,3-Dichloropropene was used as a surrogate for trans-1,3-Dichloropropene.

[d] The RSL for 1,3-Dichloropropene was used as a surrogate for cis-1,3-Dichloropropene.

[e] The RSL for Cyclohexane was used as a surrogate for Methylcyclohexane.

Matrix: Soil

Analytical Group: TCL VOCs

Concentration Level: Low

Analyte	CAS Number	Ecological Screening Level (µg/kg)[a]	Human Health Screening Level[b] (µg/kg)	Human Health Screening Level Source	Achievable Laboratory Limits	
					MDLs[g] (µg/kg)	QLs (µg/kg)

[f] The RSL for 1,3-Dichloropropene was used as a surrogate for trans-1,3-Dichloropropene.

[g] The estimated MDLs are updated annually and are subject to change.

mg/kg = milligram per kilogram; QL = quantitation limit; MDL = method detection limit

Shading represents cases where the screening levels are lower than the estimated laboratory method detection limit and/or quantitation limit. Refer to Worksheet #11, Section 11.4 for a discussion.

Worksheet #15-3—Project Action Limits and Laboratory-Specific Detection/Quantitation

Matrix: Soil Gas – Fixed Lab

Analytical Group: VOCs

Concentration Level: Low

Analyte	CAS Number	IDEM Soil Gas Screening Level Residential (µg/m³) [a]	IDEM Soil Gas Screening Level AF=0.1 Commercial / Industrial (µg/m³) [a]	IDEM Soil Gas Screening Level AF=0.01 Commercial / Industrial (µg/m³) [b]	Toxicity Basis	Residential VISL Screening Level (µg/m³) [c]	Commercial VISLs Screening Level (µg/m³)[c]	Toxicity Basis	Achievable Laboratory Limits MDLs[d] (µg/m³)	Achievable Laboratory Limits QLs (µg/m³)
1,1,1-Trichloroethane	71-55-6	52,000	220,000	2,200,000	NC	170,000	730,000	NC	0.17	0.50
1,1,2,2-Tetrachloroethane	79-34-5	4.8	21	210	C	1.6	7.0	C	0.15	0.50
1,1,2-Trichloroethane	79-00-5	2.1	8.8	88	NC	5.8	26	NC	0.16	0.50
1,1-Dichloroethane	75-34-3	180	770	7,700	C	58	260	C	0.16	0.50
1,1-Dichloroethene	75-35-4	2,100	8,800	88,000	NC	7,000	29,000	NC	0.17	0.50
1,2,4-Trichlorobenzene	120-82-1	21	88	880	NC	70	290	NC	0.16	0.50
1,2-Dibromoethane	106-93-4	0.47	2	20	C	0.16	0.68	C	0.16	0.50
1,2-Dichlorobenzene	95-50-1	2,100	8,800	88,000	NC	7,000	29,000	NC	0.15	0.50
1,2-Dichloroethane	107-06-2	11	47	470	C	3.6	160	C	0.16	0.50
1,2-Dichloropropane	78-87-5	28	120	1,200	C	9.4	41	C	0.16	0.50
1,3-Dichlorobenzene[e]	541-73-1	26	110	1,100	C	8.5	37	C	0.15	0.50
1,4-Dichlorobenzene	106-46-7	26	110	1,100	C	8.5	37	C	0.14	0.50
2-Butanone (methyl ethyl ketone)	78-93-3	52,000	220,000	2,200,000	NC	170,000	730,000	NC	0.21	5.0
2-Hexanone	591-78-6	310	1,300	13,000	NC	1,000	4,400	NC	0.16	0.50
4-Methyl-2-pentanone (Methyl isobutyl ketone)	108-10-1	31,000	130,000	1,300,000	NC	100,000	440,000	NC	0.16	0.50
Acetone	67-64-1	320,000	1,400,000	14,000,000	NC	1,100,000	4,500,000	NC	0.77	5.0

Matrix: Soil Gas – Fixed Lab

Analytical Group: VOCs

Concentration Level: Low

Analyte	CAS Number	IDEM Soil Gas Screening Level Residential (µg/m³) [a]	IDEM Soil Gas Screening Level AF=0.1 Commercial / Industrial (µg/m³) [a]	IDEM Soil Gas Screening Level AF=0.01 Commercial / Industrial (µg/m³) [b]	Toxicity Basis	Residential VISL Screening Level (µg/m³) [c]	Commercial VISLs Screening Level (µg/m³)[c]	Toxicity Basis	Achievable Laboratory Limits MDLs[d] (µg/m³)	Achievable Laboratory Limits QLs (µg/m³)
Benzene	71-43-2	36	160	1,600	C	12	52	C	0.16	0.50
Bromodichloromethane	75-27-4	7.6	33	330	C	2.5	11	C	0.15	0.50
Bromoform	75-25-2	260	1,100	11,000	C	85	370	C	0.15	0.50
Bromomethane (Methyl bromide)	74-83-9	52	220	2,200	NC	170	730	NC	0.19	0.50
Carbon disulfide	75-15-0	7,300	31,000	310,000	NC	24,000	100,000	NC	0.15	5.0
Carbon tetrachloride	56-23-5	47	200	2,000	C	16	68	C	0.15	0.50
Chlorobenzene	108-90-7	520	2,200	22,000	NC	1,700	7,300	NC	0.16	0.50
Chloroethane (Ethyl Chloride)	75-00-3	100,000	440,000	4,400,000	NC	350,000	1,500,000	NC	0.17	0.50
Chloroform (Trichloromethane)	67-66-3	12	53	530	C	4.1	18	C	0.17	0.50
Chloromethane (Methyl chloride)	74-87-3	940	3,900	39,000	NC	3,100	13,000	NC	0.15	0.50
cis-1,2-Dichloroethene	156-59-2	NA	NA	NA	C	NA	NA	C	0.16	0.50
cis-1,3-Dichloropropene[f]	10061-01-5	70	310	3,100	C	23	100	C	0.14	0.50
Cyclohexane	110-82-7	63,000	260,000	2,600,000	NC	210,000	880,000	NC	0.29	1.0
Dibromochloromethane	124-48-1	10	45	450	C	3.5	15	C	0.16	0.50
Dichlorodifluoromethane (CFC-12)	75-71-8	1,000	4,400	44,000	NC	3,500	15,000	NC	0.17	0.50
Ethylbenzene	100-41-4	110	490	4,900	C	37	160	C	0.16	0.50
m,p-Xylene[g]	179601-23-1	1,000	4,400	44,000	NC	3,500	15,000	NC	0.30	1.0
Methyl tert butyl ether	1634-04-4	1,100	4,700	47,000	C	360	1,600	C	0.17	0.50
Methylene chloride	75-09-2	6,300	26,000	260,000	NC	3,400	41,000	NC	0.17	0.50
o-Xylene	95-47-6	1,000	4,400	44,000	NC	3,500	15,000	NC	0.15	0.50

Matrix: Soil Gas – Fixed Lab

Analytical Group: VOCs

Concentration Level: Low

Analyte	CAS Number	IDEM Soil Gas Screening Level Residential (µg/m³) [a]	IDEM Soil Gas Screening Level AF=0.1 Commercial / Industrial (µg/m³) [a]	IDEM Soil Gas Screening Level AF=0.01 Commercial / Industrial (µg/m³) [b]	Toxicity Basis	Residential VISL Screening Level (µg/m³) [c]	Commercial VISLs Screening Level (µg/m³)[c]	Toxicity Basis	Achievable Laboratory Limits MDLs[d] (µg/m³)	Achievable Laboratory Limits QLs (µg/m³)
Styrene	100-42-5	10,000	44,000	440,000	NC	35,000	150,000	NC	0.15	0.50
Tetrachloroethene	127-18-4	420	1,800	18,000	NC	360	1,600	NC	0.14	0.50
Toluene	108-88-3	52,000	220,000	2,200,000	NC	170,000	730,000	NC	0.17	0.50
trans-1,2-Dichloroethene	156-60-5	NA	NA	NA	C	NA	NA	C	0.19	0.50
trans-1,3-Dichloropropene[h]	10061-02-6	70	310	3,100	C	23	100	C	0.16	0.50
Trichloroethene	79-01-6	21	88	880	NC	16	100	NC	0.14	0.50
Trichlorofluoromethane (CFC-11)	75-69-4	7,300	31,000	310,000	NC	24,000	100,000	NC	0.17	0.50
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	76-13-1	310,000	1,300,000	13,000,000	NC	1,000,000	4,400,000	NC	0.17	0.50
Vinyl chloride	75-01-4	17	280	2,800	C	5.6	93	C	0.17	0.50

[a] Values from the March 2012 IDEM Remediation Closure Guide. Screening levels calculated by applying a 0.1 soil gas attenuation factor to indoor air vapor exposure levels.

[b] Values from the March 2012 IDEM Remediation Closure Guide. Screening levels calculated by applying a 0.01 soil gas attenuation factor to indoor air vapor exposure levels. Justification for higher screening levels are evaluated at specific commercial or industrial buildings (Section 10.4 of the IDEM Remediation Closure Guide)

[c] Vapor Intrusion Screening Levels (VISLs) for residential and commercial scenarios, June 2015; based on a target ELCR = 1 x 10^{-6}, Hazard Index (HI) = 1, and default subslab to indoor air attenuation factor (AF) = 0.03.

[d] The estimated MDLs are updated annually and are subject to change.

[e] The RSL for 1,4-Dichlorobenzene was used as a surrogate for 1,3-Dichlorobenzene.

[f] The RSL for 1,3-Dichloropropene was used as a surrogate for cis-1,3-Dichloropropene.

[g] The RSL for m-Xylene was used as a surrogate for m,p-Xylene.

[h] The RSL for 1,3-Dichloropropene was used as a surrogate for trans-1,3-Dichloropropene.

µg/m³ = microgram per cubic meter; C = carcinogen; NA = not available; NC = non-carcinogen; MDL = method detection limit; QL = quantitation limit; TBD = to be determined

Worksheet #15-4—Project Action Limits and Laboratory-Specific Detection/Quantitation

Matrix: Soil Gas – Field Lab

Analytical Group: VOCs

Concentration Level: Low

Analyte	CAS Number	IDEM Soil Gas Screening Level Residential (µg/m³) [a]	IDEM Soil Gas Screening Level Commercial / Industrial (µg/m³) [a]	IDEM Soil Gas Screening Level Some Commercial / Industrial (µg/m³) [b]	Toxicity Basis	Residential VISL Screening Level (µg/m³) [c]	Commercial VISL Screening Level (µg/m³)[c]	Toxicity Basis	Achievable Laboratory Limits QLs (µg/m³)
1,1,1-Trichloroethane	71-55-6	52,000	220,000	2,200,000	NC	170,000	730,000	NC	2.8
cis-1,2-Dichloroethene	156-59-2	NA	NA	NA	C	NA	NA	C	2.0
Tetrachloroethene	127-18-4	420	1,800	18,000	NC	360	1,600	NC	3.5
trans-1,2-Dichloroethene	156-60-5	NA	NA	NA	C	NA	NA	C	2.0
Trichloroethene	79-01-6	21	88	880	NC	16	100	NC	2.8
Vinyl chloride	75-01-4	17	280	2,800	C	5.6	93	C	1.3

[a] Values from the March 2012 IDEM Remediation Closure Guide. Screening levels calculated by applying a 0.1 soil gas attenuation factor to indoor air vapor exposure levels.

[b] Values from the March 2012 IDEM Remediation Closure Guide. Screening levels calculated by applying a 0.01 soil gas attenuation factor to indoor air vapor exposure levels. Justification for higher screening levels are evaluated at specific commercial or industrial buildings (section 10.4 of the IDEM Remediation Closure Guide)

[c] VISL for residential and commercial scenarios, June 2015; based on a target ELCR = 1×10^{-6}, HI = 1, and a default subslab to indoor air AF = 0.03.

[d] The estimated MDLs are updated annually and are subject to change.

µg/m³ = microgram per cubic meter; C = carcinogen; NA = not available; NC = non-carcinogen; MDL = method detection limit; QL = quantitation limit; TBD = to be determined

Worksheet #15-5—Project Action Limits and Laboratory-Specific Detection/Quantitation

Matrix: Aqueous

Analytical Group: SVOC (1,4-Dioxane)

Concentration Level: Low

Analyte	CAS Number	Human Health Screening Level	Human Health Screening Level Source	Achievable Laboratory Limits	
				MDLs (µg/L)	QLs (µg/L)
1,4-Dioxane	123-91-1	0.46	RSL	0.016	0.040

µg/L = micrograms per liter; QL = quantitation limit; MDL = method detection limit

Worksheet #15-6—Project Action Limits and Laboratory-Specific Detection/Quantitation

Matrix: Aqueous

Analytical Group: Total Iron

Concentration Level: Low

			Achievable Laboratory Limits	
Analyte	**CAS Number**	**Project Action Limit**	**MDLs (µg/L)**	**QLs (µg/L)**
Iron	7439-89-6	NA	4.4	80

NA = not applicable, parameters will be used to evaluate natural attenuation and will not be screened against regulatory screening values.

µg/L = micrograms per liter; QL = quantitation limit; MDL = method detection limit

Worksheet #15-7—Project Action Limits and Laboratory-Specific Detection/Quantitation

Matrix: Aqueous

Analytical Group: General Chemistry

Concentration Level: Low

			Achievable Laboratory Limits	
Analyte	**CAS Number**	**Project Action Limit**	**MDLs (mg/L)**	**QLs (mg/L)**
Alkalinity	-	NA	1.431	2.0
Chloride	16887-00-6	NA	0.144	1.0
Nitrate	14797-55-8	NA	0.027	0.1
Nitrite	14979-65-0	NA	0.023	0.1
Sulfate	14808-79-8	NA	0.139	1.0
Sulfide	-	NA	0.436	1.0
Total Organic Carbon	-	NA	0.066	0.5

NA = not applicable, parameters will be used to evaluate natural attenuation and will not be screened against regulatory screening values.

mg/L = milligrams per liter; QL = quantitation limit; MDL = method detection limit

Worksheet #17—Sampling Design and Rationale

The overall RI consists of the following activities:

- Advancement of soil borings into the outwash sand and gravel aquifer underlying the site to collect lithological information along with soil and groundwater grab samples.
- Installation of permanent groundwater monitoring wells.
- Collection of groundwater samples from new and existing wells and private water supply wells.
- Groundwater elevation synoptic and aquifer slug tests to evaluate hydrogeologic conditions.
- Collection of pore water and surface water samples from within Fall Creek to evaluate the groundwater to surface water interaction and support the HHRA[1] and ERA.
- Collection of additional soil and soil gas samples to support HHRA and ERA.

RI activities will be completed over multiple phases of site work with data from each phase used to modify the sampling approach and sample locations of each subsequent phase. The EPA Scribe program will be used for field documentation of samples collected and for the generation of chains of custodies throughout the RI.

