

**MASTER QUALITY ASSURANCE PROJECT PLAN FOR  
IMPLEMENTATION OF EPA REGION 10  
FY2023 CONTAMINATED ANCSA LANDS GRANT &  
FY2023 BROWNFIELD COMMUNITY-WIDE ASSESSMENT GRANT  
(Revision 1)**

**Cooperative Agreement No. AN-02J47101 & 4B-02J55101**

**Montrose Project No. 223536 & 223502**

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**April 24, 2024**

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## List of Acronyms

°C	Degree Celsius
%R	percent recovery
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µg/m <sup>3</sup>	micrograms per cubic meter
ACM	Asbestos-Containing Material
ADEC	Alaska Department of Environmental Conservation
AHERA	American Hazard Emergency Response Act
AIHA	American Industrial Hygiene Association
ALS	ALS Global
ANCSA	Alaska Native Claims Settlement Act
ANSI/ASQ	American National Standards Institute/American Society of Quality
ASTM	American Society for Testing and Materials
BFB	bromofluorobenzene
BS	Blank Spike
CA	Corrective Action
CAA	Clean Air Act
CAR	Corrective Action Report
CAS	Chemical Abstracts Service
CBC	chlorinated biphenyl congener
CCB	continuing calibration blank
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	Calibration Factor
CFR	<i>Code of Federal Regulations</i>
CGI/O <sub>2</sub>	Combustible Gas Indicator/ Oxygen
CLP	Contract Laboratory Program
COC	chain of custody
CRQL	contract-required quantitation limit
CSM	Conceptual Site Model
CVAA	cold vapor atomic absorption
CWA	Clean Water Act
CWA	Community-Wide Assessment
DDT	dichlorodiphenyltrichloroethane
DFTPP	decafluorotriphenyl/phosphine
DMC	deuterated monitoring compounds
DO	dissolved oxygen
DOT	U.S. Department of Transportation
DQI	data quality indicator
DQO	data quality objective
DRO	diesel-range organic
DUA	data usability assessment



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## List of Acronyms (continued)

EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
FID	Flame Ionization Detector
GC	Gas Chromatograph
GC/ECD	Gas Chromatograph/Electron Capture Detector
GC/FID	Gas Chromatograph/Flame Ionization Detector
GC/MS	Gas chromatography/mass spectrometry
GIS	Geographical Information System
GPS	Global Positioning System
GRO	Gasoline-range organics
HASP	Health and Safety Plan
HCl	hydrochloric acid
HDPE	high-density polyethylene
HNO <sub>3</sub>	nitric acid
HPLC	high-performance liquid chromatography
HRGC	High Resolution Gas Chromatography
HRMS	High Resolution Mass Spectrometry
HRS	Hazard Ranking System
H <sub>2</sub> S	hydrogen sulfide
HSO	Health and Safety Officer
IATA	International Air Transport Association
ICB	initial calibration blank
ICAL	Initial Calibration
ICP-AES	Inductively coupled plasma-atomic emission spectroscopy
ICP-MS	Inductively coupled plasma-mass spectrometry
ICV	initial calibration verification
IDQTF	Intergovernmental Data Quality Task Force
IDW	investigation-derived waste
IS	internal standards
L	liter
LBP	lead-based paint
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LEB	leachate extraction blank
LEL	lower explosive limit
LF	linear feet
LFB	laboratory fortified blank
LFSM	laboratory fortified sample matrix
LFSMD	laboratory fortified sample matrix duplicate
LIMS	Laboratory Information Management System
LLOQ	lower limit of quantitation
LOD	limit of detection

## List of Acronyms (continued)

LOQ	limit of quantitation
LRB	laboratory reagent blank
MB	method blank
MCL	maximum contaminant level
MDL	method detection limit
mg	milligram
mg/cm <sup>2</sup>	milligrams per square centimeter
mg/kg	milligrams per kilogram
mg/L	milligram per liter
mL	milliliter
MPC	Measurement Performance Criteria
MS	matrix spike
MSD	matrix spike duplicate
NA	not applicable
NaHSO <sub>4</sub>	sodium bisulfate
NaOH	sodium hydroxide
NELAP	National Environmental Laboratory Accreditation Program
NFG	National Functional Guidelines
ng/kg	nanograms/kilogram
NIOSH	National Institute for Occupational Safety and Health
NOI	Notice of Incident
NTU	Nephelometric Turbidity Units
NVLAP	National Voluntary Laboratory Accreditation Program
O <sub>2</sub>	oxygen
OC	organochlorine
OCDD	octachlorodibenzo-p-dioxin
OCDF	octachlorodibenzofuran
ORO	oil-range organics
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
oz.	ounce
PAH	polycyclic aromatic hydrocarbons
PAL	project action limit
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PCB	polychlorinated biphenyl
PDF	Portable Document Format
PE	Performance Evaluation
PFAS	Per-and Polyfluoroalkyl Substances
PID	Photoionization Detector
pg/L	picograms/liter

## List of Acronyms (continued)

PLM	polarized light microscopy
PM	Program Manager
PO	Project Officer
POC	Point of Contact
ppbv	parts per billion by volume
PPE	personal protective equipment
PTFE	Polytetrafluoroethylene
QA	quality assurance
QAM	Quality Assurance Manual
QAPP	Quality Assurance Project Plan
QC	quality control
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RL	reporting limit
RPD	relative percent difference
RRF	Relative Response Factor
RRO	residual range organics
RSD	relative standard deviation
RSL	regional screening level
S/D	matrix spike and duplicate
SC	Sample Coordinator
SD	standard deviation
SDG	sample delivery group
SGS	SGS North America
SIM	selected ion monitoring
SM	Standard Method
SMO	Sample Management Office
SOP	Standard Operating Procedure
SOW	Statement of Work
SPLP	Synthetic Precipitation Leaching Procedure
SR	sample result
SSHO	Site Safety & Health Officer
Std	Standard
SVOC	semivolatile organic compound
TAL	Target Analyte List
TAT	turnaround time
TBD	to be determined
TCLP	Toxicity Characteristic Leaching Procedure
TO	Toxic Organics
TPH	total petroleum hydrocarbons
UFP	Uniform Federal Policy
VOA	volatile organic analysis

### List of Acronyms (continued)

VOC	volatile organic compound
WHO	World Health Organization
XRF	x-ray fluorescence
ZHE	Zero Headspace Extractor

## 1.0 Introduction

The purpose of this document is to describe the personnel, procedures, and methods for ensuring the quality, accuracy, and precision of environmental data associated with the U.S. Environmental Protection Agency (EPA) Region 10's Contaminated Alaska Native Claims Settlement Act (ANCSA) Lands Grant Program and Brownfield Community-Wide Assessment (CWA) Grant for Tribes Program. This Master Quality Assurance Project Plan (QAPP) covers projects where environmental data are collected and was developed for projects in the State of Alaska. This QAPP covers both hazardous substance- and petroleum-contaminated sites.

This QAPP has been prepared by Montrose Environmental Solutions, Inc. (Montrose) and is intended to be applied in tandem with Site-specific Work Plans (Work Plans) developed for, and associated with, each site approved by EPA. Work Plan will discuss Site-specific sampling locations, procedures, selected laboratories, and analytical parameters and methods and will reference this QAPP. Following the procedures outlined in this QAPP will ensure that the data collected meet project objectives. The Work Plan will incorporate any project elements not included in this QAPP and must be approved by the by the EPA Project Officer (PO) prior to conducting Site work. All Site investigation, field screening, analytical sampling and analysis activities will be performed in accordance with the processes and procedures described in this QAPP.

This document has been prepared using guidance from EPA IT/IM Directive No: CIO 2105-S-02.0, *Quality Assurance Project Plan Standard* (QAPPS, March 2023) and complies with the EPA's *Uniform Federal Policy for Quality Assurance Project Plans* (UFP-QAPP, March 2005). These two documents are similar in function but vary in presentation and organization. The flowing table (**Table 1**) provides a cross walk of the required QAPP elements from the QAPPS and the corresponding UFP-QAPP Sections and Worksheets:

Table 1 – EPA IT/IM Directive QAPP Standard / UFP-QAPP Cross Walk

EPA IT/IM Directive QAPP Standard		Associated UFP-QAPP Worksheet / Section	
Group A: Project Management and Information / Data Quality Objectives			
Element A1	Title Page	Worksheet #1 & 2	Title and Approval Page
Element A2	Approval Page		
Element A3	Table of Contents, Document Format and Document Control	Table of Contents	Table of Contents, Document Headers and Footers
Element A4	Project Purpose, Problem Definition, and Background	Worksheet #10	Conceptual Site Model
		Worksheet #11	Problem Definition and Data Quality Objectives
Element A5	Project Task Description	Worksheet #9	Project Planning Session Summary and Scoping Meetings
		Worksheet #14 & 16	Project Tasks and Schedule
		Worksheet #17 & 18	Sampling Design, Rationale, Locations and Methods
Element A6	Information / Data Quality Objectives and Performance / Acceptance Criteria	Worksheet #11	Problem Definition and Data Quality Objectives
		Worksheet #12	Measurement Performance Criteria

		Worksheet #13	Secondary Data Uses and Limitations
Element A7	Distribution List	Worksheet #3 & 5	Program Organization and QAPP Distribution
Element A8	Project Organization		
Element A9	Project QAM Independence		
Element A10	Project Organizational Chart and Communications	Worksheet #6	Communication Pathways
Element A11	Personnel Training / Certification	Worksheet #4, 7 & 8	Program Personnel Sign-Off Sheet, Responsibilities, Qualifications, and Training Requirements
Element A12	Documents and Records	Worksheet #29	Project Documents and Records

**Group B: Implementing Environmental Information Operations**

Element B1	Identification of Project Environmental Information Operations	Worksheet #15	Project Action Limits, Laboratory-specific Detection / Quantitation Limits
		Worksheet #19 & 30	Sample Containers, Preservation, and Hold Times
Element B2	Methods for Environmental Information Acquisition	Worksheet #21	Field SOPs
		Worksheet #23	Analytical SOPs
Element B3	Integrity of Environmental Information	Worksheet #26 & 27	Sample Handling, Custody and Disposal
Element B4	Quality Control	Worksheet #20	Field QC Summary
		Worksheet #28	Analytical Quality Control and Corrective Action
Element B5	Instruments / Equipment Calibration, Testing, Inspection, and Maintenance	Worksheet #22	Field Equipment Calibration, Maintenance, Testing and Inspection
		Worksheet #25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection
		Worksheet #24	Analytical Instrument Calibration
Element B6	Inspections / Acceptance of Supplies and Services	Worksheet #35	Data Verification Procedures
Element B7	Environmental Information Management	Worksheet #29	Project Documents and Records

**Group C: Assessment, Response Actions and Oversight**

Element C1	Assessments and Response Actions	Worksheet #31, 32 & 33	Assessments, Corrective Action & QA Management Reports
Element C2	Oversight and Reports to Management		

**Group D: Environmental Information Review and Usability Determination**

Element D1	Environmental Information Review	Worksheet #36	Data Validation Procedures
Element D2	Usability Determination	Worksheet #37	Data Usability Assessment

This QAPP will be reviewed annually and updated as necessary. The annual reviews will be documented (letter format is acceptable) and sent to all recipients of the QAPP with any updated materials to insert into the QAPP. Current laboratory certificates will be stored by Montrose in electronic project files and available upon request.

The applicable screening standards associated with each project are included in the Work Plan. The laboratory reporting capabilities, included in this QAPP, must meet these standards.

The laboratory selection process is outlined in this QAPP. The subcontract laboratory Point of Contact (POC) names and Quality Assurance Manuals (QAM) will be assembled and on file as laboratories are approved and procured. Standard Operating Procedures (SOP) for sample preparation and analytical methodologies will be retained on file by the contract laboratories.