Drilling and sampling locations will be located in an urban setting throughout a mixed residential and commercial area as well as from within Fall Creek. Figure 2 shows the approximate location of subsurface drilling and sampling locations; however, the final location of Phase 1 borings may change due to access constraints. Phase 2 and Phase 3 sampling locations will be determined based on the results of each proceeding phase of site activity. Figure 2 is presented to provide an overview of Phase 1 site activities. Exact locations will be identified in consultation with EPA prior to each phase of site work.

Phase 1

The first phase of the RI will focus on developing lithological descriptions from soil borings and collecting subsurface soil and groundwater grab samples at six of the seven properties where previous releases are suspected. Soil samples will be collected from these properties for the purpose of identifying specific potential source locations and at up to 2 downgradient locations if potentially impacted soils are observed. Groundwater samples will also be collected at the potential source areas and at areas cross and downgradient to identify the gross horizontal and vertical extent of the VOC plume in groundwater in the outwash aquifer.

The soil borings installed during Phase 1 will be surveyed using a handheld submeter GPS device and the coordinates entered into a site-specific database. The soil borings installed during Phase 1 will be abandoned by filling the annular space with a neat cement, bentonite slurry, or bentonite pellets following Indiana requirements.

Lithological Classification

At six of the seven properties and at locations downgradient of the potential source areas, initial soil borings will be installed with a sonic drill rig to a depth immediately above bedrock, approximately 80 feet bgs. Continuous cores will be logged and screened with a PID by the project geologist to develop a better

[1] Pore water samples will not be used in the HHRA.

understanding of the subsurface lithology, identify the depth of the intermediate clay layer and interbedded sand lenses, and evaluate possible VOC impacts of soil to be sampled.

A total of 9 soil borings will be installed throughout the 6 properties and up to 6 soil borings will be installed in areas downgradient of the potential source areas. Observations made by the field geologist and along with PID readings will be used to establish sampling depths in additional borings installed in each area. The following table summarizes the areas where initial soil borings will be installed. The proposed location of the soil borings are identified in Figure 2.

	Soil Boring Locations	Number of Soil Borings for Lithological Descriptions
Tuchman Cleaners	Near former monitoring well MW-2I	1
	Near former recovery well RW-3	1
Thomas Caterers	Area of elevated concentrations described in historical documents	1
	Second area of elevated concentrations described in historical document	1
	Between the two areas of elevated concentrations	1
Vantage Point Cleaners	One boring near the center of the property	1
Purtee Plating	One boring near the center of the property	1
Lumberman Wholesale	One boring near the center of the property	1
Imperial Cleaners	One boring near the center of the property	1
Area Downgradient of Potential Source Properties	Downgradient from suspected source areas	6
	TOTAL	**15**

Note: Soil boring will be completed to the bottom of the deep aquifer zone prior to groundwater sampling, at a total depth of approximately 80 feet bgs

Collection of Soil Samples

Following initial soil screening and soil classification, soil borings will be installed at six of the seven properties for the purpose of collecting samples of potentially VOC-impacted soils and to collect groundwater grab samples (as discussed in the following section). Results of the soil samples will be used to determine if potential source areas have been identified and to assist in the collection of samples for the purpose of assessing risk during Phase 3.

A total of 18 soil borings will be installed by a sonic drill rig throughout the 6 properties and 20 additional soil borings will be installed at areas downgradient. Up to a total of 24 samples will be collected at six of the seven properties from soils with the greatest impact as evidenced by PID, visual, or olfactory for laboratory analysis of VOCs. Soil samples will be collected from the following generally defined intervals: the shallow aquifer zone between 0 and 25 feet bgs, the intermediate clay zone between 25 and 60 feet bgs, and the deep aquifer zone between 60 and 80 feet bgs. Up to 2 additional soil samples will be collected from soils downgradient of the six properties if potentially impacted soils are observed. The soil samples will be submitted to a subcontract laboratory and analyzed for TCL VOCs with a 3-day TAT.

The following table summarizes the number of soil borings installed for the purposes of collecting samples along with the number of soil samples areas to be collected at each area. The proposed location of the soil borings are identified in Figure 2.

Potential Source Property	Soil Boring Locations	Estimated Number of Sample Locations	Estimated Number of Soil Samples
Tuchman Cleaners	Near former monitoring well MW-2I	1	4
	Near former recovery well RW-3	1	4
	Northeast property line	1	* Sample location for groundwater gab sample only
Thomas Caterers	Area of elevated concentrations described in historical documents	1	2
	Second area of elevated concentrations described in historical document	1	2
	Between the two areas of elevated concentrations	1	2
Vantage Point Cleaners	A total of three locations around the property	3	2
Purtee Plating	A total of three locations around the property	3	2
Lumberman Wholesale	A total of three locations around the property	3	4
Imperial Cleaners	A total of three locations around the property	3	2
Downgradient of Properties	Downgradient from suspected source area	20	2
	TOTAL	**38**	**26**

Note: Total number of sample per location; generally includes shallow and deep, sometimes intermediate, and a fourth sample if indicated. Sample intervals subject to field screening to include PID, visual, and olfactory indicators

Groundwater Grab Sampling

Groundwater grab samples will be collected concurrently with the soil sampling activities to assess the gross horizontal and lateral extent of the groundwater plume. Groundwater grab samples will be collected from the same boreholes advanced for the collection soil samples as described in the previous section.

A total of 47 groundwater grab samples will be collected from six properties. At each of the 18 soil borings groundwater grab samples will be collected from the shallow and deep intervals. At 11 of these locations, an additional groundwater grab sample will be collected from the variable thickness sand layer found in the intermediate clay zone. This will provide both an aerial and vertical initial profile of the current groundwater plume in the outwash aquifer.

Six grab samples will be collected from the shallow and deep portions of the aquifer within the area immediately downgradient of the properties. Four additional samples will be collected from the intermediate interbedded sand layer at downgradient soil borings.

Each groundwater grab sample will be collected from a reusable, stainless-steel screen and will be considered screening-level data only. Samples will be submitted to the subcontracted laboratory for analysis of TCL-VOCs with a 3-day TAT.

The following table summarizes the portions of the aquifer and the number of groundwater grab samples to be collected at each area. The proposed location of the soil borings are identified in Figure 2.

Potential Source Property	Soil Boring Locations	Estimated Number of Sampling Locations	Sample Zones	Number of Groundwater Grab Samples
Tuchman Cleaners	Near former monitoring well MW-2I	1	S-I-D	3
	Near former recovery well RW-3	1	S-I-D	3
	Northeast property line	1	S-D	2
Thomas Caterers	Area of elevated concentrations described in historical documents	1	S-I-D	3
	Second area of elevated concentrations described in historical document	1	S-I-D	3
	Between the two areas of elevated concentrations	1	S-I-D	3
Vantage Point Cleaners		1	S-I-D	3
	A total of three locations around the property	2	S-D	2
Purtee Plating		1	S-I-D	3
	A total of three locations around the property	2	S-D	2
Lumberman Wholesale		1	S-I-D	3
	A total of three locations around the property	2	S-D	2
Imperial Cleaners		1	S-I-D	3
	A total of three locations around the property	2	S-D	2
Downgradient of Properties		6	S-I-D	6
	Downgradient from suspected source area	14	S-D	4
	TOTAL	38		47

Note: S = shallow aquifer including the vadose zone (0-25 feet bgs); I = intermediate aquifer inclusive of the clay zone (25 to 60 feet bgs); D = deep aquifer (60 to 80 feet bgs)
Groundwater samples are in each of the shallow and deep aquifer zone, and if indicated the third interval to include the intermediate zone

Initial Survey of Existing Monitoring Wells

Anecdotal evidence suggests that monitoring wells exist in the general area from previous investigations completed by IDEM, as well as sentry wells installed by the local drinking water authority. SSPA will attempt to obtain the location and construction information for wells in the investigation area, as well as well as useable residential drinking water wells to reduce the number of wells required to be installed throughout the RI. It is assumed that 40 existing monitoring wells will be identified and incorporated into the RI, along with 12 residential drinking wells prior to Phase 2. Existing monitoring wells will be resurveyed to a common datum. It is assumed that up to five of the pre-existing wells identified in Phase 1 will require re-development.

Phase 2

The purposes of Phase 2 are to install and sample permanent groundwater monitoring wells to define the extent of the groundwater plume to levels equal to or near MCLs characterize current hydrogeologic conditions, and collect samples to asses ecological and human health risk.

Monitoring Well Installation

Up to 20 monitoring wells will be installed for the purpose of delineating the groundwater plume in areas where the results of Phase 1 suggest potential gaps in the existing well network as determined during Phase 1. If additional existing wells are located in areas that would support the investigation, fewer monitoring wells would need to be installed for this RI.

The assumed 20 monitoring wells will be installed as 10 paired monitoring wells of one in the shallow aquifer (installed to approximately 25 feet) and one in the deep aquifer (installed approximately 75 feet bgs). Each well will be constructed of 2-inch-diameter, schedule 40 polyvinyl chloride and will be installed using a sonic drill rig. At each of the 10 deep borings, continuous cores will be logged and screened with a PID by the field geologist to develop a better understanding of the site geology and potential VOC impacts. All newly installed monitoring wells will be developed and then surveyed to the same coordinate system as the existing wells surveyed in Phase 1.

Borings in the suspected source areas and north of Fall Creek will be dual-cased across the thickness of the upper aquifer and approximately 10 feet into the intermediate clay to prevent vertical migration of contaminants.

Slug Testing

Hydraulic slug tests will be conducted in 5 monitoring wells screened at varying depths to determine the transmissivity and hydraulic conductivity of the aquifer. Pressure transducers will be installed in each well and set to record the pressure of the water column every few seconds during each evaluation. One falling head test (displacement of the water column from the slug) and one rising head test (recovery of the water column after slug removal) will be completed in each of the five wells. Upon completion of the slug tests hydraulic conductivity and transmissivity will be calculated for each well. Slug testing activities will be completed following SOP #16.

Groundwater Sampling / Residential Well Sampling

Following well installation activities a complete sitewide synoptic groundwater gauging event will take place to evaluate flow patterns of the aquifer. The synoptic gauging event will consist of gauging the 20 newly installed wells and the assumed 40 pre-existing wells.

To capture a complete, sitewide picture of the current groundwater plume, the newly installed wells and approximately 40 pre-existing wells, along with 12 residential drinking water wells, will be sampled. The residential water well samples will be collected directly from the taps and/or spigots of buildings. The exact properties to be sampled will be selected after reviewing the results of the phases 1 and 2 investigations and after receiving permission to access each property.

The groundwater samples will be submitted to the subcontracted laboratory for TCL VOC analysis with a 7-day TAT. Additionally, due to the historical use of 1,4-dioxane as a preservative of 1,1,1-TCA, 10 samples will be analyzed for SVOC 1,4-dioxane, also analyzed with a 7-day TAT. Twenty of the monitoring wells will also be analyzed for MNA parameters with a 7-day TAT including the following: nitrate/nitrite, sulfate and chloride, total iron, sulfide, TOC, and alkalinity. Water quality parameters (temperature, pH, DO, SpC, ORP, and turbidity) will be recorded in the field using a Horiba U-52 or equivalent and a HACH colorimeter will be used to analyze ferrous iron during sample collection.

Pore Water and Surface Water Sampling

Historical groundwater data indicate that VOCs are potentially migrating to Fall Creek at concentrations that may pose a risk to ecological receptors. As a result, the groundwater to surface water interface pathway will

be evaluated as part of the Phase 2 activities. Data from Phase I will be evaluated to identify up to 10 pore water sample locations within Fall Creek. Well points at up to 10 locations will be installed and subsequently a pore water sample and collocated surface water grab sample collected for TCL VOC analysis. Water quality parameters (temperature, pH, DO, SpC, ORP, and turbidity) will be recorded for pore water and surface water using a Horiba U-52 or equivalent. Pore water and surface water samples will be analyzed by a subcontracted laboratory with a 7-day TAT.

Phase 3

The main objective for Phase 3 of the RI is the collection of data to support the HHRA. Activities in Phase 3 will focus on the collection of soil gas data and soil samples at potential source areas.

Soil Gas Sampling

A soil gas investigation will be performed at the site to delineate site-related VOC concentrations in soil gas at potential source areas, primarily in the northern area of the site. The soil gas investigation will be conducted in accordance with the EPA OSWER *Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air* (EPA 2015), the *EPA Region 5 Vapor Intrusion Guidebook* (EPA 2010), EPA TRIAD guidance such as EPA 542-F-05-008 "*Use of Dynamic Work Strategies Under a Triad Approach for Site Assessment and Cleanup –Technology Bulletin*" (2005), and the IDEM *Remediation Closure Guide* (2012).

Available site information such as the location of potential VOC source areas, historical groundwater and soil VOC concentrations, and previous vapor intrusion sampling data will be used to identify the areas of interest with the greatest potential for vapor intrusion. Consideration will also be given to placing external soil gas points close to buildings of interest and each soil gas location and a description of each soil gas location will be documented. Soil gas sampling will be performed in these areas initially, and will continue stepping out from them until the extent of the area(s) where soil gas VOC concentrations exceed EPA VISL and IDEM soil gas screening levels is delineated. Temporary soil gas probes and real-time field analysis of soil gas will be used to expedite this process so that up to 80 locations can be sampled in a 2-week period.

Temporary soil gas probes will be installed using the Geoprobe post-run tubing method with a DPT rig in the City of Indianapolis right-of-way and applicable private properties based on the Phase 1 and Phase 2 soil and groundwater sampling. The probe screen depths will primarily be within a foot above the capillary fringe (approximately 17 feet bgs) to target the most conservative soil gas concentrations, assuming the VOC source is groundwater. Additionally, up to 8 of the 80 locations will be sampled at 2 depths in the same boring to evaluate the vertical soil gas profile.

Soil gas samples will be collected in Tedlar bags and analyzed in the field with a HAPSITE gas chromatograph/mass spectrometer for six primary constituents to include PCE, TCE, and four common degradation products. Confirmatory samples will be collected at 10 percent of the soil gas probe locations (8 samples) in Summa canisters equipped with flow controllers set at 200 milliliters per minute for analysis through the subcontracted laboratory VOCs with a 21-day TAT.

Source Soil Sampling

Potential source areas contributing to the concentrations of PCE, TCE, and/or their degradation products in groundwater will be tentatively identified through the evaluation of groundwater and soil sample analytical results from Phases 1 and 2. Five soil borings will be installed at six of the seven potential source area properties for the purpose of collecting surface and subsurface soil samples to be used for HHRA. It is assumed that 2 soil samples will be collected from each of the 30 soil borings in the vadose zone generally from 0 to 2 feet bgs and 2 to 10 feet. The location of the borings will be discussed with EPA at the

completion of Phase 1 and Phase 2. The soil samples will be submitted to the subcontracted laboratory and analyzed for VOCs with a 7-day TAT.

Equipment Decontamination

Equipment decontamination specifics are detailed in SOP #13. Nondisposable equipment used during each phase of fieldwork will be decontaminated by washing with a phosphate-free detergent (for example, Liquinox) followed by a water rinse prior to reuse.

Investigation-derived Waste Characterization and Disposal

IDW generated during the three phases of work will include soil, purge water, development water, decontamination water, and other miscellaneous contaminated debris (for example, plastic sheeting, gloves, tubing, etc.). Three waste streams, soil cuttings, aqueous wastes, and contaminated debris are anticipated for this site, and each waste stream will be separately containerized with like waste—soil and contaminated material (such as sheeting and sampling equipment) will be stored in roll-off boxes and IDW water will be stored in a frac tank. IDW will be transferred each day from the work areas to the IDW staging area and secured. IDW will be characterized and disposed of in accordance with local, state, and federal regulations, which will be specified in the site management plan. Soil samples will be collected and analyzed by the subcontracted laboratory for the following: toxicity characteristic leaching procedure (TCLP) VOCs, TCLP SVOCs, TCLP pesticides, polychlorinated biphenyl (PCBs), TCLP RCRA 8 metals, ignitability, and corrosivity. Aqueous samples will be collected and analyzed for the following: VOCs, SVOCs, pesticides, RCRA 8 metals, and corrosivity.

Worksheet #18—Sampling Locations and Methods

Note: The sample locations and rationale for the Phases 2 and 3 sampling events will be finalized following review of the data collected during each previous phase of site activities. CH2M will submit a brief data evaluation memorandum to EPA with figures outlining proposed locations, numbers, and depth based on evaluations of phase of site work. The locations, depths, and numbers of monitoring wells, soil borings, and soil probes to be installed will be evaluated and approved by EPA prior to field activities. This worksheet will be updated prior to each phase of the field investigation.

Sampling Location/ID Number	Matrix	Depth (feet below ground surface)	Analytical Group	Concentration Level	Number of Samples (identify field duplicates)	Sampling SOP Reference[a]	Rationale for Sampling Location
Phase 1—Lithological Classification							
Continuous VOC screening of soils at 15 soil borings	Soil	Top of ground surface to top of bedrock (approximately 0 to 80 feet bgs.	VOCs – Field screening of soils with a PID for VOCs.	Low	None	SOPs #1, #9, and #13	To determine soil and groundwater grab sampling depths during Phase 1
Phase 1—Collection of Soil Samples							
Soil samples from 38 soil borings	Soil	Sample intervals to be determined based on observations and PID readings. Soil samples to be collected generally from the following intervals: shallow (0 to 25 feet bgs), intermediate (25 to 60 feet bgs), and deep (60 to 80 feet bgs).	Soil—TCL VOCs	Trace to low	Soil – Up to 26 (3)	SOPs #1, #2, #9, #11, #12, and #13	To determine initial status of nature and extent of contamination in soils at the potential source areas and at properties downgradient
Phase 1—Groundwater Grab Samples							
Groundwater grab samples from 38 soil borings	Groundwater	Sample intervals to be determined based on observations and PID readings. Groundwater samples to be collected generally from the following intervals: shallow (0 to 25 feet bgs), intermediate (25 to 60 feet bgs), and deep (60 to 80 feet bgs).	Groundwater—TCL VOCs Groundwater quality parameters, including ORP, pH, SpC, turbidity, DO, and temperature, will be recorded during purging. In addition to groundwater quality parameters, flow rate and depth to water will be monitored.	Trace to low	Groundwater - 47 (5)	SOPs #7, #9, #11, #12, #13, #14	To determine initial status of nature and extent of contamination in groundwater at the potential source areas and at properties downgradient

Sampling Location/ID Number	Matrix	Depth (feet below ground surface)	Analytical Group	Concentration Level	Number of Samples (identify field duplicates)	Sampling SOP Reference[a]	Rationale for Sampling Location
Phase 2—Groundwater/Private Well Sampling							
Samples from up to 60 monitoring wells, including the following: • 40 assumed existing monitoring wells • 20 monitoring wells installed in Phase 2 • 12 water samples from residential wells	Groundwater	Mid-screen at each well. Well construction details will be summarized prior to the groundwater sampling event.	Groundwater—TCL VOCs SVOCS (1,4-dioxane only) MNA parameters including nitrate/nitrite, sulfate and chloride, total iron, sulfide, total organic carbon, and alkalinity. Ferrous iron will be measured in the field with a HACH Colorimeter. Groundwater quality parameters, including ORP, pH, SpC, turbidity, DO, and temperature, will be recorded during purging. In addition to groundwater quality parameters, flow rate and depth to water will be monitored.	Trace to low	- 72 (8) samples analyzed for TCL-VOCs - 10 (1) samples analyzed for 1,4-dioxane -20 (0) samples analyzed for MNA parameters	SOPs #4, #7, #9, #11, #12, #13, and #15	**To determine nature and extent of contamination in groundwater at the site and evaluate** MNA as a remedial option
Phase 2—Pore Water and Surface Water Sampling							
Samples from up to 10 pore water sampling points and 10 collocated surface water samples	Surface water	Pore water – 0- to 12-inch interval below top of sediment. Surface water – approximately 6 inches below top of water level.	Groundwater—TCL VOCs Water quality parameters, including ORP, dissolved total solids, pH, SpC, turbidity, DO, and temperature, will be recorded during purging.	Trace to low	- 20 (2) samples analyzed for TCL-VOCs	SOPs #9, #11, #12, #13, and #17	Results of Phase 1 will be used to identify up to 10 locations within Fall Creek for pore water/surface water sampling

Sampling Location/ID Number	Matrix	Depth (feet below ground surface)	Analytical Group	Concentration Level	Number of Samples (identify field duplicates)	Sampling SOP Reference[a]	Rationale for Sampling Location
Phase 3—Soil Gas Sampling							
Field analysis of up to 80 samples using HAPSITE GC/MS	Soil gas	80 samples collected primarily directly above the capillary fringe (approximately 17 feet bgs) Eight locations analyzed at two depths for vertical profiling; Shallow samples will be collected at basement depth and deep samples will be collected above the capillary fringe	Soil Gas—6 VOCs	Low	- 88 (0) samples for VOCs using HAPSITE GC/MS	SOPs #5, #9, #10, #13, and #18	Sample locations to be determined based on historical groundwater, soil, and soil gas results; Locations will step out to find the extent of exceedances Additional samples collected for vertical profiling of soil gas
Samples from up to 8 HAPSITE locations	Soil gas	8 samples collected primarily directly above the capillary fringe (approximately 17 feet bgs) to confirm the results of the HAPSITE	Soil Gas—TO-15 VOCs	Low	Soil Gas – Up to 8 (1)	SOPs #5, #8, #9, #10, and #13	Confirmatory soil gas sampling at a frequency of 10 percent
Phase 3—Soil Sampling							
Collect soil samples from up to 30 soil borings from potential source areas if identified	Soil	Soil samples will be collected from two depth intervals at each soil boring (approximately 0 to 2 feet bgs and 2 to 10 feet bgs).	Soil—TCL VOCs	Trace to low	Soil – Up to 60 (6)	SOPs #1, #2, #9, #11, #12, and #13	To characterize nature and extent of contamination in soil and assess risk at potential source areas
IDW Sampling							
IDW	Soil and Drill Cuttings	NA	TCLP VOCs, TCLP SVOCs, TCLP pesticides, total PCBs, TCLP RCRA metals, ignitability, and corrosivity	Low	2 (0)	SOPs #9, #11, #12, and #13	Waste characterization
IDW	Aqueous	NA	VOCs, SVOCs, pesticides, RCRA metals, and corrosivity	Low	2 (0)	SOPs #9, #11, #12, and #13	Waste characterization

[a] Specify the appropriate letter or number for the SOP table (Worksheet #21).

Worksheets #19 and #30—Analytical SOP Requirements Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method/SOP Reference[a]	Containers (number, size, and type)	Preservation Requirements	Maximum Holding Time (preparation/analysis)	Data Package Turnaround [b]
Environmental Samples							
Aqueous	VOCs	Trace	Lab SOP #1	3 x 40-mL glass vials	HCl to pH <2; 4 °C	14 days to analysis	21 days
Aqueous	1,4-Dioxane	Low	Lab SOP#3	2 x 1 L amber G-TLC	4 °C	14 days to analysis	21days
Aqueous	Total Iron	Low	Lab SOP #5	250-mL plastic	HNO_3 to pH < 2, 4 °C	180 days	21 days
Aqueous	Chloride, Sulfate, Nitrate/ Nitrite	Low	Lab SOP #4	2 x 250-mL glass vials	4 °C	28 days 48 hours (or 28 days) 28 days	21 days
Aqueous	Alkalinity	Low	Lab SOP #7	250-mL plastic	4 °C	14 days	21 days
Aqueous	Sulfide	Low	Lab SOP #6	500-mL glass	NaOH/ZnAc, 4 °C	7 days	21 days
Aqueous	TOC	Low	Lab SOP #7	2 x 40-mL amber glass	H_2SO_4 to pH < 2, 4 °C	28 days	21 days
Soil	VOCs	Low	Lab SOP #1	EnCore Samplers	Deionized water, 4 °C	48 hours to preservation, 14 days to analysis	21 days
Soil Gas	VOCs	Low	Field SOP #18	1-liter Tedlar Bag	None	24 hours	24 hours[c]
Soil Gas	VOCs	Low	Lab SOP #2	1-or 6-liter Summa Canister	None	30 days	21 days
Waste Characterization Samples							
IDW-Soil	TCLP VOCs	Low	Lab SOP #1 and #16	4-ounce or larger wide-mouth glass jar, no head space	4 °C	14 days to TCLP, 14 days to analysis	21 days
IDW-Soil	TCLP SVOCs, TCLP Pesticides, and Total PCBs	Low	Lab SOP #9, #10, #11, and #17	16-ounce or larger wide-mouth glass jar	4 °C	14 days to TCLP, 7 days to extract, 40 days to analysis	21 days
IDW-Soil	TCLP RCRA 8 Metals	Low	Lab SOP #5, #13 and #17	4-ounce or larger wide-mouth glass jar	4 °C	14 days to TCLP, 180 days to digest and analyze (28 days for mercury)	21 days

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method/SOP Reference[a]	Containers (number, size, and type)	Preservation Requirements	Maximum Holding Time (preparation/analysis)	Data Package Turnaround [b]
IDW-Soil	pH, Flashpoint	Low	Lab SOP #14 and #15	4-ounce or larger wide-mouth glass jar	4 °C	As soon as possible, 28 days	21 days
IDW-Aqueous	VOCs	Low	Lab SOP #1	3 x 40-mL glass vials	HCl to pH <2; 4 °C	14 days to analysis	21 days
IDW-Aqueous	SVOCs	Low	Lab SOP #9	2 x 1-L amber glass	4 °C	7 days to extraction/ 40 days to analysis	21 days
IDW-Aqueous	Pesticides	Low	Lab SOP #10	2 x 1-L amber glass	4 °C	7 days to extraction/ 40 days to analysis	21 days
IDW-Aqueous	RCRA 8 Metals	Low	Lab SOP #5 and #12	500-mL plastic	HNO_3 to pH < 2, 4 °C	180 days (mercury, 28 days)	21 days
IDW-Aqueous	pH	Low	Lab SOP #15	250-mL plastic	4 °C	As soon as possible, 28 days	21 days

[a] Specify the appropriate reference letter or number from the analytical SOPs table (Worksheet #23).

[b] Final data package TAT is 21 days. Three- to 7-day TATs for preliminary data are generally required for Phase 1 and Phase 3 data as described in this QAPP.

[c] Preliminary data within 24 hours. Full data package within 21 days of project completion.

Worksheet #20—Field Quality Control Summary

Field Duplicate Samples

Field duplicates are two field samples taken concurrently at the same location. They are intended to represent the same population and are taken through all steps of the sampling and analytical procedures in the same manner as the associated native sample. The samples are used to assess the precision of the entire data collection activity, including sampling, sample handling and storage, and site heterogeneity. The field duplicates are assigned a unique sample name and are collected in a separate container from the associated native sample. One field duplicate will be collected for every 10 field samples. During collection of the field duplicate samples of soil gas, two Summa canisters will be connected with a T-connector provided by the laboratory to allow for collection of the parent and duplicate sample at the same time.

Matrix Spike/Matrix Spike Duplicate Samples

Matrix spike (MS)/matrix spike duplicate (MSD) samples are an aliquot of the sample spiked with known concentrations of specific analytes. The spiking occurs before sample preparation and analysis at the laboratory. Samples will be collected in triplicate, and the additional volume used for MS/MSD analysis. An MS/MSD pair will be collected only for the soil and groundwater samples on a frequency of 1 MS/MSD for every 20 field samples. MS/MSD samples will not be collected for the soil gas sampling effort.

Field Blanks

Field blanks are collected to assess the potential introduction of contaminants from the surroundings by pouring deionized water directly into the sampling containers while out in normal field conditions. Field blanks, if deemed necessary, would be collected at a frequency of one per week. The field blank samples are analyzed for the same parameters as the field samples. Field blanks are not deemed necessary during this field effort because there are no concerns of contamination to the samples from the environment.

Equipment Blanks

Equipment blanks are collected to assess the potential introduction of contaminants from nondedicated equipment by pouring deionized water over the decontaminated equipment and then into the sampling containers. Equipment blank samples are collected at a frequency of one per 5- to 10-day shift for each type of nondedicated sampling equipment. The equipment blanks will be analyzed for the same parameters as the field samples.

Trip Blanks

Trip blanks will be used to assess the potential introduction of contaminants to VOC sample containers during field events and during shipment of empty bottles to the site and samples to the laboratory. The trip blank consists of a VOC sample vial filled at the laboratory with laboratory grade deionized water. It is transported to the site in the same manner as the other sampling containers, stored with the samples in the field, and then returned to the laboratory for analysis. One trip blank will be included in each sample cooler containing VOC samples.

Ambient Blanks

Ambient blanks are collected to assess ambient conditions with respect to the potential introduction of contaminants in soil gas. Ambient blanks, if deemed necessary, would be collected at a frequency of one per week. The ambient blank samples are analyzed for the same parameters as the field samples.