The Work Plans are technical planning documents that provide the rationale and a historical perspective for each sampling event. The Work Plan will identify the project objectives; problems to be solved and/or decisions to be made; describe the measurements that will be made during the course of the project; state any special personnel and equipment requirements; provide sample location mapping; and provide a schedule of the work to be performed. Work Plans will also define the project's data quality objectives (DQOs), describe the project management and functional organization, outline field measurement and sample collection procedures and protocols, summarize quality control (QC) samples and evaluation procedures, identify field methodologies to be used, identify contaminants of concern and the analytical methods. The quality assurance (QA) and quality control (QC) activities incorporated into these Work Plans meet the project-specific DQOs included in this QAPP. The Work Plan will document any deviations in quality criteria and/or objectives from this QAPP.

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**WORKSHEET #1 & 2: TITLE AND APPROVAL PAGE**

**Document Title:** Master Quality Assurance Project Plan for Implementation of EPA Region 10 Contaminated ANCSA Lands Grant & Brownfield CWA Grant Projects

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## WORKSHEET #1 & 2: TITLE AND APPROVAL PAGE

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## WORKSHEET #3 & 5: PROGRAM ORGANIZATION AND QAPP DISTRIBUTION

QAPP Recipient Name	Title	Organization	E-Mail Address
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**Notes:**

QAPP = Quality Assurance Project Plan      TBD = To be determined

This QAPP is good for the life of the program or five years, whichever is longer. The QAPP will be reviewed annually and updated as necessary. The reviews will be documented (letter format is acceptable) and sent to all recipients of the QAPP with any updated materials to insert into the QAPP.

The roles and responsibilities of key staff will also be presented in the site-specific Work Plans that will supplement this QAPP.



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## **Program Quality Assurance Manager Independence**

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In all cases, the Quality Assurance Manager will not directly participate in environmental field activities.

## WORKSHEET #4, 7, & 8: PROGRAM PERSONNEL SIGN-OFF SHEET, RESONSIBILITIES, QUALIFICATIONS, AND TRAINING

### Key Project Personnel Sign-off Sheet

Project Personnel Name	Title	Organization	E-mail address	E-mail Receipt Confirmation
Adam Doubleday	Quality Assurance Scientist/Data Manager	Montrose Environmental Solutions, Inc.	<a href="mailto:adoubleday@montrose-env.com">adoubleday@montrose-env.com</a>	
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Cindy Fields	Region 10 QA Officer	EPA Region 10	<a href="mailto:fields.cindy@epa.gov">fields.cindy@epa.gov</a>	

A copy of the Key Project Personnel Sign-off Sheet shall be maintained by Montrose and made available to approval authorities upon request. "X" denotes that the named individual has signed off and Montrose has confirmed receipt of the signature page. Montrose will maintain copies of all sign-off sheets.

The Laboratory Project Manager will be provided a copy of the QAPP and corresponding Work Plan at the time of sample container order. An email confirmation of the QAPP and Work Plan receipt will be maintained by Montrose as part of the project record and made available to approval authorities upon request.

## Special Personnel Training, Experience and Certifications Requirements Table

Project Function	Specialized Training or Experience by Title or Description of Course	Training Provider	Training Date <sup>1</sup>	Personnel/ Groups Receiving Training	Personnel Titles/ Organizational Affiliation	Location of Training Records/Certificates <sup>2</sup>
Field Operations	40-Hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Site Worker Training; 8-Hour OSHA Refresher Training	Registered training organization – various <sup>1</sup>	Varies	All	Various	Montrose and Montrose subconsultant personnel records
Field Team Lead & Site Safety & Health Officer (SSHO)	Qualified Environmental Professional per 18 AAC 75.333; 40-Hour OSHA Hazardous Waste Site Worker Training; 8-Hour OSHA Refresher Training	Continuing education program requirements via registered training organization – various <sup>1</sup>	Varies	Field Team Leader	QEP, Montrose, Montrose subconsultant	Montrose and Montrose subconsultant personnel records
Remediation Specialist will provide technical oversight of the project	Qualified Environmental Professional per 18 AAC 75.333; 40-Hour OSHA Hazardous Waste Site Worker Training; 8-Hour OSHA Refresher Training	Continuing education program requirements via registered training organization – various <sup>1</sup>	Varies	Individual	QEP, Montrose	Montrose personnel records

### Notes:

- 1 Training provider and date of training will vary from person to person because of individual scheduling of training.
- 2 Training records and/or certificates are available upon request.
- 3 A Health and Safety Plan (HASP) will be prepared for each site and will identify a Site-Specific Health and Safety Officer (SSHO).

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## Program Organization Chart

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An organization chart showing both the lines of authority/reporting relationships and the lines of communication both within the lead organization and between the lead organization and all organizations involved in the program are presented in **Appendix A**.

## WORKSHEET #6: COMMUNICATION PATHWAYS

Communication Drivers	Responsible Person	Name	Phone Number	Procedure (timing, pathways, etc.)
Project Status	Program Manager	Andrea Pedersen	425-308-1727	Reporting of project information to EPA through work plans, monthly progress reports, e-mail updates, teleconference calls, and meetings.
Manage All Project Phases	Program Manager Principal-in-Charge	Andrea Pedersen Chris Gdak	425-308-1727 425-760-1342	Primary modes of communication are telephone, E- mail, letter, document submittal; timing dependent on nature of communication and pre-defined schedules, as applicable and as requested by agencies.
Stop Work due to safety issues	Field Team Leader & SSHO	Tiffany Angus Kimi Lloyd	415-730-7658	Field Team Leader or field staff notify project management regarding safety issues as they occur. Documentation may include Notice of Incident (NOI) and emails.
Corrective Actions*	Quality Assurance (QA) Manager	Lydia Work	304-552-1442	As they occur, the QA Manager will investigate programmatic, procedural, field, data validation, and analytical issues which require corrective actions. The appropriate project personnel will be involved with developing and implementing the corrective action. The issues and subsequent resolution will be documented in memorandum format.
Standard operating procedure (SOP) or quality assurance program plan (QAPP) changes in the field and field corrective action	QA Manager	Lydia Work	304-552-1442	Notify Project Manager and Field Team Leader of any changes to the procedures proposed in the approved QAPP (including SOP changes) prior to or during sampling events along with rationale for changes. Document changes in field logbook. Maintain files for progress reports and memoranda to project personnel EPA. Need for field corrective action will be determined by the EPA PO and will be documented in the daily field progress reports and memoranda to EPA.
Reporting Laboratory Data Quality Issues	Laboratory Project Manager	Justin Nelson (SGS) Brian Ford (Pace) Shari Endy (ALS)	907-562-2343 615-773-9772 360-577-7222	All laboratory QA/quality control (QC) issues with project field samples will be reported by the Laboratory Project Manager to the QA Manager.
Laboratory Analytical Corrective Actions	Laboratory QA Manager	Justin Nelson (SGS) Brian Ford (Pace)	907-562-2343 615-773-9772	Need for laboratory corrective actions will be determined by the Laboratory QA Manager. Corrective actions will be documented in project records, and if necessary, in memoranda to the EPA PO.

Communication Drivers	Responsible Person	Name	Phone Number	Procedure (timing, pathways, etc.)
Data Tracking and Management	Data Manager	Adam Doubleday	610-639-2749	The Data Manager will track data from sample collection, analysis, and validation using a database program. The laboratory will release data packages to project personnel for data validation. Any missing deliverables will be requested from the laboratory by the Data Validator.
Release of Analytical Data	Data Validator	Amy Graham	484-802-5590	The Data Validator will release the analytical data to the Field Team Leader at the completion of the validation.
Analytical/Data Validation issues and corrective actions	Data Validator	Amy Graham	484-802-5590	Laboratory data packages and validation reports will be reviewed by the Data Validator, or designee. Any issues or deficiencies will be communicated to the QA Manager for resolution and/or corrective action.
Distribution of QAPP and QAPP Updates*	QA Manager	Lydia Work	304-552-1442	The QAPP will be reviewed periodically, and changes to the QAPP that impact data quality will be submitted to, and approved by, the EPA. The QAPP is good for the life of the project.

\*These elements must be included

## WORKSHEET #9: PROJECT PLANNING SESSION SUMMARY AND SCOPING MEETINGS

### Project Scoping/Planning Session Participants Sheet

<b>Project Name</b>	Region 10 Contaminated ANCSA Lands Grant & Brownfield CWA Grant Projects		<b>Site Name</b>	Site-specific Work Plan will identify the site name	
<b>Projected Date(s) of Sampling</b>	Projected dates of sampling will be included in the Site-specific Work Plan		<b>Site Location</b>	Various locations, to be identified in the Site-specific Work Plan	
<b>Program Manager</b>	Andrea Pedersen				
<b>Date of Session</b>	TBD, will occur at least two weeks prior to field mobilization activities				
<b>Scoping/Planning Session Purpose:</b>	TBD, typically a kick-off meeting to discuss site work and schedule				
<b>Name</b>	<b>Title</b>	<b>Affiliation</b>	<b>Phone #</b>	<b>E-Mail Address</b>	<b>Project Role</b>
Identified in Work Plan	Field Team Leader & SSHO	Montrose, Montrose Subcontractor	TBD	TBD	Field Team Leader
Identified in Work Plan	Site Manager	ADEC	TBD	TBD	ADEC Site Cleanup Manager
Identified in Work Plan	Project Officer	EPA Region 10	TBD	TBD	EPA Project Officer
Andrea Pedersen	Program Manager	Montrose Environmental Solutions, Inc.	425-308-1727	anpedersen@montrose-env.com	Program Manager
Lydia Work	Principal Chemist	Montrose Environmental Solutions, Inc.	304-552-1442	lwork@montrose-env.com	QA Manager
<u>Comments/Decisions:</u> Discuss schedule and anticipated scope of work					
<u>Action Items:</u> TBD					

Notes:

EPA = U.S. Environmental Protection Agency

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## WORKSHEET #10: CONCEPTUAL SITE MODEL

The Site-specific conceptual site model (CSM) is provided in the Work Plan.

The Work Plan includes the following information where available and as applicable:

- Background information (i.e., location and site operational history).
- Sources of known chemicals used on site or suspected hazardous waste.
- Known or suspected contaminants or classes of contaminants.
- Contaminant release mechanism, volume or mass of release, and form of release (e.g., solid or liquid).
- Primary and secondary contaminant migration.
- Fate and transport considerations.
- Potential human or ecological receptors and exposure pathways.
- Current and future land use considerations
- Existing site conditions and use of the property.
- Maps (historical and current)
- Key physical aspects of the site (e.g., site assets, geology, hydrology, topography, and climate).
- Current interpretation of nature and extent of contamination to the extent that it will influence project- specific decision making (e.g., conceptual site model).

Data gaps and uncertainties related to project plans need to be identified during development of the Work Plan to identify additional data needs.

The Work Plan provides the rationale and a historical perspective for the sampling events. The Work Plan describes the proposed sampling efforts succinctly and includes a brief statement addressing the phase(s) of the work and intended objectives of the sampling investigation. Background information such as maps, plans, tables, and figures are provided to place the problem in historical perspective, giving the reviewer a sense of the project's purpose.

Further, the Work Plan states the project objectives; problem(s) to be solved and/or the decision(s) to be made; describes the measurements that will be made during the course of the project; states specific quality standards criteria and objectives; states any special personnel and equipment requirements; describes assessment tools needed; provides a schedule of the work to be performed; and states project and quality control records required, including the type of reports needed. All applicable SOPs needed for site activities, and sources of historical information are referenced in the Work Plan. The Work Plan will be made available to all field team members.



## WORKSHEET #11: PROBLEM DEFINITION AND DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are qualitative and quantitative statements and goals developed to ensure that sufficient data of known and appropriate quality are obtained to support specific decisions or regulatory actions. The principal objective of data to be collected during the project and the associated DQOs are defined in the Work Plan. DQOs will be evaluated and presented in the Work Plan.