Worksheet #20—Field Quality Control Summary Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation SOP Reference[a]	Number of Samples	Number of FDs	Number of MS/MSDs	Number of FB/EB/TB [b]/AB	Total Number of Samples
Soil gas – fixed laboratory	VOCs	Low	Laboratory SOP #2	10	1	-	1 AB	12
Soil gas – field laboratory	VOCs	Low	Field SOP #18	88	0	-	-	-
Aqueous	TCL VOCs	Trace	Laboratory SOP #1 and #3	139	15	7/7	25 TB, 12 EB	190
	1,4-Dioxane			10	1	1/1	2 EB	14
Aqueous	Total iron, alkalinity, nitrate, nitrite, sulfate, chloride, sulfide, TOC	Low	Laboratory SOP #4 Laboratory SOP #5 Laboratory SOP #6 Laboratory SOP #7 Laboratory SOP #8	20			-	20
Soil	TCL VOCs	Low	Laboratory SOP #1	86	9	5/5	3 TB 1 EB	100 (soil) 4 (aqueous)
IDW-Soil	TCLP VOCs, TCLP SVOCs, TCLP pesticides, PCBs, TCLP metals, pH, and flashpoint	Low	Laboratory SOP #1 Laboratory SOP #9 Laboratory SOP #10 Laboratory SOP #11 Laboratory SOP #5 Laboratory SOP #13 Laboratory SOP #14 Laboratory SOP #15 Laboratory SOP #16 Laboratory SOP #17	6	-	-	-	6
IDW-Aqueous	VOCs, SVOCs, Pesticides, RCRA 8 metals, pH	Low	Laboratory SOP #1 Laboratory SOP #9 Laboratory SOP #10 Laboratory SOP #11 Laboratory SOP #5 Laboratory SOP #12 Laboratory SOP #14 Laboratory SOP #15	7	-	-	-	7

[a] Specify the appropriate reference letter or number from the analytical SOPs table (Worksheet #23).
[b] Assumes samples will be shipped daily
FD = field duplicate; MS/MSD = matrix spike/matrix spike duplicate; FB – field blank; EB = equipment blank; TB = trip blank; AB = ambient blank

Worksheet #21—Field Standard Operating Procedures

Reference Number	Title, Revision, Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Check if yes)	Comments
SOP #1	Soil Logging	CH2M	Logging Tools	☐	
SOP #2	Soil Sample Collection (Rotary Sonic Drilling)	CH2M	Rotary Sonic Drill Rig	☐	
SOP #3	Direct-Push Soil Sample Collection	CH2M	Direct-Push Drill Rig	☐	
SOP #4	Groundwater Monitoring Well Installation	CH2M	Rotary Sonic or Direct-Push Drill Rig	☐	
SOP #5	Installation of Temporary Soil Gas Sampling Probes	CH2M	Direct-Push Drill Rig, PRT Sampler	☐	
SOP #6	Well Development	CH2M	Surge Block, Well Pump	☐	
SOP #7	Low-Flow Groundwater Sample Collection	CH2M	Submersible pump, Flow Through Cell, Water Parameter Meter, Water Level Indicator	☐	
SOP #8	Collection of Soil Gas Samples from Temporary and Permanent Probes Using Canisters	CH2M	Canister, Flow Controller and Vacuum Gauge	☐	
SOP #9	Note-taking and Field Logbook	CH2M	Procedural Guidance	☐	
SOP #10	Utility Clearance for Intrusive Operations	CH2M	Procedural Guidance	☐	
SOP #11	Sample Handling and Chain-of-Custody Procedures	CH2M	Procedural Guidance	☐	
SOP #12	Packing and Shipping of Environmental Samples	CH2M	Procedural Guidance	☐	
SOP #13	Equipment Decontamination Procedures	CH2M	Procedural Guidance	☐	
SOP #14	Groundwater Grab Sample Collection	CH2M	Rotary Sonic Drill Rig, Reusable Stainless-Steel Screen, Well Pump	☐	

Reference Number	Title, Revision, Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Check if yes)	Comments
SOP #15	Private Well Groundwater Sampling Procedures	CH2M	Water Parameter Meter	☐	
SOP #16	Aquifer Slug Test	CH2M	Slug(s), Pressure Transucers, Water Level Indicator	☐	
SOP #17	Well Point Method Pore Water and Surface Water Sampling Procedures	CH2M	Well Point Apparatus, Water Parameter Meter, Water Pump, Water Level Indicator	☐	
SOP #18	Analytical Method For The Determination Of Volatile Organics In Soil Gas Using The HAPSITE Field GC/MS	CH2M	HAPSITE	☐	

Worksheet #22—Field Equipment Calibration, Maintenance, Testing, and Inspection

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[a]
PID	Calibrate with standards.	Model-specific, per manufacturer's recommendation.	Soil Screening, Air Monitoring	Daily	Model specific, per manufacturer's recommendation.	As needed per SOP.	Field Team Leader	Model- and manufacturer-specific
Combustible gas/oxygen/ hydrogen sulfide monitors	Calibrate with standards.	Model-specific, per manufacturer's recommendation.	Air Monitoring	Daily	Model specific, per manufacturer's recommendation.	As needed per SOP.	Field Team Leader	Model- and manufacturer-specific
Water level indicator or oil/water interface probe	Calibrate annually to determine the accuracy of the measurement.	Perform maintenance per manufacturer's instructions.	Measures depth-to-liquid and total well depth	Daily before use	± 0.01 foot	If meter fails to calibrate, do not use this meter.	Field Team Leader	Model- and manufacturer-specific
Multiprobe water quality meter	Calibrate with standards.	Model-specific, per manufacturer's recommendation.	PH, dissolved oxygen, ORP, temperature, conductivity, turbidity	Daily	Model specific, per manufacturer's recommendation.	As needed per SOP.	Field Team Leader	SOP #7, model- and manufacturer-specific
Helium detector	Bump Check with 10% helium gas (factory calibration only).	Charge batteries. Allow the batteries to totally discharge before recharging to prevent battery memory from occurring. Perform maintenance per manufacturer's instructions.	Leak check of subslab probe and tubing	Daily before use	±5% of bump check gas	If meter fails to calibrate correctly, do not use this meter.	Field Team Leader	SOP #8, model- and manufacturer-specific

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[a]
Hach Ferrous Iron Test Kit	None	Confirm reagents used are within expiration dates.	Field groundwater ferrous iron test	Daily before use	Reagents are within expiration dates	Replace expired reagents.	Field team member	None (see test kit instructions)
LandTec GEM 2000 landfill gas meter	Check fresh air levels to confirm they are within the typical range.	Perform maintenance per manufacturer's instructions.	Field screen soil gas for oxygen, carbon dioxide, and methane.	Daily before use	±5% of typical air concentrations	If meter fails to calibrate correctly, do not use this meter.	Field Team Leader	SOP #8, model- and manufacturer-specific
Purge Pump / Rotometer / Manifold	Calibrate Rotometer using Dry Cal	Perform maintenance per manufacturer's instructions; tighten connections daily.	Manifold leak check	Daily before use	No change in manifold vacuum for 30 seconds.	If leaks are indicated, tighten fittings. If manifold continues to leak or if rotometer fails to calibrate correctly, do not use equipment.	Field Team Leader	SOP #8
Pressure Transducer	Test transducer in bucket of water to determine if changes in depth are detected	Perform maintenance per manufacturer's instructions.	Field check to ensure unit is working prior to slug tests	Daily before use	The difference of the two real-times values should correlate directly with the distance the transducer was moved or the depth to which the transducer was submerged.	If transducer fails to calibrate correctly, do not use this meter.	Field Team Leader	SOP #16
HAPSITE gas chromatograph/mass spectrometer	Initial Calibration	NA	5 point initial calibration. Low point at or below reporting limit.	Prior to sample analysis	Percent RSD ≤ 30 or linear ≤0.995	Correct problem then repeat IC Curve	Field Chemist	

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[a]
	Calibration Check	NA	Midpoint of calibration curve	At the start and end of each day	70-130 percent	Perform maintenance and repeat test. If the system still fails the CCV, perform a new initial calibration. For closing CCV, flag data.	Field Chemist	
	Maintenance	As outlined in the manufacturer's instruction manual.	NA	Proper storage during inactive periods	NA	Follow procedure as outlined in the manufacturer's water quality meter instruction manual or contact vendor technical support.	Field Chemist	

[a] Refer to the project SOPs table (Worksheet #21).

CCV = continuing calibration verification

Worksheet #23—Analytical SOPs

Reference Number	Title, Revision, Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?
Laboratory SOP #1	Volatile Organic Compounds SW-846 Method 8260B/5030C/5035A	Definitive	VOCs (Groundwater, Surface Water , Pore Water, Private Wells, Soil, IDW)	GC/MS	ALS	☐
Laboratory SOP #2	Analysis of Volatile Organic Compounds in Ambient Air Using Polished Stainless Steel Passivated Caniters by EPA Method TO-15 for VAP Analysis	Definitive	VOCs (Soil Gas)	GC/MS	ALS	☐
Laboratory SOP #3	Semivolatile Organic Compounds by GC/MS Selective Ion Monitoring EPA Method 8270D SIM	Definitive	1,4-Dioxane (Groundwater)	GC/MS	ALS	☐
Laboratory SOP #4	Anions by Ion Chromatography SW846 9056A/EPA 300.0	Definitive	Chloride, Nitrate, Nitrite, Sulfate (Groundwater)	Ion Chromatograph	ALS	☐
Laboratory SOP #5	Metals by ICP-AES EPA 200.7 / SW-846 6010C	Definitive	Total Iron (Groundwater) and Metals (IDW)	ICP-AES	ALS	☐
Laboratory SOP #6	Total, Reactive, and Acid-Soluble Sulfide EPA 376.1/ SM 4500S2-F/ SW846 9034/ SW846 9030B/ SW846 7.3.4.2	Definitive	Sulfide (Groundwater)	Titration	ALS	☐
Laboratory SOP #7	Total Organic Carbon SW-846 9060/ SM 5310C /EPA 415.3	Definitive	TOC (Groundwater)	Carbonaceous Analyzer	ALS	☐
Laboratory SOP #8	Alkalinity SM 2320B/ SM 4500CO2 D	Definitive	Alkalinity (Groundwater)	Titration	ALS	☐
Laboratory SOP #9	Semi-Volatile Organic Compounds SW-846 Method 8270C/ 8270D/ EPA 625	Definitive	SVOCs (IDW))	GC/MS	ALS	☐
Laboratory SOP #10	Organochlorine Pesticides SW-846 Method 8081A	Definitive	Pesticides (IDW)	GC/ECD	ALS	☐
Laboratory SOP #11	Polychlorinated Biphenyls SW-846 8082/8082A	Definitive	Total PCBs (IDW)	GC/ECD	ALS	☐
Laboratory SOP #12	Mercury – Aqueous EPA 245.1/ SW846 7470A	Definitive	Mercury (IDW)	CVAA	ALS	☐
Laboratory SOP #13	Mercury – Solids SW846 7471A/B	Definitive	Mercury (IDW)	CVAA	ALS	☐
Laboratory SOP #14	Flash Point by Pensky-Martens Closed Cup ASTM D93-11	Definitive	Flashpoint (IDW)	Pensky-Martens tester & Thermometer	ALS	☐
Laboratory SOP #15	pH Measurement SM4500-H B/ EPA 150.1/ SW9040C/ SW9045D	Definitive	pH (IDW)	pH meter	ALS	☐

Reference Number	Title, Revision, Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?
Laboratory SOP #16	Toxicity Characteristic Leaching Procedure – Zero Headspace Extraction SW846 1311	-	IDW	-	ALS	☐
Laboratory SOP #17	Toxicity Characteristic Leaching Procedure – Non-Volatile Extraction SW846 1311	-	IDW	-	ALS	☐
Laboratory SOP #18	Sample Receipt)	-	All	-	ALS	☐

GC/MS = gas chromatograph/mass spectrometry, GC/ECD = gas chromatograph/electron capture detector, ICP-AES =inductively coupled plasma-atomic emission spectroscopy, CVAA = cold vapor atomic absorption

Worksheet #24—Analytical Instrument Calibration

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[a]
GC/MS (for VOCs in Soil Gas)	Initial Calibration (IC)	Instrument receipt, instrument change (new column, source cleaning, etc.), when continuing calibration verification (CCV) is out of criteria.	Five-point curve - The percent relative standard deviation (%RSD) for all analytes must be ≤ 30%, with at most two exceptions up to a limit of 40%.	Repeat calibration if criterion is not met.	Analyst	Laboratory SOP #1
	Initial Calibration Verification (ICV)	Once after each IC.	All analytes within 70 to 130 %R.	Correct problem, rerun ICV. If that fails, repeat IC.		
	CCV	Daily.	All project analytes within ± 30% of true value.	Correct problem, rerun CCV. If that fails, repeat IC.		
	BFB Tune	Every 24 hours.	Refer to method for specific ion criteria.	Retune and/or clean source.		
GC/MS (for VOCs)	IC	Instrument receipt, instrument change (new column, source cleaning, etc.), when CCV is out of criteria.	Five-point curve - The average RFs for system performance check compounds (SPCCs) must be ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachlorobenzene and ≥ 0.10 for chloromethane, 1,1-dichloroethane and bromoform. The %RSD for RFs for calibration check compounds (CCCs) must be ≤ 30%, and one option below must be met: Option 1) %RSD ≤ 15% for all other compounds. If not met: Option 2) Linear least squares regression: correlation coefficient (r) ≥ 0.995. Option 3) Non-linear regression: coefficient of determination (r^2) ≥ 0.99 (6 points for second order).	Repeat calibration if criterion is not met.	Analyst	Laboratory SOP #2
	ICV	Once after each IC.	All project analytes within ± 20% of true value.	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat IC.		

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[a]
	CCV	At the beginning of each 12-hour shift immediately after BFB tune.	(1) Average RF for SPCCs: VOCs ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachloroethane; ≥ 0.1 for chloromethane, bromoform and 1,1-dichloroethane. (2) %Difference/Drift for all target compounds and surrogates: VOCs ≤ 20%D (Note, D = Difference when using RFs, D = Drift when using least squares regression or non-linear calibration.)	Repeat IC and reanalyze all samples analyzed since the last successful calibration verification.		
	BFB Tune	Every 12 hours.	Refer to method for specific ion criteria.	Retune and/or clean source.		
	Retention time window position establishment	Once after each IC for each analyte and surrogate.	Position shall be set using the midpoint standard of the IC curve when IC is performed. On days when IC is not performed, the initial CCV is used.	N/A		
	Evaluation of relative retention times (RRT)	With each sample.	RRT of each target analyte within ± 0.06 RRT units.	Correct problem, then rerun IC. Flagging criteria are not appropriate.		
GC/MS (for SVOCs)	ICAL	Instrument receipt, instrument change (new column, source cleaning, etc.), when CCV is out of criteria.	Five-point curve - The average RF for SPCCs must be ≥ 0.050; The %RSD for RFs for CCCs must be <30%, and one option below must be met: Option (1) %RSD ≤ 15% for all other compounds. If not met: Option (2) Linear least squares regression: r ≥ 0.995. Option (3) Non-linear regression: r^2 ≥ 0.99 (6 points for second order).	Repeat calibration if criterion is not met.	Analyst	Laboratory SOP #5
	ICV	Once after each IC.	All analytes within ± 20% of the expected value.	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat IC.		

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[a]
	CCV	At the beginning of each 12-hour shift immediately after DFTPP tune.	(1) Average RF for SPCCs: SVOCs ≥ 0.050 (2) %Difference/Drift for all target compounds and surrogates: VOCs ≤ 20%D (Note, D = Difference when using RFs, D = Drift when using least squares regression or non-linear calibration.)	Repeat IC and reanalyze all samples analyzed since the last successful calibration verification.		
	DFTPP Tune	Every 12 hours.	Must meet the ion abundance criteria required by the method.	Retune and/or clean source.		
	Retention time window position establishment	Once after each IC for each analyte and surrogate.	Position shall be set using the midpoint standard of the ICAL curve when IC is performed. On days when IC is not performed, the initial CCV is used.	N/A		
	Evaluation of RRT	With each sample.	RRT of each target analyte within ± 0.06 RRT units.	Correct problem, then rerun IC. Flagging criteria are not appropriate.		
GC/ECD (for Pesticides)	ICAL	Instrument receipt, major instrument change, when CCV does not meet criteria.	Five-point curve - One of the options below: Option 1: RSD for each analyte ≤ 20%; Option 2: linear least squares regression: r ≥ 0.995; Option 3: non-linear regression: r^2 ≥ 0.99 (6 points shall be used for second order) Midpoint calibration of Toxaphene; if detected in sample, 6-point calibration is performed.	Repeat IC and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst	Laboratory SOP #6
	ICV	Immediately following IC.	All project analytes within ± 20% of expected value from the ICAL.	Correct problem, rerun ICV. If that fails, repeat IC.		
	CCV	After every 10 samples; If calibration curve previously analyzed, analyze daily before samples.	%D ≤ 20 for both the quantitation and confirmation columns.	Correct problem, then rerun calibration verification. If that fails, repeat IC. Reanalyze samples since last successful calibration verification.		
	Breakdown Check	At beginning of each 12 hour period.	Degradation <15% for both DDT and Endrin.	Correct problem, then repeat breakdown check.		

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[a]
GC/ECD (for Herbicides)	ICAL	Instrument receipt, major instrument change, when CCV does not meet criteria.	Six-point curve - One of the options below: Option 1: RSD for each analyte ≤ 20%; Option 2: linear least squares regression: r ≥ 0.995	Repeat IC and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst	Laboratory SOP #7
	ICV	Immediately following IC.	%D ≤ 15	Correct problem, rerun ICV. If that fails, repeat IC.		
	CCV	After every 10 samples; If calibration curve previously analyzed, analyze daily before samples.	%D ≤ 15	Correct problem, rerun CCV. If that fails, repeat IC.		
	Retention time window position establishment	With each sample.	RRT of each target analyte within ± 0.66 RRT units.	Correct problem, then rerun IC. Flagging criteria are not appropriate.		
GC/ECD (for PCBs	IC	Instrument receipt, major instrument change, when CCV does not meet criteria.	Six-point curve - One of the options below: Option 1: RSD for each analyte ≤ 20%; Option 2: linear least squares regression: r ≥ 0.995	Repeat IC and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst	Laboratory SOP #8
	ICV	Immediately following IC.	%D ≤ 20	Correct problem, rerun ICV. If that fails, repeat IC.		
	CCV	After every 10 samples; If calibration curve previously analyzed, analyze daily before samples.	%D ≤ 20	Correct problem, rerun CCV. If that fails, repeat IC.		
	Retention time window position establishment	Once after each IC for each analyte and surrogate.	Position shall be set using the midpoint standard of the IC curve when IC is performed. On days when IC is not performed, the initial CCV is used.	N/A		
ICAP (metals)	IC	Instrument receipt, major instrument change, when CCV does not meet criteria.	Minimum one high standard and a calibration blank for all analytes. If more than one calibration standard is used, correlation coefficient (r) ≥ 0.995 (r^2>0.990).	Correct problem, then repeat IC. Flagging criteria are not appropriate.		Laboratory SOP #4
	ICV	Once after each IC, prior to beginning a sample run.	All analytes within 90 to 110 %R.	Correct problem and verify second source standard.		

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[a]
				Rerun ICV. If that fails, correct problem and repeat IC. Flagging criteria are not appropriate.		
	CCV	After every 10 field samples and at the end of the analysis sequence.	All analytes within 90 to 110 %R.	Correct problem, rerun CCV. If that fails, then repeat IC. Reanalyze all samples since the last successful CCV.		
	Linear dynamic range or high-level check standard	Every 6 months	Within ±10% of true value.	N/A		
	Low-level calibration check standard	Daily, after 1-point IC.	Within ±20% of true value.	Correct problem, then reanalyze. Flagging criteria are not appropriate.		
	Calibration Blank	Before beginning a sample run, after every 10 samples, and at end of the analysis sequence.	No analytes detected > 3x MDL.	Correct problem. Reprepare and reanalyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed.		
	Interference check solutions (ICSs)	After beginning of the analytical run.	ICS-A: Absolute value of concentration for all non-spiked analytes < 2x LOQ ICS-AB: Within 20% of true value	Terminate analysis; locate and correct problem; reanalyze ICS, reanalyze all samples.		
CVAA (for mercury)	IC	Instrument receipt, major instrument change, at the start of each day.	Five-point curve. If more than one calibration standard is used, correlation coefficient (r) ≥ 0.995 (r^2>0.990).	Correct problem, then repeat IC. Flagging criteria are not appropriate.	Analyst	Laboratory SOP #9
	ICV	Once after each IC, prior to beginning a sample run.	All analytes within 80 to 120 %R.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat IC. Flagging criteria are not appropriate.		
	CCV	After every 10 field samples and at the end of the analysis sequence.	All analytes within 80-120 %R.	Correct problem, rerun CCV. If that fails, then repeat IC. Reanalyze all samples since the last successful CCV.		

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[a]
	Calibration Blank	Before beginning a sample run, after every 10 samples, and at end of the analysis sequence.	No analytes detected < LOQ.	Correct problem. Re-prep and reanalyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed.		

[a] Specify the appropriate reference letter or number from the Analytical SOP References table (Worksheet #23).

GC/ECD = gas chromatograph/electron capture detector, GC/MS = gas chromatograph/mass spectrometry, ICAP = inductively coupled argon plasma, CVAA = cold vapor atomic absorption, SPCC = system performance check compound, IC = initial calibration, ICV = initial calibration verification, CCV = continuing calibration verification, DFTPP = decafluorotriphenylphosphine, BFB = 4-bromoflurobenzene, %D = percent drift, RRT = relative retention time, %RSD = percent relative standard deviation, RF = response factor, CCC = calibration check compounds, ICS = interference check solution, LOQ = level of quantitation

Worksheet #25—Analytical Instrument and Equipment Maintenance, Testing, and Inspection

☑ Worksheet Not Applicable (State Reason)

The subcontract laboratory will keep all maintenance, testing, and inspection records on file at the laboratory. The instrument and equipment maintenance, testing, and inspection activities are documented per the SOPs listed in Worksheet #23. If requested, a reference attachment from the subcontract laboratory's quality manual will be included in the final QAPP once the laboratory has been procured.

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[a]

[a] Specify the appropriate reference letter or number from the analytical SOPs table (Worksheet #23).

Worksheets #26 and #27—Sample Handling, Custody, and Disposal

Sample Collection, Packaging, and Shipment
Sample Collection (Personnel/Organization): Field team leader/CH2M
Sample Packaging (Personnel/Organization): Field team leader/CH2M
Coordination of Shipment (Personnel/Organization): Field team leader/CH2M
Type of Shipment/Carrier: Federal Express Overnight
Sample Receipt and Analysis
Sample Receipt (Personnel/Organization): Laboratory
Sample Custody and Storage (Personnel/Organization): Laboratory
Sample Preparation (Personnel/Organization): Laboratory
Sample Determinative Analysis (Personnel/Organization): Laboratory
Sample Archiving
Field Sample Storage (No. of days from sample collection): See QAPP Worksheet #19 for allowable holding time
Sample Extract/Digestate Storage (No. of days from extraction/digestion): See QAPP Worksheet #19 for allowable holding time
Sample Disposal
Personnel/Organization: Laboratory
Number of Days from Analysis: The laboratory will retain samples for at least 90 days and sample extracts for at least 30 days, after submittal, pending the need for reanalysis.

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory)

Sample handling and chain-of-custody procedures will be performed in accordance with SOP #11, and packaging and shipping of environmental samples will be performed in accordance with SOP #12.

Sample coolers will be shipped to arrive at the laboratory the morning after sampling (priority overnight) or will be sent by a courier to arrive the same day. The laboratory will be notified of the sample shipment and the estimated date of arrival of the samples being delivered.

For the soil gas sampling, soil gas samples will be shipped in boxes provided by the laboratory and will be shipped for priority overnight delivery. Regulations for packaging, marking/labeling, and shipping of hazardous materials and wastes are promulgated by the U.S. Department of Transportation. Air carriers that transport hazardous materials, in particular Federal Express, require compliance with the current edition of the International Air Transport Association Dangerous Goods Regulations, which applies to shipment and transportation of hazardous materials by air carrier. Following current International Air Transport Association regulations will ensure compliance with U.S. Department of Transportation regulations.

Laboratory Sample Custody Procedures (receipt of samples, archiving, and disposal)

Laboratory sample custody procedures will be performed in accordance with the laboratory SOP. Upon sample receipt, the laboratory sample custodian will verify package seals, open the packages, check temperature blanks, record temperatures, verify sample integrity, and inspect contents against chain-of-custody forms. The project chemist will be contacted to seek resolution of any discrepancies between sample containers and chain-of-custody forms through contract-defined channels of communication. Once the shipment and chain-of-custody form are in agreement, the sample custodian will initiate an internal chain-of-custody form, as well as supply the laboratory task manager with a sample acknowledgement letter. When applicable, sample preservation will be checked and pH documented. If the sample temperatures are outside the required range, the laboratory will contact the project chemist as to the proper course of action. Soil gas sample canister vacuums will be checked upon receipt and the vacuum readings will be provided to the project chemist.

Samples will be logged in and assigned a unique laboratory number for each sample, and the number will be used by all laboratory personnel handling samples to ensure all sample information is captured. Analyses required will be specified by codes assigned to samples at login. Labels containing the laboratory sample number are generated and placed on sample bottles.

After the laboratory labels the samples, they will be moved to refrigerators where they will be maintained at 4 $\pm$ 2 degrees Celsius. Sample canisters for TO-15 analysis do not require refrigeration.

When the analyst is ready to prepare and/or analyze the sample(s), an appropriate member of the sample management department will locate the sample(s) in the locked refrigerator, sign and date the internal sample tracking form, and provide the sample(s) to the analyst. When the analyst is finished with the sample(s), unused portions will be returned to an appropriate member of the sample management department for replacement in a secure refrigerator. The analyst will sign and date internal chain-of-custody forms. In the event that entire samples are depleted during analysis, a notation of “sample depleted” or “entire sample used” will be written on the internal chain-of-custody forms.

Samples will be stored in designated secure, refrigerated storage areas. Samples and sample extracts will be maintained in a secure storage until disposal. No samples or extracts will be disposed of without prior written approval from an appropriate member of the project team. The sample custodian will note the sample disposal date in the sample ledger. The laboratory will dispose of samples in accordance with applicable regulations.

Documentation will be placed in a single, secured project file maintained by the laboratory project manager. The file will consist of the following components: agreements, correspondence, memorandums, notes, and data.

Reports (including QA reports) will be filed with correspondence. Analytical laboratory documentation, field data, and notes will be filed with the laboratory data. Filed materials may only be removed by authorized personnel on a temporary basis. The name of the person removing the file will be recorded. Laboratories will retain project files and data packages for 5 years, unless otherwise agreed.

Sample Identification Procedures

A sample numbering system will be used to identify each sample, including duplicate, field blank, and equipment blank samples. The sample number will be a unique identifier.

Each sample, regardless of analytical protocol, will also be assigned a CH2M site-specific identifier, which will contain a site- and sample-specific location identifier that indicates where the sample was obtained.

The sample number and station location identifier will be included on the sample tag, the traffic report, and the chain-of-custody record.

The site-specific identifier is based on the following system:

- **Site**—KC (Keystone Corridor).
- **Station Location**—The station location identifier is the unique name of the sampling location:
  - Soil gas "SG"
  - Soil "SO"
  - WS "water supply well"
  - Monitoring well "MW"
  - Groundwater grab "GW"
  - Pore Water "PW"
  - Surface Water "SW"

  Immediately following the sampling location type is the unique sampling location identifier three-digit number that indicates exactly where the sample was collected.

  - For previously installed monitoring wells located throughout the site, use a MW-"001" and go up in number for each well sampled. This will be done to avoid confusion over possible duplicate historical well IDs from multiple properties. A letter identifier "S" (for shallow), "I" (for intermediate), or "D" (for deep) will be added at the end of the sample ID to denote the screen position in the aquifer.
  - For new wells installed during this RI, start with "101" and go up in number and add S, I, or D for position in the aquifer.
  - For private wells, start with RW-001 and go up in number and add S, I, or D for position in the aquifer.
  - For groundwater grab samples, start with GW-001 and go up in number.
  - For locations analyzed through the HAPSITE method, start with HS-001.
  - For locations where soil gas samples are collected via a Summa canister, start with SG-001.
  - For soil samples start with SO-001.
- **Sample Depth**—For soil, groundwater gab, HAPSITE, Summa soil gas, and soil samples, the interval sampled will be added to the sample ID following the station location code. Sample depths will be designated with two digits for the top of the interval (rounded to the nearest foot bgs) and two digits for the bottom of the interval (rounded to the nearest foot bgs). The exact sample depth interval should recorded to the field book rounded to the nearest tenth of a foot.
- **Date**—Samples IDs will end with a six-digit date,
- **Soil Samples**—The soil interval sampled will be added to the sample ID between the station location and the date, with two digits for the top of the interval (rounded to the nearest foot bgs) and two digits for the bottom of the interval (rounded to the nearest foot bgs). The exact sample depth interval should recorded to the field book rounded to the nearest tenth of a foot.
- **QC Samples**—Blind field duplicates will be submitted for all sample media in the format "KC-SO-FD-001-11162015" for the first soil sample field duplicate for submitted on November 16, 2015. Field blanks will

have a “FB” identifier, trip blanks will have a “TB” identifier, and equipment blanks will have an “EB” identifier followed by the sample date. MS/MSDs are not identified in the station location identifier, but on the tag and the chain-of-custody form. QC samples will be sequentially numbered starting at “-001” for each day, and a record of those assigned will be kept in the field logbook and sample processing log.

- **IDW Samples**—Samples collected for the purpose of characterizing waste will be designated with a station location of “IDW”, followed by either a “SO” for soil or “WW” for wastewater, followed by a sequential three digit number noting the number of sample collected that day. The sample ID will also include a six-digit date, with two digits for the month, two digits for the day, and two digits for the year.