EPA's 7-step DQO process outlined in EPA QA/G-4, Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA/240/B-06/001 (EPA 2006) should be followed (outlined below). Background information/data, pre-planning site visits, and scoping meetings/conference calls may be used to support the DQO process and the development of site-specific DQOs. Because different data uses may require different quantities of data and levels of quality, DQOs must be established for each site.

Site-specific DQOs describe site activities, including project management and functional organization, sample collection and field methodologies, identify contaminants of concern and reporting limits, specify laboratory and field analytical methods, and details QA/QC activities to meet the site DQOs.

When the data do not meet the project DQOs, the root cause of the deficiency should be investigated. Reasons may include laboratory operation, such as the failure of laboratory reporting limits to meet site criteria. In these situations, project management should determine corrective actions commensurate with the project's needs. Corrective actions may include:

- Re-sampling for all or some of the parameters.
- Preparing a technical memorandum to the site file, detailing limitations to the data.
- Validating the data at a higher tier level to better qualify the results.
- Preparing a technical memorandum describing the bias of field results.

The DQO process will be utilized to identify the type and quality of environmental data needed for site-specific projects that allow the user to determine:

- The nature of the problem that has initiated the study and a conceptual model of the environmental hazard;
- The decisions or estimates that need to be made and the order of priority for resolving them;
- The type of data needed;
- An analytical approach or decision rule that defines the logic for how the data will be used to draw conclusions from the study findings;
- Acceptable criteria (tolerable limits or acceptable uncertainty) on the quality and quantity of the data to be collected; and
- Data collection design which specifies the type, number, location, and physical quantity of samples and data including QA/QC activities.

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## EPA 7-Step DQO Process

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Site-specific DQOs shall be developed using the EPA's 7-step DQO process. The DQOs will be presented in a Work Plan that will be submitted to the EPA PO for review and approval. The 7-step process, described verbatim in the guidance for Worksheet #11 in the Optimized UFP-QAPP Worksheets (Intergovernmental Data Quality Task Force [IDQTF] 2012), includes the following:

- 1. State the Problem.** The problem statement should be consistent with information contained in the site-specific CSM (Worksheet #10).
- 2. Identify the Goals of the Study.** Identify specific study questions and define alternative outcomes. The goals for either decision or estimation problems should explain how the data will be used to answer questions and choose among the stated alternatives. Characterizing the "nature and extent of contamination" is a commonly stated but inappropriate study goal because it is vague and not focused on potential outcomes.
- 3. Identify Information Inputs.** Specify the types of data that are required to fill gaps in the CSM. Explain in specific terms how all data will be used. In addition to analytical data, this could include published information on geology, climate, population distributions, endangered species, etc. Information inputs should be consistent with decisions made during project planning.
- 4. Define the Boundaries of the Study.** Specify the target population and characteristics of interest, define spatial/temporal limits and the scale of inference (i.e., which populations will be represented by which data). Developing the list of target analytes presents one of the greatest opportunities for streamlining a project, as it can help avoid unnecessary costs associated with not only sampling, but also analysis, data review, reporting and management. Target analytes should be focused on specific constituents reasonably known or suspected to be present. The list of target analytes should be based on data gaps in the CSM. Focusing the list of analytes also provides better opportunities for optimizing method performance to best suit those analytes.]
- 5. Develop the Analytic Approach.** Define the parameter(s) of interest, specify the type of inference (e.g., "samples from groundwater monitoring wells x, y, and z will represent potable water at the site) and develop the logic for drawing conclusions from findings (i.e., which sample results will be used to support which decisions). For decision problems, these are expressed as "if---then" statements, or decision rules, that link the potential results with conclusions or future actions. For estimation problems, specify the estimator and the estimation procedure.
- 6. Specify Performance or Acceptance Criteria.** For projects that involve hypothesis testing (e.g., presence or absence of contamination exceeding some threshold value) for decision-making, this will involve specifying probability limits for decision errors. For estimations and other analytic approaches (e.g., estimating the volume of groundwater or soil potentially requiring remediation), this will involve the development of performance criteria (for new data being collected) or acceptance criteria (for existing data being considered for use).
- 7. Develop the Detailed Plan for Obtaining Data.** Worksheet #11 will briefly explain the basis for the sampling design, and then refer to Worksheet #17 – Sample Design and Rationale. Worksheets #19/30, 20, and 24 to 28 will specify analytical design requirements.

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## Analytical Performance Criteria

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Once DQOs are defined, analytical performance criteria must be established to ensure that analytical methods will accurately and adequately identify the contaminants of concern, and to ensure that the analyses selected will be able to achieve the quantitation limits less than or equal to the target cleanup levels. Worksheet #15 summarizes the contaminants of concern, the concentration levels, and the associated matrices; the project action levels, method detection limits, and quantitation limits for each contaminant of concern; and the source of the action level (regulation, health-based criteria, water quality standards, etc.)

### Laboratory Accreditation

The laboratories used must be a DEC certified laboratory or possess accreditation from an accrediting authority such as National Environmental Laboratory Accreditation Program (NELAP), National Voluntary Laboratory Accreditation Program (NVLAP), or American Industrial Hygiene Association (AIHA) for the specific analytical methods used for the project. Certified laboratories have undergone performance evaluation performed by an applicable state program, accrediting authority, or through the NELAP, NVLAP, or AIHA programs, for method accuracy and precision, and meet the requirements set forth by the state or EPA. All potential analyses (volatile organic compounds [VOCs], semi-volatile organic compounds [SVOCs], polycyclic aromatic hydrocarbons [PAHs], metals, total petroleum hydrocarbons [TPH] compounds, polychlorinated biphenyls [PCBs], dioxin/furans, Per- and Polyfluoroalkyl Substances [PFAS], cyanide, pesticides, herbicides, waste characterization, and natural attenuation parameters) should be performed by a state-certified laboratory, or NELAP-, NVLAP-, or AIHA-certified laboratory.

Note that asbestos testing laboratories should have NVLAP certification and lead-based paint (LBP) testing laboratories should be AIHA-certified.

### Field Screening

Field-screening instruments provide a lower quality of analytical data compared with laboratory equipment in a controlled environment. However, field methods provide rapid “real-time” results for field personnel to help guide field decision-making processes. These techniques are often used for health and safety monitoring, initial site characterization to locate areas for detailed assessment, and preliminary comparison or remedial objective. This type of field-screening data can include measurements of pH, temperature, conductivity, turbidity, oxidation reduction potential (ORP), dissolved oxygen (DO), or similar monitoring data. Field measurements of pH, temperature, conductivity, turbidity, ORP, and DO will be collected during groundwater and surface water sampling activities. During sampling and other property assessment activities, the breathing space of site personnel may be monitored for the presence of VOC using a photoionization detector (PID) or flame ionization detector (FID) based on the suspected or known contamination at the site. The PID or FID may also be used to perform field screening of soil and sediment sample to assist in the selection of samples to be submitted for laboratory analysis. Field screening may also include the use of x-ray fluorescence (XRF) to estimate metals concentration in soil.

All field instruments shall be calibrated in accordance with the manufacturer's instructions at least once per day during field use. Calibration should also be performed whenever accuracy and reproducibility of results become inconsistent. Worksheet #22 lists field screening instrument calibration, maintenance, testing, and inspection activities with the required frequency; details acceptance criteria, corrective actions, and responsible personnel; and it provides SOP references. Records for each field instrument used shall be maintained to ensure its capability of providing accurate and precise measurements. Records will be maintained on instrument maintenance and calibration during the field effort.

## WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA

### Analytical Method Categories and Method Selection

Analytical methods were developed by EPA and other related organizations for specific programs or analytical needs; analyses from any of these method categories should be used. General categories of analyses include:

- EPA SW-846 Methods developed for organic and inorganic analyses of water, soil, oil, and waste matrices for compliance with the Resource Conservation and Recovery Act (RCRA).
- Alaska Series Laboratory Methods for the Analysis of Gasoline Range Organics (AK101), Diesel Range Organics (AK102), and Residual Range Organics (AK103), Alaska Series Laboratory Methods for the Analysis of Aliphatic and Aromatic Gasoline Range Organics (AK101AA), Aliphatic and Aromatic Diesel Range Organics (AK 102AA), and Aliphatic and Aromatic Residual Range Organics (AK 103AA).
- Clean Air Act (CAA) methods developed for air samples.
- Miscellaneous analyses (such as asbestos and National Institute for Occupational Safety and Health [NIOSH] methods).

Most samples will be analyzed using methods included in the EPA's methods compendium *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846). However, there may be instances where the sample matrix, parameters to be analyzed, DQOs, or intended use of the data require the use of methods other than SW-846 methods. For example, discharges to surface waters may require analysis using methods approved under the Clean Water Act (CWA) regulations, which include EPA methods and non-EPA methods (e.g., *Standard Methods for the Examination of Water and Wastewater* [Standard Methods or SM])) and methods published by the ASTM International (ASTM). Methods approved under the CWA include EPA, SMs, and ASTM methods. Ambient air and soil gas samples may require volatile organic compound analysis using EPA Toxic Organics (TO) method 15.

During the project planning phase, the Program Manager will work with the QA Manager to select the appropriate analytical methods and detection limits, based on the DQOs established for the site. The selected laboratory needs to hold state certifications appropriate for the analytical method, if applicable.

In addition to the EPA TO-15 method for the analysis of air volatile organic compounds, a summary of methods included by parameter in Worksheet #12 that are most likely to be utilized during this program includes the following:

Parameter	Method <sup>1,2</sup>
Volatile organic compounds (VOCs)	SW-846 8260C/D
Semivolatile organic compounds (SVOCs)	SW846- 8270D/E
Polycyclic aromatic hydrocarbons (PAH)	SW846- 8270D/E SIM
Organochlorine pesticides	SW-846 8081B
Polychlorinated biphenyls (PCB) (Aroclors)	SW-846 8082A
Herbicides	SW-846 8151A
Gasoline-, diesel-, and residual-range organics	AK101/102/103, SW-846 8015C
Metals (by Inductively Coupled Plasma - Atomic Emission Spectroscopy)	SW-846 6010C/D

Parameter	Method <sup>1,2</sup>
Metals (by Inductively Coupled Plasma - Mass Spectroscopy)	SW-846 6020A/B
Mercury	SW-846 7470A/7471B
Cyanide (Total)	SW-846 9012A/B
Dioxins/Furans	SW-846 8290A or EPA 1613B
PCB Congeners	EPA1668C
Per-and Polyfluoroalkyl Substances (PFAS)	SW-846 Method 8327 or EPA 537.1 (drinking water)
Asbestos	PLM & PCM

Notes:

- 1 Various versions of the listed method are indicated by the A, B, C, D and E suffixes. SIM denotes selected ion monitoring to achieve lower reporting limits.
- 2 If necessary, additional analytical methods will be added the site-specific Work Plans.

Analytical requirements including methods, reported analytes, and reporting limit and method will be identified during the project planning process and presented in each site-specific WP. The number and types of QC samples and analytical methods will depend on the site DQOs and proposed data use. Each Work Plan will identify the analytical methods to be utilized during the project. The analytical method numbers, extraction and/or digestion method numbers, method detection limits (MDLs), limits of quantitation (LOQs) and limits of detection (LODs, one-half of the LOQ) for each parameter are included in Worksheets #12 and #15 of this QAPP.

To determine project-specific analytical methods, the Program Manager will take into consideration toxicological levels, remediation goals, screening levels, and maximum contaminant levels. Whenever, possible, the level of reporting should be ten times below the action level.

Field QC samples are QC samples collected in the field and shipped in coolers with investigative samples for the purpose of evaluating data quality. Types of field QC samples collected may include field duplicates, field blanks, MS/MSD samples, PFAS blank samples, VOC trip blanks, and temperature indicator bottles.

Regardless of the laboratory and analytical method, all soils should be reported on a dry-weight basis.