Examples

- KC-MW-005-I-100915 is a groundwater sample from an existing well location identified during the initial stages of the RI.
- KC-MW-113-D-102215 is a groundwater sample from new well location MW-113-D.
- KC-PW-015-S-92315 is a tap water sample from a privately owned water supply well.
- KC-GW-007-23-25-101315 is a groundwater grab sample collected from approximately 23 to 25 feet bgs.
- KC-HS-064-11-15-092915 is a HAPSITE field analysis sample collected from approximately 11 to 15 feet bgs.
- KC-SG-003-16-18-111515 is a soil gas sample collected from approximately 16 to 18 feet bgs.
- KC-SO-013-05-07-120915 is a soil sample collected from approximately 5 to 7 feet bgs.
- KC-GW-FD-003-120115 is the third groundwater grab field duplicate collected on December 1, 2015.
- KC-MW-TB-005-101815 is the fifth trip blank collected during groundwater sampling activities on October 1, 2015.

Chain-of-Custody Procedures

Chains of custody will include, at a minimum, laboratory contact information, client contact information, sample information, and relinquished by/received by information in accordance with the SOP. Sample information will include sample identification, date and time collected, number and type of containers, preservative information, analysis method, and comments. The chain of custody will also have the sampler’s name and signature. The chain of custody will link location of the sample from the field logbook and sample processing log through sample disposal by the laboratory. See Appendix A, SOP #11, Attachment 2, for an example of a chain-of-custody form. The laboratory will use the sample information to populate the laboratory database for each sample.

Worksheet #28-1—Analytical Quality Control and Corrective Action

Matrix: Aqueous

Analytical Group: TCL VOCs

Analytical Method/SOP Reference: Laboratory SOP #1

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)
Performance Check	Prior to IC, CC, and every 12 hours	Must meet method criteria	Retune instrument and verify.	Laboratory analyst	Sensitivity
Method Blank	1/Extraction Batch	All analytes < RL	Correct problem, then re-prepare and analyze MB and all samples processed with the contaminated blank.	Laboratory analyst	Accuracy/Bias
Matrix Spike/Matrix Spike Duplicate	1/20 Samples	Percent Recovery and RPD calculated according to the method	If the MS and/or MSD are outside of either accuracy or precision tolerances, flag MS/MSD results.	Laboratory analyst	Accuracy/Bias Precision
LCS	1/Extraction Batch	Percent Recovery calculated according to the method	Correct problem, then re-prepare and analyze the LCS and all samples in the affected analytical batch.	Laboratory analyst	Sensitivity
Internal Standard	Every sample, spiked sample, standard, and MB	Area within -50% to +100% of IC midpoint std.	Inspect mass spectrometer and GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning.	Laboratory analyst	Precision
Surrogate Spike (organics)	Every sample, spiked sample, standard, and MB	Recovery within limits stated in method	Re-extract and reanalyze sample.	Laboratory analyst	Accuracy/Bias

IC = initial calibration, CC = continuing calibration, MB = method blank, MS/MSD = matrix spike/matrix spike duplicate, LCS = laboratory control sample, RPD = relative percent difference, GC = gas chromatography

Worksheet #28-2—Analytical Quality Control and Corrective Action

Matrix: Soil

Analytical Group: TCL VOCs

Analytical Method/SOP Reference: Laboratory SOP #1

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)
Performance Check	Prior to IC, CC, and every 12 hours	Must meet method criteria	Retune instrument and verify.	Laboratory analyst	Sensitivity
Method Blank	1/Extraction Batch	All analytes < Reporting Limit	Correct problem, then re-prepare and analyze MB and all samples processed with the contaminated blank.	Laboratory analyst	Accuracy/Bias
Matrix Spike/Matrix Spike Duplicate	1/20 Samples	Percent Recovery and RPD calculated according to the method	If the MS and/or MSD are outside of either accuracy or precision tolerances, flag MS/MSD results.	Laboratory analyst	Accuracy/Bias Precision
LCS	1/Extraction Batch	Percent Recovery calculated according to the method	Correct problem, then re-prepare and analyze the LCS and all samples in the affected analytical batch.	Laboratory analyst	Sensitivity
Internal Standard	Every sample, spiked sample, standard, and MB	Area within -50% to +100% of IC midpoint std.	Inspect mass spectrometer and GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning.	Laboratory analyst	Precision
Surrogate Spike (organics)	Every sample, spiked sample, standard, and MB	Recovery within limits stated in method	Re-extract and reanalyze sample.	Laboratory analyst	Accuracy/Bias

IC = initial calibration, CC = continuing calibration, MB = method blank, MS/MSD = matrix spike/matrix spike duplicate, LCS = laboratory control sample, RPD = relative percent difference, GC = gas chromatography

Worksheet #28-3—Analytical Quality Control and Corrective Action

Matrix: Soil Gas

Analytical Group: VOCs

Analytical Method/SOP Reference: Laboratory SOP #2

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)
Performance Check	Prior to IC, CC, and every 24 hours	Must meet method criteria	Retune instrument and verify.	Laboratory analyst	Sensitivity
Method Blank	1/Extraction Batch or 1 per 24-hr tune	No target compound ≥ ½ Reporting Limit	Correct problem, then re-prepare and analyze MB and all samples processed with the contaminated blank.	Laboratory analyst	Accuracy/Bias
Laboratory Duplicate	1/20 Samples	Concentration of reported analytes are > 5 times the RL in either sample and RPD > 25%. One sample result < RL and a difference of ±times the RL.	If sufficient sample is available, reanalyze samples. Qualify data as needed.	Laboratory analyst	Precision
LCS	1/Extraction Batch or 1 per 24-hr tune	70-130% Recovery	Correct problem, then re-prepare and analyze the LCS and all samples in the affected analytical batch.	Laboratory analyst	Sensitivity
Internal Standard	Every sample, spiked sample, standard, and MB	Area within -50% to +100% of IC midpoint std.	Inspect mass spectrometer and GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning.	Laboratory analyst	Precision
Surrogate Spike	Every sample, spiked sample, standard, and MB	Recovery within limits stated in method	Correct the problem and reanalyze sample.	Laboratory analyst	Accuracy/Bias

IC = initial calibration, CC = continuing calibration, MB = method blank, MS/MSD = matrix spike/matrix spike duplicate, LCS = laboratory control sample, RPD = relative percent difference, GC = gas chromatography, RL = reporting limit

Worksheet #28-4—Analytical Quality Control and Corrective Action

Matrix: Aqueous

Analytical Group: SVOCs (1,4-Dioxane)

Analytical Method/SOP Reference: Laboratory SOP #5

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)
Performance Check	Prior to IC, CC, and every 12 hours	Must meet method criteria	Retune instrument and verify.	Laboratory analyst	Sensitivity
Method Blank	1/Extraction Batch	All analytes < RL	Correct problem, then re-prepare and analyze MB and all samples processed with the contaminated blank.	Laboratory analyst	Accuracy/Bias
Matrix Spike/Matrix Spike Duplicate	1/20 Samples	Percent Recovery and RPD calculated according to the method	If the MS and/or MSD are outside of either accuracy or precision tolerances, flag MS/MSD results.	Laboratory analyst	Accuracy/Bias Precision
LCS	1/Extraction Batch	Percent Recovery calculated according to the method	Correct problem, then re-prepare and analyze the LCS and all samples in the affected analytical batch.	Laboratory analyst	Sensitivity
Internal Standard	Every sample, spiked sample, standard, and MB	Area within -50% to +100% of IC midpoint std.	Inspect mass spectrometer and GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning.	Laboratory analyst	Precision
Surrogate Spike (organics)	Every sample, spiked sample, standard, and MB	Recovery within limits stated in method	Re-extract and reanalyze sample.	Laboratory analyst	Accuracy/Bias

IC = initial calibration, CC = continuing calibration, MB = method blank, MS/MSD = matrix spike/matrix spike duplicate, LCS = laboratory control sample, RPD = relative percent difference, GC = gas chromatography, SVOC = semivolatile organic compound

Worksheet #28-5—Analytical Quality Control and Corrective Action

Matrix: Aqueous

Analytical Group: Total Iron

Analytical Method/SOP Reference: Laboratory SOP #3

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)
Preparation Blank	1/Analytical Batch	All analytes < RL	Reanalyze preparation blank. If fails, analyze a calibration blank. Re-prepare/reanalyze analytical batch as appropriate.	Laboratory analyst	Accuracy/Bias
Matrix Spike/Matrix Spike Duplicate	1/20 Samples	35-125% Recovery and < 30%	If the MS and/or MSD are outside of either accuracy or precision tolerances, flag MS/MSD results.	Laboratory analyst	Accuracy/Bias Precision
Laboratory Duplicate	1/Analytical Batch	Concentration of reported analytes are > 5 times the reporting limit and RPD > 20%	None.	Laboratory analyst	Accuracy/Bias
LCS	1/Analytical Batch	% Recovery within ± 15% of true value	Correct problem, then re-prepare and analyze the LCS and all samples in the affected analytical batch.	Laboratory analyst	Sensitivity

ICP = inductively coupled plasma, MS/MSD = matrix spike/matrix spike duplicate, LCS = laboratory control sample, PDS = post digestion spike, RPD = relative percent difference

Worksheet #28-6—Analytical Quality Control and Corrective Action

Matrix: Aqueous

Analytical Group: General Chemistry[a]

Analytical Method/SOP Reference: Laboratory SOPs #4, #5, #6 and #7

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)
Method Blank	1/Preparation and Analytical Batch	< Reporting Limit	Correct problem, then re-prepare and analyze method blank and all samples processed with the contaminated blank.	Laboratory analyst	Accuracy/Bias
Matrix Spike/Matrix Spike Duplicate	1/20 Samples	35-125% Recovery and RPD < 30%	If the MS and/or MSD are outside of either accuracy or precision tolerances, flag MS/MSD results.	Laboratory analyst	Accuracy/Bias Precision
Laboratory Duplicate	1/Analytical Batch	Concentration of reported analytes are > 5 times the reporting limit and RPD > 20%. One sample result < RL and a difference of ±2 times the RL.	None.	Laboratory analyst	Accuracy/Bias
LCS	1/Analytical Batch	35-125% Recovery	Correct problem then re-prepare and analyze the LCS and all samples in the affected analytical batch.	Laboratory analyst	Sensitivity

[a] General chemistry for groundwater includes the following parameters: alkalinity, chloride, nitrate, nitrite, sulfate, sulfide, and total organic carbon.
LCS = laboratory control sample, RPD = relative percent difference, RL = reporting limit,
MS/MSD = matrix spike/matrix spike duplicate

Worksheet #29—Project Documents and Records

Sample Collection Documents and Records	Onsite Analysis Documents and Records	Offsite Analysis Documents and Records	Data Assessment Documents and Records	Other
Field Notes Boring Logs Scribe Database Chain-of-Custody Records Air Bills Custody Seals Telephone Logs Corrective Action Forms	Sample Receipt, Custody, and Tracking Records Equipment Calibration Logs Equipment Maintenance, Testing, and Inspection Logs Corrective Action Forms Reported Field Sample Results Telephone Logs Analysis Logs	Sample Receipt, Custody, and Tracking Records Narrative Standard Traceability Logs Equipment Calibration Logs Sample Preparation Logs Run Logs Equipment Maintenance, Testing, and Inspection Logs Corrective Action Forms Reported Field Sample Results Reported Results for Standards, QC Checks, and QC Samples Instrument Printout (raw data) for Field Samples, Standards, QC Checks, and QC Samples Data Package Completeness Checklists Extraction/Cleanup Records Raw Data (stored electronically) QA Review Records	Data Verification/Validation Reports Corrective Action Forms	Project database for analytical and field data Health and saftey briefing information Staff health and safety records

Electronic analytical data will be similar in format to that of the CLP laboratory. The laboratory data package will be organized such that the analytical results are reported on a per-analytical-batch basis, unless otherwise specified. In addition to the summary data deliverable, a full-supporting raw data deliverable package is required from the laboratory. All data will be provided electronically as a PDF file. CH2M will provide data copies to EPA.

An EDD is also required for all data. The laboratory will provide CH2M with an EDD in the current EQuIS format. The data will undergo QA reviews prior to being loaded to the project database. Delivery time for data from the laboratory will vary based on project-specific data use.

Sample Tracking Program

The EPA Scribe program will be used for field documentation and generation of chains of custody. Refer to EPA Office of Solid Waste and Emergency Response 9240.0-44, EPA 540-R-07-06 Contract Laboratory Program Guidance for Field Samplers, dated July 2007.

Project-specific Deliverables

Analytical data will be exported into a format consistent with the EDD format specified by EPA Region 5. Data will be submitted to EPA Region 5 in accordance with the requirements located here: http://www.epa.gov/region5superfund/edman/. Documentation and reports specified in this QAPP will be retained in Adobe PDF format.

Worksheets #31, #32, and #33—Assessments and Correction Action

Assessments:

Assessment Type	Frequency	Assessment Deliverable	Person(s) Responsible for Performing Assessment (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)	Projected Delivery Date(s)
Field progress report	Daily	Summarizing e-mail	TBD, field team leader, CH2M	Dave Reamer, Task Manager, CH2M Brett Fishwild, site manager, CH2M	Daily during field activities
Data review and verification	For all analytical delivery packages	E-mail of deficiencies	Heather Hodach, project chemist, CH2M	Laboratory QA manager	After arrival of data from the laboratory and during data verification activities
Data validation	Three total – One each after data are validated from each phase (phases 1, 2, and 3)	Data validation reports	Heather Hodach, project chemist, CH2M	Leslie Blake, work assignment manager, EPA	21 days after receipt of all analytical data from laboratory
Data evaluation	Three total - One each after data collected and validated from phases 1, 2, and 3	Interim Technical Memoranda	Brett Fishwild, site manager, CH2M	Leslie Blake, work assignment manager, EPA	45 days after receipt of validated data
Data evaluation	One, after completion of field investigations	RI Report	Brett Fishwild, site manager, CH2M	Leslie Blake, work assignment manager, EPA	45 days after receipt of validated data

Assessments and Corrective Action:

Assessment Type	Corrective Action Documentation	Person(s) Responsible for Identifying and Implementing Corrective Actions (Title and Organizational Affiliation)	Person(s) Responsible for Monitoring Effectiveness of Corrective Action (Title and Organizational Affiliation)	Timeframe for Corrective Action
Daily field documentation reviews	Documented in emails saved to the project folder and in field notes as applicable	Field team leader, CH2M and final review of forms by RI lead Dave Reamer.	Dave Reamer, RI Lead, CH2M Brett Fishwild, site manager, CH2M TBD, field team leader, CH2M	As soon as notification of corrective action is received
Data review and verification	Corrective action reports and/or updated case narratives and corrected data submissions	Heather Hodach, project chemist, CH2M Chad Stoike, Laboratory QA manager, ALS Gloval	Heather Hodach, project chemist, CH2M	3 to 5 business days

Worksheet #34—Data Verification and Validation Inputs

To ensure that scientifically sound data of known and documented quality are used in making environmental decisions, the following three-step data review will be performed. Step I (verification) will confirm that all specified activities involved in collecting and analyzing samples have been completed and documented and that the necessary records (objective evidence) are available to proceed to data validation. Step II (validation) will assess whether the sampling and analytical processes comply with the contract-specific and the QAPP-specific requirements. Step III (usability assessment) will determine whether the resulting data are suitable as a basis for the decision being made. Worksheets #34 to #37 describe the processes to be followed. Worksheet #34 establishes the procedures that will be followed to verify project data, including, but not limited to, sampling documents and analytical data package. The items subject to verification and validation are listed in the following table.