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## Field QC Samples

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### ***Field Blanks***

Field blanks consist of blank matrix samples collected in the field and are normally an aqueous matrix. Field blanks include ambient field blanks, equipment blanks, trip blanks, and lot blanks. Each field blank type is described below. The need for collection of field blanks will be evaluated during the project planning process and be identified in the Work Plan.

### ***Ambient Field Blank***

An ambient field blank is primarily used to provide information about contaminants that may be introduced into samples from the atmosphere during sample collection. In addition, the ambient field blank may also be exposed to contamination during storage, transport, sample preparation, and analysis.

The ambient field blank is an aqueous sample exposed to field conditions to evaluate the potential for contamination by ambient site contaminants. Ambient field blank samples will only be collected for the collection of water samples for volatile constituents such as VOCs, PFAS blank, gasoline-range organics (GRO), and wherever specifically required by the analytical method. Ambient field blanks will not be collected for soil samples.

Analyte-free water, typically distilled or deionized (DI) water, is carried to the sampling site in sealed containers, exposed to sampling conditions upon transfer into sample containers, preserved, transported to the laboratory, and treated as an environmental sample. Since field blanks are transported, stored, prepared, and analyzed in the laboratory, they may be exposed to contamination from both field and laboratory sources. Method blank results, which aid in identifying laboratory cross-contamination, are used to evaluate potential sources of contamination in field blanks during data validation. Certain drinking water methods refer to the field blank as a field reagent blank. For the purpose of streamlining QAPP worksheets, field reagent blanks and ambient field blanks will be referred to as “ambient field blanks.”

Ambient field blanks will be collected at a minimum frequency of one per day or 1 per 20 water samples, whichever is more frequent. Ambient field blanks will be shipped to the same laboratory as the associated samples and analyzed for the same analytical parameters.

### ***Equipment Blanks (Rinsate Blank)***

An equipment blank (i.e., “rinsate blank” or “equipment rinsate blank”) consists of a sample of analyte-free DI water poured over or through decontaminated field sampling equipment. Equipment blanks will be collected from non-disposable sampling equipment and heavy machinery and will primarily be used to assess the adequacy of the equipment decontamination process. Since equipment blanks are transported, stored, prepared, and analyzed in the laboratory, they may be exposed to contamination from both field and laboratory sources. The method blank results, which would aid in identifying laboratory cross-contamination, are used to evaluate potential sources of contamination in equipment blanks during data validation.

Equipment blanks will be collected at a minimum frequency of one per day per matrix or 1 per 20 samples per matrix, whichever is more frequent. Equipment blanks and heavy equipment blanks will be shipped to the same laboratory as the associated samples and analyzed for the same analytical parameters.

### ***Trip Blank***

A trip blank is primarily used to provide information about volatile contaminants that may be introduced into field samples during transport and sample storage. A trip blank is a sample of analyte-free media prepared by the laboratory that accompanies the sampling kits through all of the sample collection and transportation operations. The trip blank is analyzed for the same target analytes to identify storage and transportation cross-contamination. Since trip blanks are transported, stored, prepared and analyzed in the laboratory, they may be exposed to contamination from both field and laboratory sources. During data validation, the method blank results aid in identifying laboratory contaminants and the trip blanks are used to evaluate potential sources of contamination due to storage/shipping issues.

Trip blanks will be collected at a minimum frequency of one per cooler of VOC and GRO samples. Trip blanks will be shipped to the same laboratory as the associated VOC and GRO samples and analyzed for the same list of target analytes.

### ***Lot Blank***

A lot blank is primarily used to identify contamination from the sampling media used to collect field samples (e.g., filters from cartridges used to collect air samples, gauze, and Ghost wipes media for wipe samples). The lot blank sample consists of an unopened unit of sampling media that can be tracked by lot number, and is assigned a sample identifier, accompanies the field samples to the laboratory, and is analyzed for the same target analytes. Lot blank results are used in conjunction with method blank results to aid in identifying the source of contaminants which may impact field sample results.

### ***Field Duplicate***

A field duplicate is a field sample collected at the same time and in the same location as another sample or its associated “parent sample”. A pair of field duplicate samples are collected using the same equipment, placed in separate but identical types of sample containers, and preserved in the same manner. Field duplicates are shipped to the laboratory and are treated as separate samples by the laboratory for laboratory analysis. Field duplicates provide information on the precision of the sample collection and the overall analytical process. There are two categories of field duplicate samples which are defined by the sample collection method: co-located field duplicates and subsample field duplicates.

Co-located field duplicates are independent samples collected from side-by-side locations at the same point in time and space to be considered identical. Co-located field duplicate samples are homogenized individually (except for VOC/GRO samples) prior to placement in the sample container. An example of co-located field duplicates is soil samples collected for VOC analysis which are collected side-by-side using EnCore or similar sampling devices. It is not acceptable to homogenize soil for VOC analysis due to loss of VOCs during the homogenization process; therefore, collecting co-located field duplicates for VOCs is the only acceptable sampling method.

Subsample field duplicate samples are obtained from one sample collection at one sample location. Soil field duplicate samples will be homogenized and subsampled in the field into separate sample containers with separate sample identifiers to generate an original (parent) sample and a field duplicate sample.

Field duplicate samples will be collected at a frequency of 10% (1 field duplicate for every 10 samples collected per matrix). Depending on the site DQOs, field duplicates may not be collected for some sample



types; for example, a sample collected solely for the purpose of waste characterization would not require field duplicate analysis.

### ***Temperature Indicator***

A temperature indicator is a container of water that is packed and shipped to the laboratory with the field samples requiring preservation by cooling to  $\leq 6$  degrees Celsius ( $^{\circ}\text{C}$ ). Upon opening the sample cooler, the laboratory measures the temperature of the temperature indicator. The temperature reading is used to document whether field samples were received within the acceptable temperature range. This information is used by both the laboratory and by the data validator. If the temperature indicator is outside the acceptance criteria, the laboratory is expected to notify the QA Manager immediately for guidance on whether to proceed with analysis. The QA Manager, in conjunction with program management, will direct the laboratory on whether to analyze the samples or if re-sampling may be required. It should be noted that samples received by the laboratory on the same day as collection may not have adequate time to achieve ideal preservation temperatures. Generally, by providing the laboratory documentation as evidence that the preservation process is underway during sample receipt (e.g., solid ice remaining in the cooler), data quality will not likely be impacted.

## **Laboratory QC Samples**

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Laboratory QC sample types typically include method blanks, instrument blanks, storage blanks, laboratory control samples (LCS), laboratory duplicates, and matrix spike/matrix spike duplicate (MS/MSDs). Surrogates are not separate QC samples. They are compounds added to field and QC samples to evaluate instrument calibration, extraction efficiency, and matrix interference on a sample-specific basis. They are commonly reported by the analytical laboratory and are therefore included in Worksheet #12.

### ***Method Blank***

The laboratory method blank consists of analyte-free reagent water or solid matrix to which solvents, surrogates, internal standards, etc. are added in the same volumes or proportions as in field samples of the same matrix. The method blank is then carried through the complete sample preparation and analytical process. The purpose of the method blank is to assess contamination introduced during the sample preparation process. A method blank shall be included in every volatile analytical or extraction/digestion/distillation batch. Most but not all analytical methods define a batch as including up to 20 samples analyzed or prepared within a 7-day period. Certain analytical methods refer to the laboratory method blank as a laboratory reagent blank (LRB). *For the purpose of streamlining QAPP worksheets, LRBs will be referred to as “method blanks.”*

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## **Instrument Blanks**

Instrument blanks consist of analyte-free water samples which are introduced as sample injections into analytical instruments to verify that the analytical system of measurement is clean. Instrument blanks are either incorporated as a requirement into the analytical method (e.g., metals, pesticides, and PCBs) or often injected after a highly contaminated sample.

## **Laboratory Control Sample**

The LCS consists of analyte-free water (for analysis of aqueous samples), or analyte-free solid matrix (for analysis of solid samples) spiked with the known quantities of target analytes of interest. LCS samples are not required for all analytical methods. The LCS is analyzed to assess accuracy by measuring analyte recovery from a clean matrix. LCS samples are prepared at the same frequency as method blanks: one per analytical or extraction/digestion/distillation batch. Certain analytical methods refer to the LCS as a laboratory fortified blank (LFB). For the purpose of streamlining QAPP worksheets, LFBs will be referred to as laboratory control samples or "LCS."

## **Laboratory Duplicate Samples**

Laboratory duplicate samples are performed by splitting a field sample into two separate aliquots and performing separate analyses on each aliquot. The analysis of laboratory duplicate samples monitors laboratory precision; however, it may be affected by sample non-homogeneity, particularly in the case of non-aqueous samples. Laboratory duplicates are typically performed for inorganic analyses (e.g., metals, mercury, and cyanide) and certain drinking water methods.

For the purposes of streamlining QAPP worksheets and maintaining sampling program consistency, laboratory duplicates will be collected only for inorganic test parameters. Organic MS/MSD samples will be collected in lieu of laboratory duplicates for drinking water methods because many target analytes organics are frequently not detected in drinking water samples and often do not provide sufficient evaluation of laboratory precision; the MSD allows for evaluating laboratory precision.

A laboratory duplicate will be run for every preparation batch of up to 20 inorganic field samples. In the case of VOCs, double the amount will be collected. Typically, laboratories require two to three sample containers for each sample location, therefore four to six sample containers will be collected for laboratory MS/MSD analyses (nine TerraCores or six EnCore sample tubes will be collected for soil/sediment matrix). The need for collection of additional sample volume for the field sample designated for laboratory duplicate analysis will be evaluated during the project planning process in conjunction with the QAM.

## **Matrix Spikes/Matrix Spike Duplicates (MS/MSD)**

A MS is prepared from an aliquot of a field sample that is spiked by the laboratory with known concentrations of method-specific target analytes, then carried through the entire sample preparation and analytical process. Accuracy is calculated from the spike recoveries in the matrix spike sample and results are used to assess the nature of the sample matrix and direction of analytical bias. Certain organic methods often refer to the MS as a laboratory fortified sample matrix (LFSM).

An MSD is prepared from a second aliquot of a field sample that is spiked by the laboratory with known concentrations of method-specific target analytes, then carried through the entire sample preparation and analytical process. Accuracy is calculated from the spike recoveries in the matrix spike duplicate sample

and direction of analytical bias. The precision between the MS and MSD can also be calculated mathematically as the relative percent difference (RPD) and results are used to assess the nature of the sample matrix. Certain organic methods often refer to the MSD as a laboratory fortified sample matrix duplicate (LFSMD) for the purpose of streamlining QAPP worksheets.

Laboratory QC for inorganic samples typically includes a single MS analysis (e.g., metals, mercury, and cyanide) collected at a frequency of 1 per 20 field samples.

MS and MSD are typically performed for organic analyses; a minimum of one MS/MSD pair will be collected per 20 field samples for each matrix collected. Sampling locations selected for the purpose of assigning an MS/MSD should be an area anticipated to be free from contamination or with low concentrations of targeted analytes. During collection of soil MS/MSD samples, field personnel will avoid areas that are stained or known or suspected to have high levels of contamination. The need for collection of MS and MSDs will be evaluated during the site scoping process in conjunction with the QAM.

MSD samples will be collected in lieu of laboratory duplicates for organic gas chromatography (GC) and high-performance liquid chromatography (HPLC) methods. Frequently, many organic target analytes are not detected in drinking water samples and often do not provide sufficient evaluation of laboratory precision; the MSD allows for evaluating laboratory precision. MS/MSD analyses are not conducted for air samples analyzed by Method TO-15.

### **Surrogate Spikes**

Surrogates are organic compounds similar to the target analyte(s) in structure and chemical behavior but are not normally detected in environmental samples. Surrogate results are used to evaluate accuracy, method performance, and extraction efficiency. Surrogate compounds are spiked by the laboratory into environmental samples, QC samples, and blank samples according to method requirements. Several organic methods refer to surrogates as deuterated monitoring compounds (DMC). For the purpose of streamlining QAPP worksheets, surrogates and DMCs will be referred to as “surrogates.”