Item	Description	Verification (completeness)	Validation (conformance to specifications)
		Planning Documents/Records	
1	Approved QAPP	X	
2	Field SOPs	X	
3	Laboratory SOPs	X	
		Field Records	
4	Field logbooks	X	X
5	Sample processing logs	X	X
6	Boring logs	X	X
7	Chain-of-Custody and Shipping Forms	X	X
8	Field corrective action reports	X	X
		Analytical Data Package	
9	Cover sheet (laboratory identifying information)	X	X
10	Case narrative	X	X
11	Internal laboratory chain-of-custody	X	X
12	Sample receipt records	X	X
13	Sample chronology (that is, dates and times of receipt, preparation, and analysis)	X	X
14	RL/MDL establishment and verification	X	X
15	Standards traceability	X	X
16	Instrument calibration records	X	X
17	Definition of laboratory qualifiers	X	X
18	Results reporting forms	X	X
19	QC sample results	X	X
20	Corrective action reports	X	X
21	Electronic data deliverable	X	X

Worksheet #35—Data Verification Procedures

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Organization)
Field Notes	Verify that records are present and complete for each day of field activities. Verify boring logs. Verify that all planned samples including field QC samples were collected and that sample collection locations are documented. Verify that meteorological data were provided for each day of field activities. Verify that changes/exceptions are documented and were reported in accordance with requirements.	Internal	TBD, field quality manager, CH2M Brett Fishwild, site manager, CH2M
Chain-of-Custody and Shipping Forms	Verify the completeness of chain-of-custody records. Examine entries for consistency with the field logbook and sample processing log. Check that appropriate methods and sample preservation have been recorded. Verify that the required volume of sample has been collected and that sufficient sample volume is available for QC samples (for example, MS/MSD). Verify that all required signatures and dates are present. Check for transcription errors.	Internal/ External	TBD, field quality manager, CH2M Heather Hodach, project chemist, CH2M (TBD) Laboratory QA Manager
Laboratory Data	Verify that the laboratory deliverable contains all records specified in the QAPP. Check sample receipt records to ensure sample condition upon receipt was noted, and any missing/broken sample containers were noted and reported according to plan. Compare the data package with the chains of custody to verify that results were provided for all collected samples. Review the narrative to ensure all QC exceptions are described. Check for evidence that any required notifications were provided to project personnel as specified in the QAPP. Verify that necessary signatures and dates are present.	Internal	Heather Hodach, project chemist, CH2M
HAPSITE Data	Verify that the HAPSITE deliverable contains all records specified in the SOP.	Internal	Heather Hodach, project chemist, CH2M

Worksheet #36—Data Validation Procedures

Matrix	Analytical Group	Required Deliverable	Validation Percentage	Validation Criteria	Data Validator (title and organizational affiliation)
Aqueous, Soil and Soil Gas (fixed laboratory)	VOCs	Level IV Data Report and EQuIS-compatible EDD	100% Level III	EPA National Functional Guidelines, laboratory SOPs, and QAPP criteria	Heather Hodach project chemist, CH2M
Aqueous	SVOC (1,4-Dioxane)	Level IV Data Report and EQuIS-compatible EDD	100% Level III	EPA National Functional Guidelines, laboratory SOPs, and QAPP criteria	Heather Hodach project chemist, CH2M
Aqueous	Total Iron and General Chemistry parameters	Level IV Data Report and EQuIS-compatible EDD	100% Level II	EPA National Functional Guidelines, laboratory SOPs, and QAPP criteria	Heather Hodach project chemist, CH2M

Data Verification/Validation Scope Overview

The CH2M project chemist will perform level III data validation on 100 percent of the VOC analytical data (groundwater, soil, and soil gas), SVOC analytical data (groundwater) and level II data validation on 100 percent of the total iron (groundwater), and general chemistry results (groundwater and soil) in accordance with EPA's National Functional Guidelines, the site-specific QAPP, and laboratory SOPs.

Field Data Review

Field-generated information may include field logbooks, boring logs, sample chain-of-custody forms, shipping documents, sampling observations, sample labels, and other miscellaneous field observations. All field measurements and or field log information will be entered into field logbooks and reviewed daily by the field quality manager or designee. The designee may be a qualified field geologist, engineer, environmental scientist, and/or technician.

Laboratory Data Review Requirements

All analytical data generated by the laboratory will be verified before submittal to the CH2M project chemist. The internal data review process, which is multi-tiered, will include all aspects of data generation, reduction, and QC assessment. In each laboratory analytical section, the analyst performing the tests shall review 100 percent of the definitive data. After the analyst's review has been completed, 100 percent of the data will be reviewed independently by a senior analyst or by the supervisor of the respective analytical section using the same criteria.

Elements for review or verification at each level must include, but not be restricted to, the following:

- Sample receipt procedures and conditions
- Sample preparation
- Appropriate SOPs and analytical methodologies
- Accuracy and completeness of analytical results
- Correct interpretation of all raw data, including all manual integrations
- Appropriate application of QC samples and compliance with established control limits

- Documentation completeness (for example, all anomalies in the preparation and analysis have been identified, appropriate corrective actions have been taken and documented in the case narrative[s], associated data have been appropriately qualified, and anomaly forms are complete)
- Accuracy and completeness of data deliverables (electronic)

Laboratory Data Evaluation

The calibration, QC, corrective actions, and flagging requirements for definitive data are shown in Worksheets #12, #15, #24, and #28. The laboratory may apply data qualifiers based on their review or add a note in the laboratory case narrative. The definitions of any data qualifiers applied by the laboratory must be defined in the case narrative. The data qualifiers are reviewed by the supervisor of the respective analytical sections after the first and second level reviews of the laboratory data have been performed.

Data Review Guidelines

The laboratory assessment of the data quality will be reviewed for completeness and accuracy. Data review will be performed by a combination of electronic and manual methods and will include, but is not limited to, the following:

- Sampling documentation (such as the chain-of-custody form)
- Preservation summary and technical holding times
- Presence of all analyses and analytes requested
- Use of the required sample preparation and analysis procedures
- The method detection and reporting limits will be evaluated against the project requirements
- The correctness of the concentration units
- Case narrative

Data Verification/Validation Guidelines

The data verification process builds on data review. Project data will be reviewed and verified as part of the data assessment for this project. The review will be performed on an analytical batch basis by assessing QC samples and associated field sample results. Data verification guidelines have been developed in accordance with the method requirements, professional judgment, and general EPA National Functional Guidelines.

Summary data review and verification will be performed as follows:

- Chain-of-custody documentation
- Holding time
- QC sample frequencies
- Method and field blanks
- Laboratory control samples
- Surrogate spikes
- MS/MSD
- Initial and continuing calibration information
- Field duplicate precision
- Case narrative review and other method-specific criteria

The verification/validation process will be performed by a combination of electronic and manual methods and includes data flagging for issues related to method blanks, laboratory control samples, MS/MSD samples, field duplicates, surrogate recoveries, holding time, and reconciliation of dilutions and

re-extractions. Data flags, as well as the reason for each flag, are entered into an electronic database and made available to the data users. The Data Qualification Manager User Manual for EQuIS 6 is provided in Appendix C. A final flag is applied to the data by the CH2M project chemist after evaluating all flags entered into the database and selecting the most conservative of the verification flags.

If, during the data review and verification process, a systematic problem or other major issue with the data is identified, the CH2M project chemist will contact the laboratory's project manager or QA manager. Additional evaluation of the data may be performed including an in-depth review of the raw data to verify accuracy followed by analysis and interpretation of the data in the context of the project objectives and end-use as part of the usability assessment.

A data validation report will be prepared summarizing the findings and discussing their impact on the overall data usability. It will be incorporated into the final data evaluation summary report.

Flagging Conventions

CH2M-specific final data qualifier definitions are summarized in Table 36-1.

Table 36-1. Verification/Validation Data Qualifiers

Qualifier	Description
R	The data are unusable. The sample results are rejected due to serious deficiencies in meeting QC criteria. The analyte may or may not be present in the sample.
J	The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the action limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

Table 36-2 presents the general data validation guidelines with consideration to the EPA National Functional Guidelines to be used by CH2M for applying the data qualifiers.

Table 36-2. Data Qualifying Conventions—General

QC Requirement	Criteria	Flag	Flag Applied To
Holding Time	Time exceeded for extraction or analysis by a factor of 2 or more	J for positive results; R or UJ for nondetects*	All analytes in the sample
Sample Preservation	Sample not preserved (if sample preservation was not done in the field but was performed at the laboratory upon sample receipt, no flagging is required)	J for positive results; R or UJ for nondetects*	Sample
	Temperature out of control	J for positive results; UJ for nondetects*; R based on professional judgment	Sample
Sample Integrity (SW8260)	Bubbles in VOA vial greater than 4 millimeters (pea size) used for analysis	J for the positive results; UJ for nondetects; R based on professional judgment	Sample

Table 36-2. Data Qualifying Conventions—General

QC Requirement	Criteria	Flag	Flag Applied To
Instrument Tuning	Mass assignment error or Ion abundance method-specific criteria not met	R for all results, if critical ions involved, use judgment otherwise	All associated samples in analytical batch
Initial Calibration	All analytes must be within method specified criteria	J for positive results; UJ for nondetects; R based on professional judgment	All associated samples in analytical batch
Second Source Check or Continuing Calibration	All analytes must be within method specified criteria	High Bias: J for positive results, no flag for nondetects Low Bias: J for positive results, UJ for nondetects J positive/R all nondetects greater than twice the control criteria	All associated samples in analytical batch
Low-level Calibration Check or Interference Check Sample (SW6010 Only)	All analytes must be within 20% of expected value	High Bias: J positive results, no flag for nondetects Low Bias: J positive results, UJ nondetects J positive/R all nondetects greater than twice the control criteria	All associated samples in analytical batch
Internal Standards	Area greater than UCL Area less than LCL Sample is re-extracted and reanalyzed and recovery outside of criteria is confirmed as a matrix effect	J for positive results J for the positive results; UJ for the nondetects If area is too low based on professional judgment, UJ or R nondetects	Sample
Surrogates	%R greater than UCL %R less than LCL and greater than 10% %R less than 10% Excessive dilution	J for positive results J for positive results; UJ for nondetects J for positive results; R for nondetects No flag required	Sample
LCS	%R greater than UCL %R less than LCL and greater than 10% %R less than LCL and less than 10%	J for the positive results; J for the positive results; UJ for the nondetects J for the positive results; R for the nondetects	The specific analyte(s) in all samples in the associated analytical batch
Blanks (Method, Field, Equipment, Trip or Calibration)	Analyte(s) detected (use the blank of the highest concentration)	UB for positive sample results ≤ 5x highest blank concentration (10x for common laboratory contaminants)	All samples in preparation, field or analytical batch, whichever one applies
Field duplicates or Laboratory Duplicates	RPD > 30% RPD > 20%	J for positive results, no flag for nondetects	The specific analyte(s) in the associated sample Note: No flagging is required for results less than the reporting limit

Table 36-2. Data Qualifying Conventions—General

QC Requirement	Criteria	Flag	Flag Applied To
Confirmation (Split samples)	RPD > 50%	J for positive results, no flag for nondetects	The specific analyte(s) in the associated sample Note: No flagging is required for results less than the reporting limit
MS/MSD and Post-digestion Spikes	%R greater than UCL	J for positive results	The specific analyte(s) in the parent sample
	%R less than LCL and >10%	J for positive results; UJ for nondetects	
	%R less than 10% or MS/MSD RPD > 30%	J for positive results; R for nondetects	
		J for positive results	
	Sample concentration > 4 times the spike concentration	No flag required	
	Excessive dilution*	No flag required	
Serial Dilution (SW6010 Only)	All analytes must be within 10% of expected value	J positive results, UJ nondetects	The specific analyte(s) in the parent sample
	Sample concentration < 50× MDL	No flag required	
Retention Time Window	Analyte within established window	R for all results	Sample
Canister Pressure (not applicable to Grab Samples) Initial vacuum should be 28 inches Hg (30 inches fully evacuated)	If Initial pressure 24 to 26 inches Hg	J for positive results; UJ for nondetects	Sample
	If < 24 inches of Hg—Reject all data if used	R for all results	Sample
	If final pressure >10 <20 inches Hg—sampling time may be extended if DQOs allow or the laboratory will dilute the sample	No Flag required	Sample
Final vacuum should be between 2 and 10 inches Hg (5 inches ideal)	If Final pressure > 20 inches Hg: Slight change (20 to 27 inches)	J for positive results; UJ for nondetects	Sample
	No change in pressure	Apply R to all data	Sample
Canister/Flow controller Certification (Individual)	Analyte(s) detected greater than RL	UB for positive sample results ≤ 5x blank concentration (10× for common laboratory contaminants)	Sample

* Based on analyte-specific review

%R = percent recovery, LCL = lower confidence limit, LCS = laboratory control sample, MS = matrix spike, MSD = matrix spike duplicate, UCL = upper confidence limit

Worksheet #37—Data Usability Assessment

The data usability assessment is an evaluation based on the results of data verification and validation in the context of the overall project decisions or objectives. The assessment determines whether project execution and resulting data meet the project DQOs. Both the sampling and analytical activities must be considered, with the ultimate goal of assessing whether the final, qualified results support the decisions to be made with the data.

The following subsections summarize the processes to determine whether the collected data are of the right type, quality, and quantity to support the environmental decision making for the project, and describes how data quality issues will be addressed and how limitations of the use of the data will be handled.

Summary of Usability Assessment Processes

It is the responsibility of the CH2M project chemist and the laboratory to ensure that the data meet the detection limits and laboratory QC limits listed in this QAPP. During the data verification assessment, nonconformances are documented and data are qualified for use in decision making. The data are determined to be usable by the project chemist based on the requirements of this QAPP. Data gaps will be present if a sample is not collected, a sample is not analyzed for the requested parameters, or the data are determined to be unusable. The need for further investigation will be determined on a case-by-case basis. All data are usable as qualified by the data validator, with the exception of rejected data. Estimated and/or biased results are usable. Outliers, if present, can be addressed on a case-by-case basis. There is no generic formula for determining whether a result is an outlier. Potential outliers will be referred to a statistician and senior consultant, who will determine which formulas are appropriate for classifying data points in a statistically appropriate and defendable manner.