## WORKSHEET #12.1: MEASUREMENT PERFORMANCE CRITERIA FOR VOLATILE ORGANIC COMPOUNDS (VOCs) BY GC/MS

**Matrix:** Water, Drinking Water, Soil/Sediment, Solid, Waste, TCLP Leachate, SPLP Leachate, Air (ambient, indoor, and soil gas)

**Analytical Group/Method:** VOCs/ SW-846 8260C/D, EPA 624.1, EPA 524.2, TO-15

**Concentration Level:** Trace/Low/Medium

Data Quality Indicators (DQIs)	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Precision - Overall	Field Duplicates: 1 per 10 field samples or fewer per matrix (Water, drinking water, and soil/sediment matrices; not required for Waste or TCLP/SPLP leachates)	Water RPD: ≤30%; Soil RPD: ≤50%; Air RPD: ≤30%
Accuracy/Bias - Laboratory	LCS: 1 per analysis batch of up to 20 samples (Full list LCS is required for SW-846 8260C/D, EPA 624.1, and EPA 524.2)	%R within statistically derived laboratory acceptance limits
Precision and Accuracy/Bias – Laboratory (matrix interference)	MS/MSD: 1 MS/MSD per 20 or fewer samples per matrix	Air (TO-15) – If laboratory has capability, if not lab should do LCS/LCSD. %R within statistically derived laboratory acceptance limits RPD within statistically derived control limits developed by the laboratory
Accuracy/Bias – Laboratory	Surrogates added to each field and QC sample as specified by the method and/or laboratory SOP	%R within statistically derived control limits developed by the laboratory if not specifically stated in the NFGs
Accuracy/Bias (Laboratory Contamination)	Laboratory Blanks include: <ul style="list-style-type: none"> <li>SW-846 8260C/D: 1 per 12-hour shift</li> <li>Method blank (EPA 624.1): 1 per day (minimum)</li> <li>Method blank (EPA 524.2): 1 per 8-hour shift</li> <li>Method blank for TO-15: 1 per 24-hour shift</li> <li>Instrument blank (all methods): after samples with analytes exceeding the instrument calibration range or detector saturation.</li> <li>TCLP/SPLP LEB (SW-846 8260C/D): 1 per extraction batch of up to 20 samples</li> </ul>	<u>SW-846 8260C/D Blanks:</u> <ul style="list-style-type: none"> <li>Method: analyte concentrations &lt; LOQ</li> <li>Instrument: analyte concentrations &lt; LOQ</li> <li>Storage: not required; trip blank results may be used to monitor for contamination during storage</li> <li>TCLP/SPLP LEB: required but no acceptance criteria</li> </ul> <u>EPA 624.1 and EPA 524.2 Blanks:</u> <ul style="list-style-type: none"> <li>Method: analyte concentrations &lt; LOQ</li> <li>Instrument: analyte concentrations &lt; LOQ</li> <li>Storage: none, refer to field reagent blank</li> </ul>

Data Quality Indicators (DQIs)	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Overall Accuracy/Bias (Contamination)	Field Blanks include: <ul style="list-style-type: none"> <li>• Trip Blank – 1 trip blank per cooler containing samples for VOC analysis</li> <li>• Equipment Blank – 1 per 20 samples, minimum 1 per day for non-dedicated equipment</li> <li>• Ambient Field Blank<sup>1</sup></li> </ul>	<ul style="list-style-type: none"> <li>• All analyte concentrations &lt; LOQ</li> </ul>
Sensitivity (method)	Review Laboratory LOQs and MDLs <sup>2</sup>	Action Level at least 3 to 10x > LOQ, if feasible
Completeness	Review data package for required elements	Refer to Worksheet #37

Notes:

QC Samples for VOCs by GC/MS are listed along with their method-specified frequency and MPCs.

Soil samples for VOCs will be collected using EnCore or equivalent sampling devices or using Terra-Core devices and placed in tared VOA vials in the field. Soil samples for VOCs only will also require collection of a separate jar for percent solids determination. Refer to optimized QAPP Worksheet #19&30 for details.

- 1 Ambient field blanks will be collected for aqueous VOC and GRO regardless of whether an Equipment Blank is collected. Equipment blanks are not required if the sample is collected with dedicated sampling equipment.
- 2 Laboratory LOQs and MDLs will be reviewed prior to award of an analytical services subcontract to a laboratory. Laboratory LOQs and MDLs will be compared with RSLs or other appropriate action levels in the DQOs and sampling design prepared for each site.

%R = percent recovery

GC/MS = Gas Chromatography/Mass Spectrometry

LCS = Laboratory Control Sample

LEB = Leachate Extraction Blank

LOQ = Limit of Quantitation

MDL = Method Detection Limit

MS = Matrix Spike

MSD = Matrix Spike Duplicate

QC = Quality Control

RPD = Relative Percent Difference

SDG = Sample Delivery Group

SPLP = Synthetic Precipitation Leaching Procedure

TCLP = Toxicity Characteristic Leaching Procedure

VOC = Volatile Organic Compound

## WORKSHEET #12.2: MEASUREMENT PERFORMANCE CRITERIA FOR SEMIVOLATILE ORGANIC COMPOUNDS (SVOCs) INCLUDING POLYNUCLEAR AROMATIC HYDROCARBONS (PAHS) BY GC/MS WITH/WITHOUT SELECTED ION MONITORING (SIM)

**Matrix:** Water, Drinking Water, Soil/Sediment, Solid, Wipe, Waste, TCLP Leachate, SPLP Leachate

**Analytical Group/Method:** SVOCs/SW-846 8270D/E, EPA 625.1, EPA 525.2

**Concentration Level:** Trace/Low/Medium

Data Quality Indicators (DQIs)	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Precision - Overall	Field Duplicates: 1 per 10 field samples or fewer per matrix (Water, drinking water, and soil/sediment matrices; not required for Wipe, Waste or TCLP/SPLP leachates)	Water RPD: ≤30% Soil RPD: ≤50%
Accuracy/Bias - Laboratory	LCS: 1 per analysis batch of up to 20 samples of each matrix (Full list LCS is required for SW-846 8270D/E, EPA 625.1, and EPA 525.2)	%R within statistically derived laboratory acceptance limits
Precision and Accuracy/Bias – Laboratory (matrix interference)	MS/MSD: 1 MS/MSD per 20 or fewer samples per matrix	%R within statistically derived laboratory acceptance limits RPD within statistically derived control limits developed by the laboratory
Accuracy/Bias – Laboratory	Surrogates added to each field and QC sample as specified by the method and laboratory SOP	%R within statistically derived control limits developed by the laboratory if not specifically stated in the NFGs
Accuracy/Bias (Laboratory Contamination)	Laboratory Blanks include: <ul style="list-style-type: none"> <li>Method blank (all methods): 1 per extraction batch of 20 samples</li> <li>Instrument blank (all methods): run after high concentration samples or detector saturation</li> <li>TCLP/SPLP LEB (SW-846 8270D/E): 1 per TCLP/SPLP extraction batch of 20 samples</li> </ul>	<u>SW-846 8270C/D Blanks:</u> <ul style="list-style-type: none"> <li>Method: analyte concentrations &lt; LOQ</li> <li>Instrument: analyte concentrations &lt; LOQ</li> <li>TCLP/SPLP LEB: required but no acceptance criteria</li> </ul> <u>EPA 625.1 and EPA 525.2 Blanks:</u> <ul style="list-style-type: none"> <li>LRB (method blank): analyte concentrations &lt; LOQ</li> <li>Instrument: analyte concentrations &lt; LOQ</li> </ul>
Overall Accuracy/Bias (Contamination)	Field Blanks include: Equipment Blank – 1 field blank per 20 samples, minimum 1 field blank per day for non-dedicated equipment Lot Blank (wipes only) – 1 per lot of media <sup>1</sup>	<ul style="list-style-type: none"> <li>All analyte concentrations &lt; LOQ</li> </ul>

Data Quality Indicators (DQIs)	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Sensitivity (method)	Review Laboratory LOQs and MDLs against action limits <sup>2</sup>	Action Level at least 3 to 10x > LOQ, if feasible
Completeness	Review data package for required elements	Refer to Worksheet #37

Notes:

QC Samples for SVOCs by GC/MS are listed along with their method-specified frequency and MPCs.

1 Blank media which have not been opened and exposed to the sampling environment will be provided as lot blanks.

2 Laboratory LOQs and MDLs will be reviewed prior to award of an analytical services subcontract to a laboratory. Laboratory LOQs and MDLs will be compared with RSLs or other appropriate action levels in the DQOs and sampling design prepared for each site.

%R = percent recovery

GC/MS = Gas Chromatography/Mass Spectrometry

LCS = Laboratory Control Sample

LEB = Leachate Extraction Blank

LOQ = Limit of Quantitation

LRB = Laboratory Reagent Blank

MDL = Method Detection Limit

MS = Matrix Spike

MSD = Matrix Spike Duplicate

RPD = Relative Percent Difference

SPLP = Synthetic Precipitation Leaching Procedure

TCLP = Toxicity Characteristic Leaching Procedure



## WORKSHEET #12.3: MEASUREMENT PERFORMANCE CRITERIA FOR ORGANOCHLORINE (OC) PESTICIDES BY GC/ECD

**Matrix:** Water, Drinking Water, Soil/Sediment, Solid, Wipe, Waste, TCLP Leachate, SPLP Leachate

**Analytical Group/Method:** Pesticides/ SW-846 8081B, EPA 608.3, EPA 508.1

**Concentration Level:** Low

Data Quality Indicators (DQIs)	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Precision - Overall	Field Duplicates: 1 per 10 field samples or fewer per matrix (Water, drinking water, and soil/sediment matrices; not required for Wipe, Waste or TCLP/SPLP leachates)	Water RPD: ≤30% Soil RPD: ≤50%
Accuracy/Bias - Laboratory	LCS: 1 per analysis batch of up to 20 samples of each matrix (Full list spike is required for SW-846 8081B, EPA 608.3, and EPA 508.1)	%R within statistically derived laboratory acceptance limits
Precision and Accuracy/Bias – Laboratory (matrix interference)	MS/MSD: 1 MS/MSD per 20 or fewer samples per matrix	SW-846 8081B, EPA 608.3: %R within statistically derived laboratory acceptance limits if not specifically stated in the NFGs EPA 508.1: %R within 70-130% RPDs within statistically derived laboratory acceptance limits
Accuracy/Bias – Laboratory	Surrogates added to each field and QC sample as specified by the method and laboratory SOP	%R within statistically derived laboratory acceptance limits
Accuracy/Bias (Laboratory Contamination)	Laboratory Blanks include: <ul style="list-style-type: none"> <li>Method blank (all methods): 1 per extraction batch</li> <li>Instrument blank: After high concentration samples</li> <li>TCLP/SPLP LEB (SW-846 8081B): 1 per extraction batch of 20 samples</li> </ul>	<ul style="list-style-type: none"> <li>Method: analyte concentrations &lt; LOQ</li> <li>Instrument: analyte concentrations &lt; LOQ</li> <li>TCLP/SPLP LEB: required but no acceptance criteria</li> </ul>
Overall Accuracy/Bias (Contamination)	Field Blanks include: <ul style="list-style-type: none"> <li>Equipment Blank – 1 field blank per 20 samples, minimum 1 field blank per day for non-dedicated equipment</li> <li>Lot Blank (wipes only) – 1 per lot of media<sup>1</sup></li> </ul>	All analyte concentrations < LOQ
Sensitivity (method)	Review Laboratory LOQs and MDLs against action limits <sup>2</sup>	Action Level at least 3 to 10x > LOQ, if feasible
Completeness	Review data package for required elements	Refer to Worksheet #37



## Notes:

- 1 Blank media which have not been opened and exposed to the sampling environment will be provided as lot blanks.
- 2 Laboratory LOQs and MDLs will be reviewed prior to award of an analytical services subcontract to a laboratory. Laboratory LOQs and MDLs will be compared with RSLs or other appropriate action levels in the DQOs and sampling design prepared for each site.

%R = percent recovery

GC/ECD = Gas Chromatography/Electron Capture  
Detector

LCS = Laboratory Control Sample

LEB = Leachate Extraction Blank

LOQ = Limit of Quantitation

MDL = Method Detection Limit

MS = Matrix Spike

MSD = Matrix Spike Duplicate

QC = Quality Control

RPD = Relative Percent Difference

SPLP = Synthetic Precipitation Leaching Procedure

TCLP = Toxicity Characteristic Leaching Procedure

## WORKSHEET #12.4: MEASUREMENT PERFORMANCE CRITERIA FOR POLYCHLORINATED BIPHENYLS (PCBs) AS AROCLORS BY GC/ECD

**Matrix:** Water, Soil/Sediment, Solid, Wipe, Waste

**Analytical Group/Method:** PCBs (Aroclors)/ SW-846 8082A, EPA 608.3

**Concentration Level:** Low

Data Quality Indicators (DQIs)	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Precision - Overall	Field Duplicates: 1 per 10 field samples or fewer per matrix (Water and soil/sediment matrices; not required for Wipe and Waste)	Water RPD: ≤30% Soil RPD: ≤50%
Accuracy/Bias - Laboratory	LCS: 1 per analysis batch of up to 20 samples of each matrix	%R within statistically derived laboratory acceptance limits
Precision and Accuracy/Bias – Laboratory (matrix interference)	MS/MSD: 1 per 20 samples or fewer of each matrix	%R within statistically derived laboratory acceptance limits RPDs within statistically derived laboratory acceptance limits
Accuracy/Bias – Laboratory	Surrogates added to each field and QC sample as specified by the method and laboratory SOP	%R within statistically derived laboratory acceptance limits if not specifically stated in the NFGs
Accuracy/Bias (Laboratory Contamination)	Laboratory Blanks include: <ul style="list-style-type: none"> <li>Method blank for SW-846 8082A: 1 per extraction batch of 20 samples</li> <li>Instrument blank: At the beginning and the end every 12-hour period in which samples were analyzed and/or after high concentration samples</li> </ul>	<ul style="list-style-type: none"> <li>Method: analyte concentrations &lt; LOQ</li> <li>Instrument: analyte concentrations &lt; LOQ</li> </ul>
Overall Accuracy/Bias (Contamination)	Field Blanks include: <ul style="list-style-type: none"> <li>Equipment Blank – 1 field blank per 20 samples, minimum 1 field blank per day for non-dedicated equipment</li> <li>Lot Blank (wipes only) – 1 per lot of media<sup>1</sup></li> </ul>	All analyte concentrations < LOQ
Sensitivity (method)	Review Laboratory LOQs and MDLs against action limits <sup>2</sup>	Action Level at least 3 to 10x > LOQ, if feasible
Completeness	Review data package for required elements	Refer to Worksheet #37

## Notes:

- 1 Blank media which have not been opened and exposed to the sampling environment will be provided as lot blanks.
- 2 Laboratory LOQs and MDLs will be reviewed prior to award of an analytical services subcontract to a laboratory. Laboratory LOQs and MDLs will be compared with RSLs or other appropriate action levels in the DQOs and sampling design prepared for each site.

%R = percent recovery

GC/ECD = Gas Chromatography/Electron Capture  
Detector

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

MDL = Method Detection Limit

MS = Matrix Spike

MSD = Matrix Spike Duplicate

QC = Quality Control

RPD = Relative Percent Difference

SOP = Standard Operating Procedure

## WORKSHEET #12.5: MEASUREMENT PERFORMANCE CRITERIA FOR CHLORINATED HERBICIDES BY GC/ECD

**Matrix:** Water, Soil/Sediment, Solid, Waste/TCLP or SPLP Leachate

**Analytical Group/Method:** Herbicides/ SW-846 8151A, EPA 615

**Concentration Level:** Low

Data Quality Indicators (DQIs)	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Precision - Overall	Field Duplicates: 1 per 10 field samples or fewer per matrix (Water/soil/sediment matrices; not required for Waste or TCLP/SPLP leachate)	Water RPD: ≤30% Soil RPD: ≤50%
Accuracy/Bias - Laboratory	LCS: 1 per extraction batch of up to 20 samples of each matrix ( <i>Full list spike is required</i> )	%R within statistically derived laboratory acceptance limits
Precision and Accuracy/Bias – Laboratory (matrix interference)	MS/MSD: 1 per 20 samples or fewer of each matrix	%R within statistically derived laboratory acceptance limits RPDs within statistically derived laboratory acceptance limits
Accuracy/Bias – Laboratory	Surrogates added to each field and QC sample as specified by the method and laboratory SOP	%R within statistically derived laboratory acceptance limits
Accuracy/Bias (Laboratory Contamination)	Laboratory Blanks include: <ul style="list-style-type: none"> <li>Method blank: 1 per extraction batch</li> <li>Instrument blank: After high concentration samples</li> <li>TCLP/SPLP LEB: 1 per extraction batch of 20 samples</li> </ul>	<u>SW-846 8151A Blanks:</u> <ul style="list-style-type: none"> <li>Method: analyte concentrations &lt; Reporting Limits</li> <li>Instrument: analyte concentrations &lt; MDL</li> <li>TCLP/SPLP LEB: required but no acceptance criteria</li> </ul>
Overall Accuracy/Bias (Contamination)	Field Blanks include: Equipment Blank – 1 field blank per 20 samples, minimum 1 field blank per day for non-dedicated equipment	All analyte concentrations < LOQ
Sensitivity (method)	Review Laboratory LOQs and MDLs against action limits <sup>1</sup>	Action Level at least 3 to 10x > LOQ, if feasible
Completeness	Review data package for required elements	Refer to Worksheet #37

## Notes:

- 1 Laboratory RLs and MDLs will be reviewed prior to award of an analytical services subcontract to a laboratory. Laboratory LOQs and MDLs will be compared with RSLs or other appropriate action levels in the DQOs and sampling design prepared for each site.

%R = percent recovery

GC/ECD = Gas Chromatography/Electron Capture  
Detector

LCS = Laboratory Control Sample

LEB = Leachate Extraction Blank

LOQ = Limit of Quantitation

MDL = Method Detection Limit

MS = Matrix Spike

MSD = Matrix Spike Duplicate

QC = Quality Control

RPD = Relative Percent Difference

SOP = Standard Operating Procedure

SPLP = Synthetic Precipitation Leaching Procedure

TCLP = Toxicity Characteristic Leaching Procedure

## WORKSHEET #12.6: MEASUREMENT PERFORMANCE CRITERIA FOR NONHALOGENATED ORGANIC COMPOUNDS (GASOLINE RANGE ORGANICS [GRO], DIESEL RANGE ORGANICS [DRO], RESIDUAL RANGE ORGANICS [RRO]) BY GC/FID

**Matrix:** Water, Soil/Sediment, Waste

**Analytical Group/Method:** AK101/102/103

**Concentration Level:** Low

Data Quality Indicators (DQIs)	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Precision - Overall	Field Duplicates: 1 per 10 field samples or fewer per matrix	Water RPD: $\leq 30\%$ Soil RPD: $\leq 50\%$
Accuracy/Bias - Laboratory	LCS: 1 per analysis batch of up to 20 samples	%R within statistically derived control limits developed by the laboratory
Precision and Accuracy/Bias – Laboratory (matrix interference)	MS/MSD: 1 per 20 samples or fewer of each matrix	%R within statistically derived control limits developed by the laboratory RPD within statistically derived control limits developed by the laboratory
Accuracy/Bias – Laboratory	Surrogates added to each field and QC sample as specified by the method and laboratory SOP	%R within statistically derived laboratory acceptance limits
Accuracy/Bias (Laboratory Contamination)	Laboratory Blanks include: <ul style="list-style-type: none"> <li>Method blank: 1 per extraction batch</li> <li>Instrument blank: after high concentration samples or when interference is suspected</li> </ul>	<ul style="list-style-type: none"> <li>Method: analyte concentrations &lt; LOQ</li> <li>Instrument: analyte concentrations &lt; LOQ</li> </ul>
Overall Accuracy/Bias (Contamination)	Field Blanks include: <ul style="list-style-type: none"> <li>Trip Blank (GRO only)</li> <li>Equipment Blank</li> <li>Ambient field blank (GRO only) <sup>1</sup></li> </ul>	All analyte concentrations < LOQ
Sensitivity (method)	Review Laboratory LOQs and MDLs against action limits <sup>2</sup>	Action Level at least 3 to 10x > LOQ, if feasible
Completeness	Review data package for required elements	Refer to Worksheet #37

## Notes:

- 1 Ambient field blanks for GRO will be collected for aqueous samples regardless of whether an Equipment Blank is collected. Equipment blanks are not required if the sample is collected with dedicated sampling equipment.
- 2 Laboratory LOQs and MDLs will be reviewed prior to award of an analytical services subcontract to a laboratory. Laboratory LOQs and MDLs will be compared with RSLs or other appropriate action levels in the DQOs and sampling design prepared for each site.

%R = percent recovery

GC/FID = Gas Chromatography/Flame Ionization  
Detector

GRO = Gasoline Range Organic

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

MDL = Method Detection Limit

MS = Matrix Spike

MSD = Matrix Spike Duplicate

QC = Quality Control

RPD = Relative Percent Difference

SOP = Standard Operating Procedure

## WORKSHEET #12.7: MEASUREMENT PERFORMANCE CRITERIA FOR METALS AND MERCURY

**Matrix:** Water, Drinking water, Soil/Sediment, Solid, Waste, Wipe, TCLP and SPLP Leachates

**Analytical Group/Method:** Metals and Mercury / SW-846 6010C/D, EPA 200.7, SW-846 6020B, EPA 200.8, SW-846 7470A/7471B, EPA 245.1, EPA 245.2

**Concentration Level:** Low

Data Quality Indicators (DQIs)	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Precision - Overall	Field Duplicates: 1 per 10 field samples or fewer per matrix (Required for water, drinking water, and soil/sediment; not required for Solid, Waste, Wipe, or TCLP/SPLP leachates)	Water RPD: ≤30% Soil RPD: ≤50%
Precision - Laboratory	Lab Duplicate: (Required for water, drinking water, and soil/sediment; not required for Solid, Wipe, and TCLP/SPLP leachates)	RPD within statistically derived control limits developed by the laboratory if not specifically stated in the NFGs
Accuracy/Bias - Laboratory	LCS: 1 per analysis batch of up to 20 samples	%R within statistically derived control limits developed by the laboratory
Precision and Accuracy/Bias – Laboratory (matrix interference)	MS: 1 per 20 samples or fewer of each matrix	%R within statistically derived control limits developed by the laboratory if not specifically stated in the NFGs
Accuracy/Bias (Laboratory Contamination)	Laboratory Blanks include: <ul style="list-style-type: none"> <li>Method blank: 1 per extraction batch</li> <li>Instrument blank: at beginning of analytical run (ICB), and after every 10 analytical samples (CCB)</li> <li>TCLP/SPLP LEB: 1 per extraction batch of 20 samples</li> </ul>	<ul style="list-style-type: none"> <li>Method: analyte concentrations &lt; LOQ</li> <li>Instrument: analyte concentrations &lt; LOQ</li> <li>TCLP/SPLP LEB: required but no acceptance criteria</li> </ul>
Overall Accuracy/Bias (Contamination)	Field Blanks include:  Equipment Blank – 1 field blank per 20 samples, minimum 1 field blank per day for non-dedicated equipment	All analyte concentrations < LOQ
Sensitivity (method)	Review Laboratory LOQs and MDLs against action limits <sup>1</sup>	Action Level at least 3 to 10x > LOQ, if feasible
Completeness	Review data package for required elements	Refer to Worksheet #37

**Notes:**

- <sup>1</sup> Laboratory LOQs and MDLs will be reviewed prior to award of an analytical services subcontract to a laboratory. Laboratory LOQs and MDLs will be compared with RSLs or other appropriate action levels in the DQOs and sampling design prepared for each site.