Evaluation Procedures to Assess Project-specific Overall Measurement Error

In-depth assessment occurs during the data verification process. The verification will assess conformance with the requirements of the methods, SOPs, and objectives of this QAPP. The findings of the data verification process will generate qualifiers applied to the data considered in context to assess overall usability of the data.

Personnel Responsible for Performing Usability Assessment

- Heather Hodach, project chemist, CH2M
- Rick Dobbins, database manager, CH2M
- David Boehnker, subject matter expert/CERCLA, CH2M
- Barrie Selcoe, subject matter expert/human health risk assessor, CH2M
- Ron Utter, subject matter expert/environmental/IDW manager, CH2M
- Brett Fishwild, site manager, CH2M
- Hope Mauer, field team leader, CH2M

Usability Assessment Documentation

The data verification report will identify precision and accuracy exceedances with respect to the fixed laboratory performance for each batch of samples, as well as comparability of field duplicates. All the results will be assembled and statistically reported for an overall quality assessment provided in the final data

evaluation summary report. Discussion will cover precision, accuracy/bias, representativeness, comparability, and completeness defined in the following subsections.

Precision

Laboratory precision is measured by the variability associated with duplicate (two) or replicate (more than two) analyses.

Total precision is the measurement of the variability associated with the entire sampling and analytical process. It is determined by analysis of duplicate field and/or laboratory samples and measures variability introduced by both the laboratory and field operations. Field duplicate and MS/MSD samples will be analyzed to assess field and laboratory precision. For duplicate sample results, the precision is evaluated using the RPD. For replicate results, the precision is measured using the relative standard deviation (RSD). The formula for the calculation of RPD is provided below.

If calculated from duplicate measurements:

$$RPD = \frac{(C_1 - C_2)\, x100\%}{(C_1 + C_2)/2} \qquad (1)$$

Where:

RPD = relative percent difference
C_1 = larger of the two observed values
C_2 = smaller of the two observed values

If calculated from three or more replicates, use RSD rather than RPD:

$$RSD = (s/\bar{y})\, x100\% \qquad (2)$$

Where:

RSD = relative standard deviation
s = standard deviation
$\bar{y}$ = mean of replicate analyses

Standard deviation, s, is defined as follows:

$$S = \sqrt{\sum_{i=1}^{n} \frac{(yi - \bar{y})^2}{n-1}} \qquad (3)$$

Where:

S = standard deviation
yi = measured value of the ith replicate
$\bar{y}$ = mean of replicate analyses
n = number of replicates

Accuracy

Accuracy reflects the total error associated with a measurement. A measurement is considered accurate when the reported value agrees with the true value or known concentration of the spike or standard within

acceptable limits. Analytical accuracy is measured by comparing the percent recovery of analytes spiked into an LCS and/or MS/MSD to a control limit. Surrogate compound recoveries are also used to assess accuracy and method performance for each sample analyzed.

Both accuracy and precision are calculated for each analytical batch, and the associated sample results are interpreted by considering these specific measurements.

The formula for calculation of accuracy is included below as percent recovery (%R).

$$\%R = 100\%\ x \left[\frac{S - U}{C_{sa}} \right] \quad (4)$$

Where:

%R = percent recovery
S = measured concentration in spiked aliquot
U = measured concentration in unspiked aliquot
C_{sa} = actual concentration of spike added

For situations where a standard reference material is used instead of or in addition to MSs:

$$\%R = 100\%\ x \left[\frac{C_m}{C_{sm}} \right] \quad (5)$$

Where:

%R = percent recovery
C_m = measured concentration of standard reference material
C_{sm} = actual concentration of standard reference material

Representativeness

Representativeness is the degree to which sample data accurately reflect the characteristics of a population of samples. It is achieved through a well-designed sampling program and by using standardized sampling strategies and techniques and analytical procedures. Factors that can affect representativeness include sample collection, storage, preservation procedures, site homogeneity, sample homogeneity at a single point, and available information around which the sampling program is designed.

Completeness (Statistical)

Completeness is a measure of the amount of valid data obtained compared with the amount expected under correct, normal conditions. It is calculated for the aggregation of data for each analyte measured as a compound of concern for the project objectives. Valid data are data that are usable in the context of the project goals. Completeness is calculated and reported for each method, matrix, and analyte combination. The number of valid results divided by the number of possible individual analyte results, expressed as a percentage, determines the completeness of the data set. For completeness requirements, valid results are all results not qualified with an R-flag after a usability assessment has been performed. The goal for completeness, based on specific project goals, is 90 percent.

Defined as follows for all measurements:

$$\%C = 100\% \; x\left[\frac{V}{T}\right] \tag{6}$$

Where:

%C	=	percent completeness
V	=	number of measurements judged valid
T	=	total number of measurements

Comparability

Comparability is the confidence with which one data set can be compared to another. It is achieved by maintaining standard techniques and procedures for collecting and analyzing samples and reporting the analytical results in standard units.

References

BCA Consultants, Inc. (BCA). 2005. *Remediation Work Plan Revision 1, Former Lumbermens (Former U.S. Towel) Site.* September 15.

Indiana Department of Environmental Management (IDEM). 2002. *Brownfield Environmental Assessment for U.S. Towel, Indianapolis, Indiana, Marion County.* January 10.

Indiana Department of Environmental Management (IDEM) Office of Land Quality. 2010. *Site Inspection Report for Keystone Corridor Groundwater Contamination Site, Indianapolis, Indiana.* January 31.

Indiana Department of Environmental Management (IDEM) Office of Land Quality. 2012. *The Remediation Closure Guide*, Indianapolis, Indiana. March 22.

Indiana Department of Environmental Management (IDEM) Office of Land Quality. 2012. *Expanded Site Inspection Report for Keystone Corridor Groundwater Contamination Site, Indianapolis, Indiana.* March 28.

SESCO Group (SESCO). 2009. *Final Characterization Results and Remediation Workplan. Lumbermans – Former US Towel, Inc*. November, 25.

SESCO Group (SESCO). 2012. *Remediation Implementation Report. Former Lumberman's Wholesale Supply*. March 15.

URS. 2004. *Report Remedial Investigation – Phase II*. November 24.

U.S Environmental Protection Agency (EPA). 2005. *Use of Dynamic Work Strategies Under a Triad Approach for Site Assessment and Cleanup –Technology Bulletin*. September.

U.S. Environmental Protection Agency (EPA). 2009. *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use. Office of Solid Waste and Emergency Response No. 9200.1-85, EPA 540-R-08-005.* Office of Solid Waste and Emergency Response. January.

U.S. Environmental Protection Agency (EPA) Region 5. 2010. *Vapor Intrusion Guidebook.*

U.S. Environmental Protection Agency (EPA). 2013. *HRS Documentation Record Keystone Corridor Groundwater Contamination, INN000510399*. May.

U.S. Environmental Protection Agency (EPA), 2015. *Office of Solid Waste and Emergency Response (OSWER) Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Sources to Indoor Air.* June.

U.S. Environmental Protection Agency (EPA), 2015. Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites. June.

Figures

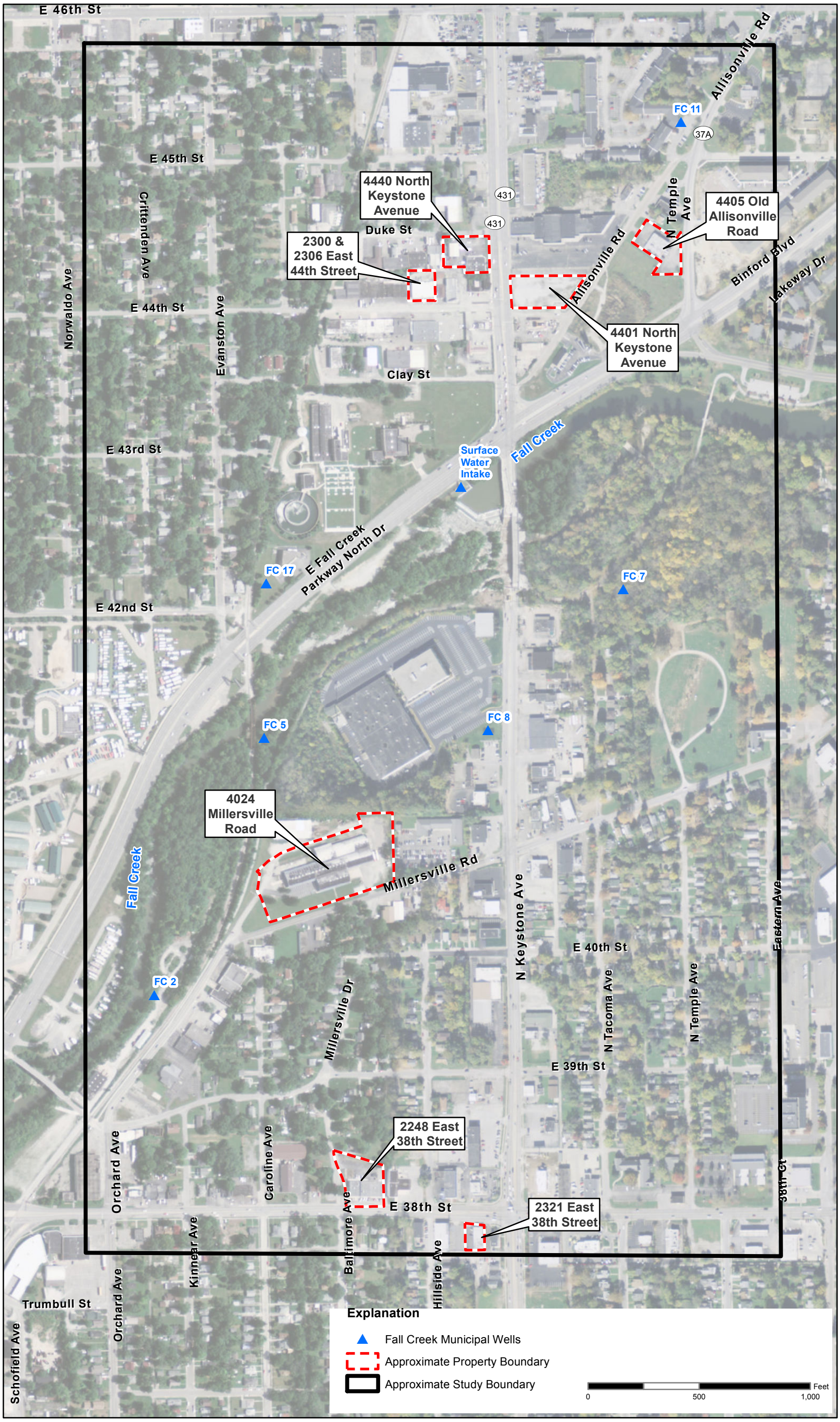


Figure 1 - Area Location Map

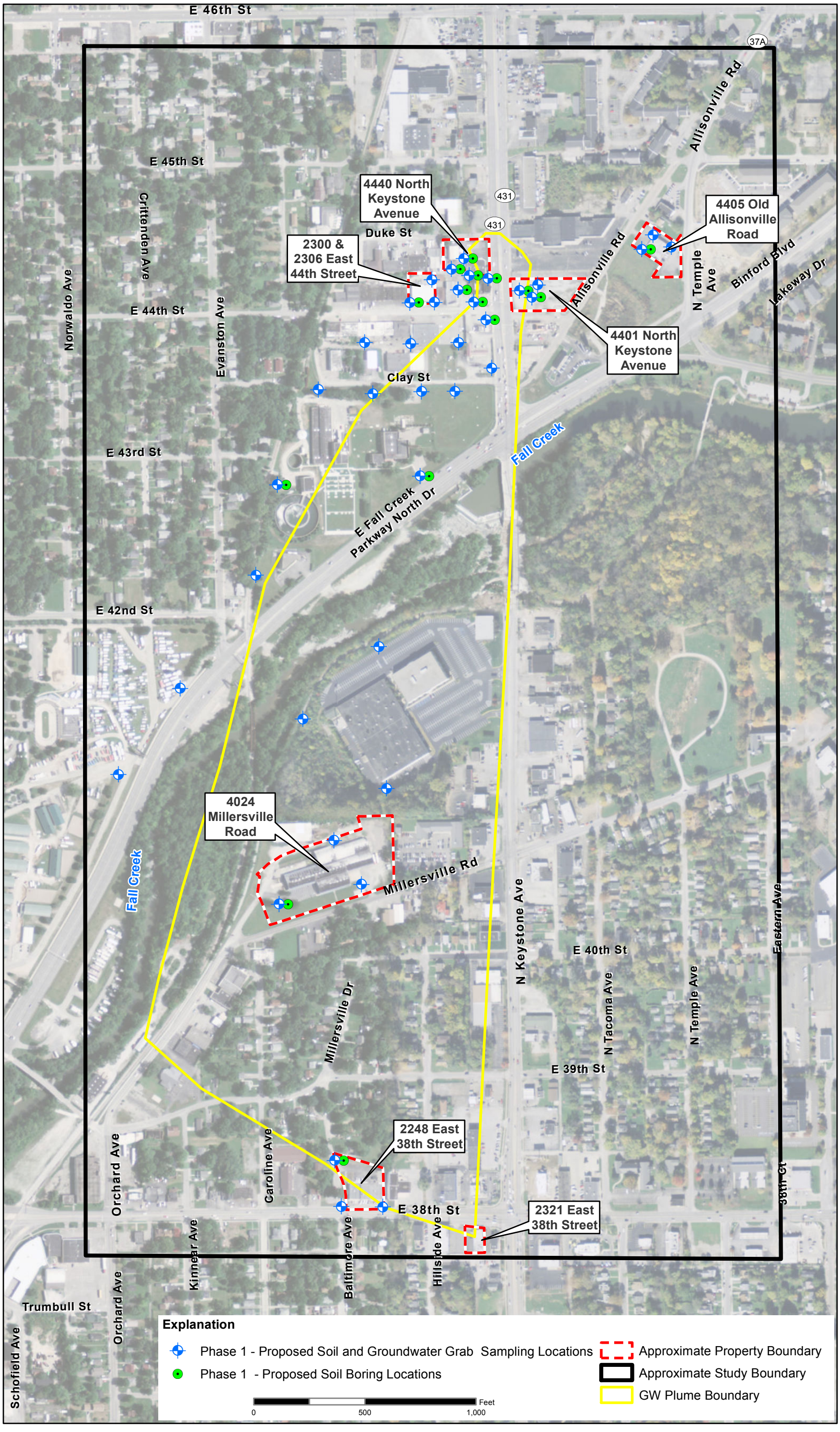


Figure 2 - Potential Sampling Locations