%R = percent recovery  
CCB = continuing calibration blank  
ICB = initial calibration blank  
LCS = Laboratory Control Sample

LEB = Leachate Extraction Blank  
LOQ = Limit of Quantitation  
MDL = Method Detection Limit  
MS = Matrix Spike

NFG = National Functional Guidelines  
RPD = Relative Percent Difference  
SPLP = Synthetic Precipitation Leaching Procedure  
TCLP = Toxicity Characteristic Leaching Procedure

## WORKSHEET #12.8: MEASUREMENT PERFORMANCE CRITERIA FOR TOTAL CYANIDE

**Matrix:** Water, Drinking Water, Soil/Sediment, Solid, Waste

**Analytical Group/Method:** Total Cyanide / SW-846 9012A/B, EPA 335.4

**Concentration Level:** Low

Data Quality Indicators (DQIs)	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Precision - Overall	Field Duplicates: 1 per 10 field samples or fewer per matrix (Required for water, drinking water, and soil/sediment matrices; not required for Solid or Waste)	Water RPD: ≤30% Soil RPD: ≤50%
Accuracy/Bias - Laboratory	LCS: 1 per analysis batch of up to 20 samples	%R within statistically derived control limits developed by the laboratory
Precision and Accuracy/Bias – Laboratory (matrix interference)	MS/MSD: 1 per 20 samples or fewer of each matrix	%R within statistically derived control limits developed by the laboratory if not specifically stated in the NFGs RPD within statistically derived control limits developed by the laboratory if not specifically stated in the NFGs
Accuracy/Bias (Laboratory Contamination)	Laboratory Blanks include: <ul style="list-style-type: none"> <li>Preparation (Method) blank: 1 per distillation batch</li> <li>Instrument blank: at beginning of analytical run (ICB), and hourly and after every CCV (CCB)</li> </ul>	<ul style="list-style-type: none"> <li>Method: analyte concentrations &lt; LOQ</li> <li>Instrument: analyte concentrations &lt; LOQ</li> </ul>
Overall Accuracy/Bias (Contamination)	Field Blanks include: <ul style="list-style-type: none"> <li>Equipment Blank – 1 field blank per 20 samples, minimum 1 field blank per day for non-dedicated equipment</li> </ul>	All analyte concentrations < LOQ
Sensitivity (method)	Review Laboratory LOQs and MDLs against action limits <sup>1</sup>	Action Level at least 3 to 10x > LOQ, if feasible
Completeness	Review data package for required elements	Refer to Worksheet #37

Notes:

<sup>1</sup> Laboratory LOQs and MDLs will be reviewed prior to award of an analytical services subcontract to a laboratory. Laboratory LOQs and MDLs will be compared with RSLs or other appropriate action levels in the DQOs and sampling design prepared for each site.

%R = percent recovery

CCB = continuing calibration blank

CCV = continuing calibration verification

ICB = initial calibration blank

ICV = Initial Calibration Verification

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

MDL = Method Detection Limit

MS = Matrix Spike

MSD = Matrix Spike Duplicate

NFG = National Functional Guideline

RPD = Relative Percent Difference

## WORKSHEET #12.9: MEASUREMENT PERFORMANCE CRITERIA FOR DIOXINS/FURANS BY HRGC/HRMS

**Matrix:** Water, Soil/Sediment, Sludge, Tissue, Ash, Oil/Oily matrices

**Analytical Group/Method:** Dioxins/Furans (Chlorinated dibenzo-p-dioxins /Chlorinated dibenzofurans) / SW-846 8290A

**Concentration Level:** Low

Data Quality Indicators (DQIs)	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Precision - Overall	Field Duplicates: 1 per 10 field samples or fewer per matrix (Required for water, drinking water, and soil/sediment)	Water RPD: ≤30% Soil RPD: ≤50%
Accuracy/Bias – Laboratory	Labeled compounds added to each field and QC sample	%R within method control limits
Precision and Accuracy/Bias - Laboratory	LCS and LCSD: 1 per analysis batch of up to 20 samples of the same matrix MSD and Lab Duplicate <sup>1</sup> : not required	%R within statistically derived control limits developed by the laboratory RPD within statistically derived control limits developed by the laboratory
Accuracy/Bias – Laboratory (matrix interference)	MS <sup>1</sup> : not required	Not applicable
Accuracy/Bias (Laboratory Contamination)	Laboratory Blanks include: • Method blank: 1 per extraction batch Instrument blank: 1 per analytical sequence	Method blank: Analyte concentrations < ½ LOQ except for OCDD and OCDF which are allowed concentrations of < 3x LOQ Instrument blank: All analyte concentrations < LOQ
Overall Accuracy/Bias (Contamination)	Field Blanks include: • Equipment Blank	All analyte concentrations < LOQ
Sensitivity (method)	Review Laboratory LOQs and MDLs against action limits <sup>2</sup>	Action Level at least 3 to 10x > LOQ, if feasible
Completeness	Review data package for required elements	Refer to Worksheet #37

Notes:

1 MS/MSD and Laboratory duplicates are not required but are left in this table to alert the sampler that they are not required.

2 Laboratory LOQs and MDLs will be reviewed prior to award of an analytical services subcontract to a laboratory. Laboratory LOQs and MDLs will be compared with RSLs or other appropriate action levels in the DQOs and sampling design prepared for each site.

%R = percent recovery

CRQL = Contract Required Quantitation Limit

HRGC = High Resolution Gas Chromatography

HRMS = High Resolution Mass Spectrometry

LCS = Laboratory Control Sample

LCSD = Laboratory Control Sample Duplicate

LOQ = Limit of Quantitation

MDL = Method Detection Limit

MS = Matrix Spike

MSD = Matrix Spike Duplicate

OCDD = Octachlorinated dibenzo-p-dioxin

OCDF = Octachlorinated dibenzofuran

QC = Quality Control

RPD = Relative Percent Difference

## WORKSHEET #12.10: MEASUREMENT PERFORMANCE CRITERIA FOR PER-AND POLYFLUOROALKYL SUBSTANCES (PFAS) BY LIQUID CHROMATOGRAPHY/TANDEM MASS SPECTROMETRY (LC/MS/MS)

**Matrix:** Water, Drinking Water Soil/Sediment, Sludge

**Analytical Group/Method:** Per-and Polyfluoroalkyl Substances (PFAS) by Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)

**Concentration Level:** Low

Data Quality Indicators (DQIs)	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Precision - Overall	Field Duplicates: 1 per 10 field samples or fewer per matrix (Required for water, drinking water, and soil/sediment)	Water RPD: ≤30% Soil RPD: ≤50%
Accuracy/Bias – Laboratory	Surrogate compounds added to each field and QC sample	%R within method control limits
Accuracy/Bias - Laboratory	LCS: 1 per analysis batch of up to 20 samples	%R within statistically derived control limits developed by the laboratory
Precision and Accuracy/Bias – Laboratory (matrix interference)	MS/MSD: 1 per 20 samples or fewer of each matrix	%R within statistically derived control limits developed by the laboratory if not specifically stated in the NFGs RPD within statistically derived control limits developed by the laboratory if not specifically stated in the NFGs
Overall Accuracy/Bias (Contamination)	Field Blanks include: • Equipment Blank • Rinse Blank	All analyte concentrations < LOQ
Sensitivity (method)	LLOQ verification	50-150% recovery
Sensitivity (method)	Review Laboratory LOQs and MDLs against action limits <sup>2</sup>	Action Level at least 3 to 10x > LOQ, if feasible
Completeness	Review data package for required elements	Refer to Worksheet #37

Notes:

- MS/MSD and Laboratory duplicates are not required but are left in this table to alert the sampler that they are not required.
- Laboratory LOQs and MDLs will be reviewed prior to award of an analytical services subcontract to a laboratory. Laboratory LOQs and MDLs will be compared with RSLs or other appropriate action levels in the DQOs and sampling design prepared for each site.

%R = percent recovery

CRQL = Contract Required Quantitation Limit

LLOQ = Lower Limit of Quantitation

LCS = Laboratory Control Sample

LCSD = Laboratory Control Sample Duplicate

LOQ = Limit of Quantitation

MDL = Method Detection Limit

MS = Matrix Spike

MSD = Matrix Spike Duplicate

QC = Quality Control

RPD = Relative Percent Difference

## WORKSHEET #12.11: MEASUREMENT PERFORMANCE CRITERIA FOR CHLORINATED BIPHENYL CONGENERS BY HRGC/HRMS

**Matrix:** Water, Soil/Sediment, Sludge, Tissue, Ash, Oil/Oily matrices

**Analytical Group/Method:** Chlorinated Biphenyl Congeners/EPA 1668C

**Concentration Level:** Low

Data Quality Indicators (DQIs)	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Precision - Overall	Field Duplicates: 1 per 10 field samples or fewer per matrix	Water RPD: ≤30% Soil RPD: ≤50%
Precision - Laboratory	LCSD: MSD and Lab Duplicate <sup>1</sup> – not required	LCS/LCSD: 30% RPD
Accuracy/Bias – Laboratory	Labeled congeners added to each field and QC sample	%R within method control limits
Accuracy/Bias - Laboratory	LCS and LCSD: 1 per analysis batch of up to 20 samples of the same matrix	%R within statistically derived laboratory acceptance limits
Accuracy/Bias – Laboratory (matrix interference)	MS <sup>1</sup> : not required	Not applicable
Accuracy/Bias (Laboratory Contamination)	Laboratory Blanks include: <ul style="list-style-type: none"> <li>Method blank: 1 per extraction batch</li> <li>Instrument blank: 1 per analytical sequence</li> </ul>	Method and Instrument blanks: Concentrations for the 12 Toxic CBC congeners <sup>3</sup> < ½ RSL
Overall Accuracy/Bias (Contamination)	Field Blanks include Equipment Blank	All analyte concentrations < RSL
Sensitivity (method)	Review Laboratory RSLs and MDLs against action limits <sup>2</sup>	Action Level at least 3 to 10x > RSL, if feasible
Completeness	Review data package for required elements	Refer to Worksheet #37

**Notes:**

- MS/MSD and Laboratory duplicates are not required but are left in this table to alert the sampler that they are not required.
- Laboratory LOQs and MDLs will be reviewed prior to award of an analytical services subcontract to a laboratory. Laboratory LOQs and MDLs will be compared with RSLs or other appropriate action levels in the DQOs and sampling design prepared for each site.
- 12 Toxic Congeners (WHO list) = PCB77, PCB81, PCB105, PCB114, PCB118, PCB123, PCB126, PCB156/157, PCB167, PCB169, and PCB189.

%R = percent recovery

CBC = Chlorinated Biphenyl Congener

HRGC = High Resolution Gas Chromatography

HRMS = High Resolution Mass Spectrometry

LCS = Laboratory Control Sample

LCSD = Laboratory Control Sample Duplicate

MDL = Method Detection Limit

MS = Matrix Spike

MSD = Matrix Spike Duplicate

QC = Quality Control

RPD = Relative Percent Difference

RSL = Regional Screening Level

## WORKSHEET #13: SECONDARY DATA USES AND LIMITATIONS

Secondary Data	Data Source (originating organization, report title and date)	Data Generator(s) (originating organization, data types, data generation / collection dates)	How Data Will Be Used	Limitations on Data Use
Background Site Data	EPA Region 10, various regional agencies, consultants, and historical reports documenting site activities	EPA Region 10, and regional agencies and associated consultants.  Analytical data types may include results for soil, sediment, groundwater, surface water, air, source waste, and investigative-derived waste (IDW).  Multiple collection dates.	Analytical results will be used to evaluate the site and/or data gaps that will need to be completed to meet the needs identified in the Work Plan.	Limitations based on data quality, presence of data validation reports, and level of Quality Control (QC) available for review. Field screening vs. laboratory data and associated data validation qualifiers.

Notes:

EPA = U.S. Environmental Protection Agency

IDW = investigative derived waste

QC = quality control

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## WORKSHEET #14/16: PROJECT TASKS & SCHEDULE

### Documentation and Records

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#### *Field Documentation and Records*

All sample documents will always be legibly written in ink. Any corrections or revisions to sample documentation shall be made by lining through the original entry and initialing any changes. To reiterate these requirements the following sub-sections are provided to outline sample documentation procedures which will be employed when conducting field investigations.

#### **Field Logbooks**

Field logbooks should be used to document where, when, how, and from whom any vital project information was obtained. Logbook entries should be complete and accurate enough to permit reconstruction of field activities. Maintain a separate logbook for each sampling event or site. Logbooks should have consecutively numbered pages. All entries should be legible, written in black ink, and signed by the individual making the entries. Use factual, objective language.

At a minimum, the following information will be recorded during the collection of each sample:

- Sample location and description
- Sampler's name(s)
- Date and time of sample collection
- Designation of sample as composite or grab
- Type of sample (soil, sediment, water, etc.)
- Type of sampling equipment used
- Field instrument readings and calibration
- Field observations and details related to analysis or integrity of samples (e.g., weather conditions, noticeable odors, colors, etc.)
- Preliminary sample descriptions (e.g., for soils: clay loam, very wet; for water: clear water with strong ammonia-like odor)
- Sample preservation
- Shipping arrangements (overnight air bill number, if applicable)
- Name(s) of recipient laboratory(ies)

In addition to the sampling information, the following specific information will also be recorded in the field records for each day of sampling:

- Time of arrival/entry on site and time of site departure
- Other personnel on site
- Deviations from sampling plans, site safety plans, and QAPP procedures
- Changes in personnel and responsibilities with reasons for the changes
- Records of photographs

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## Field Data Records

All real-time measurements and observations must always be recorded in project logbooks, field data records, or in similar types of recordkeeping books. Field data records will be organized into standard formats whenever possible and retained in permanent files. SOPs for field documentation are included in Appendix B.

## Sample Handling, Custody, and Disposal

Procedures for sample handling, chain of custody, and investigation derived waste (IDW) disposal are Included on Worksheet #26/27.

## Laboratory Documentation and Records

The analytical data deliverable package for screening and definitive data will include the following:

- Sample documentation (location, date and time of collection and analysis, etc.)
- Chain of custody
- Initial and continuing calibration
- Determination and documentation of detection limits
- Analyte(s) identification (include chromatograms)
- Analyte(s) quantitation
- Raw data
- QC blanks
- Matrix spike recoveries
- Quality Control sample results
- Duplicate results

Concentrations in liquids and air are expressed in terms of weight per unit volume (e.g., micrograms per liter [ $\mu\text{g/L}$ ], milligrams per liter [ $\text{mg/L}$ ], picograms per liter [ $\text{pg/L}$ ], or, for air, micrograms per cubic meter [ $\mu\text{g/m}^3$ ] or parts per billion by volume [ppbv]). Concentrations in solid or semisolid matrices are expressed in terms of weight per unit weight of sample (e.g., micrograms per kilogram [ $\mu\text{g/kg}$ ], milligrams per kilogram [ $\text{mg/kg}$ ], or nanograms per kilogram [ $\text{ng/kg}$ ]). Solid and semisolid matrices will also be reported on a dry weight basis except for unknown waste or product samples where sample drying may pose a hazard in the laboratory. Sample reporting limits must take into account all appropriate sample weights/volumes, percent moisture, dilution, and/or extraction concentration factors.

The target TAT for most subcontracted laboratories is 15 business days for data packages. Subcontracted laboratories will retain all data related to sample preparation, analysis, and general observations in appropriate hardbound laboratory notebooks, hardcopy, and computer files for a period of at least seven years unless otherwise specified in the subcontract agreement.

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## Data Management Tasks

### Data Reduction

Data reduction is the process for collecting and transforming measurements, through mathematical and/or statistical formulas, into final reportable measurements. The calculations may be performed manually or electronically. This section describes the quality assurance processes that will be applied



during data reduction to ensure that the data collected at the site and the laboratory data are accurately reported.

### **Field Data Reduction**

For field measurement data that require calculations to obtain final concentrations/values (e.g., well purge volumes), the equations used, and the calculations performed will be recorded in the appropriate field log. The field team member performing the field measurement will check all calculations at least once.

Occasionally, a field measurement will result in an outlier with a value significantly outside the expected range for most field conditions (e.g., a zero reading for specific conductance). During the field measurements, the field team, based on their experience, will attempt to identify outliers. When outliers are identified during a field effort, the outlier will be recorded as any other field measurement; field instrumentation and calibration will be checked, as appropriate; and at least two additional measurements will be made and recorded to verify or invalidate the suspected outlier. After this check, if the value remains the same, it is considered a valid measurement. If the value is determined invalid, the other measurements will be used.

### **Laboratory Data Reduction**

The responsibility for data reduction is with the person generating the data (typically the laboratory analyst) and consists of calculating concentrations in samples from the raw data. The complexity of the data reduction depends on the analytical method and the number of discrete operations involved (e.g., extractions, dilutions, instrument readings, and concentrations). The analyst calculates the final results from the raw data or uses appropriate computer programs to assist in the calculation of final reportable values. Copies of all raw data and the calculations used to generate the final results, such as bound laboratory notebooks, strip-charts, chromatograms, spreadsheets, and computer record files, are retained on file at the laboratory and included as part of the laboratory data package.

Calculations and data reduction steps for various methods are summarized in the respective laboratory SOPs or laboratory QAM.

### ***Data Review***

Data review is performed to assess whether the quality control requirements are met. Data review will be performed on 100% of the data deliverables.

### **Field Data Review**

The field technician reviews the completeness of the data records continually. When the field technician has completed the entries for the week, a peer or supervisor will perform a secondary review. The extent of the review will be commensurate with the type and quantity of data produced. For small data sets, all of the results may be checked, but for larger data sets a percentage of the data may be checked at the discretion of the Program Manager or QA Manager. The secondary reviewer will verify that the data records are complete. After the secondary reviewer has verified the data are complete, or taken corrective action to correct an entry, the reviewer will sign and date the data collection form.

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## Laboratory Data Review

The individual analyst reviews the quality of data through calibration checks and QC sample results. The analyst initiates data review during, immediately following, and after the completed analysis. The laboratory supervisor or a different analyst/data specialist performs a secondary (peer) review of the data. The peer reviewer should have training for this task.

## Assessment and Audit Tasks

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The QA Manager will constantly assess and evaluate the QA system and QC practices during the course of the project. If at any time it becomes apparent that these are not adequate to ensure collection of data of the quality required, the QA Manager or Program Manager (PM) may discontinue the project until sufficient revisions can be made. These revisions may be made in the field at the direction of the Field Team Leader and noted by the Field Team Leader in the field logbook or may be recommended to the PM or QA Manager for implementation by the Field Team Leader. The PM and/or QA Manager will review any such revisions with the appropriate EPA PO.

### Audits

#### Technical Performance Audits

The PM or assigned qualified Montrose personnel will perform technical performance monitoring on an ongoing basis during the project, as field data are generated, reduced and analyzed. These monitoring activities will serve as a performance audit and will essentially be ongoing due to the length of the project schedule. All numerical analyses such as manual calculations, mapping, and computer modeling, will be documented and will be the subject of performance audits in the form of quality control review, numerical analysis, and peer review.

#### Field Performance Audits

Montrose will perform at least one internal field performance audit during the sampling efforts of the Program to monitor compliance with the QAPP and Work Plan, as applicable. Field sampling and associated activities will be audited at least once annually. The purpose of field performance audits is to ensure that the methods and protocols detailed in the QAPP are being consistently adhered to in the field.

These activities will be reviewed for their adherence to the procedures established in this QAPP. As part of the field audit, the field logbook maintained by the Field Team Leader will be reviewed to verify that field-related activities were performed in accordance with appropriate project procedures. Other items reviewed will include, but are not limited to, field equipment calibration records, chain-of-custody records, and adherence to sample preservation and sample collection/handling procedures.

#### Project System Audits

The EPA, at its discretion, may periodically perform a project system audit. The EPA PO must respond by submitting the QAPP to the designated 3<sup>rd</sup>-party Auditor, and the Auditor will then determine whether the QAPP is being followed. The Auditor will also determine whether the audits and monitoring called for in the QAPP have been, or are being, conducted. Certain projects may be identified for a more formal audit on a scheduled basis. Those audits evaluate, in-depth, the implementation of the QAPP in the

project as it applies to field and laboratory data analysis and reduction procedures.

## **Assessments**

Assessments are conducted with the express aim of determining the status of a particular subject in order to improve objective quality and client (internal and external) satisfaction. Assessments should be fair and impartial and are not meant to be adversarial or punitive.

The initial responsibility for monitoring the quality of field measurements and observation lies with the field personnel. The PM is responsible for verifying that all QC procedures are being followed. This requires the PM to assess the correctness of field methods and their ability to meet the QA objectives. If a problem occurs that might jeopardize the integrity of the project or cause some specific QA objective to not be met, it is the responsibility of all field project personnel to report it. Field project personnel must report all such suspected problems to the Field Team Leader. The Field Team Leader must report all such suspect problems to the PM. The PM will document the problem, develop the corrective action, and document the results. The PM will initiate the corrective action and identify and direct the appropriate personnel to implement the corrective action.

If, in the opinion of the Field Team Leader, sufficient adjustment cannot be made to QC practices in the field, the Field Team Leader will report these findings to the PM and the QA Manager and discontinue data collection under the current QA system. The PM and QA Manager, in consultation with the Field Team Leader and EPA PO will revise the QA system, as necessary, to ensure that data of adequate quality are obtained.

QA reports will consist of prior notification of activities and reports on activities. QA reports will encompass both routine reports and special reports, including written reports and memoranda documenting data assessment activities, results of data validations, audits, non-conformance, corrective actions, and quality notices. The management hierarchy receiving the QA reports will include the QA Manager, the Grantee PM, and the EPA PO.

Notification of all QA activities will be provided in the final report and describe the progress, the completion, and sometimes the results of QA activities. Description of the completion of activities will serve as notice to all managers of the availability of QA reports.

## **Data Review, Validation, and Verification Tasks**

Data quality assessment is performed by evaluating the results of data review, data verification, and/or data validation to determine the usability of the data for the original project objectives. Data review, data verification, and data validation are each separate levels of review that can be performed by themselves or in conjunction with each other. Each of these levels of review is defined below. While it is possible to apply these levels of review to field data, they are almost always associated only with analytical data from laboratories for field data.

### **Data Review, Verification, and Validation**

Data review and evaluation is performed on all data to assess whether the quality control requirements for field duplicates, laboratory duplicates, field blanks, trip blanks, surrogates, matrix spikes, percent

solids, laboratory blanks, and laboratory control samples were met. Data review and evaluation will be performed on 100% of the laboratory deliverables generated during this program.

The results of field QC samples such as field duplicates, MS/MSD samples, equipment blanks, and trip blanks that rely on laboratory analysis and reporting will be reviewed and reported for accuracy and precision as part of the data validation process.

### **Data Verification and Validation Methods**

To ensure that measurement data generated when performing these sampling activities are of an appropriate quality, all data (100%) will be validated. Data validation is a systematic procedure of reviewing a body of data against a set of established criteria to provide a specified level of assurance of its validity prior to its intended use. It requires that the techniques utilized are applied to the body of the data in a systematic and uniform manner. The process of data validation must be close to the origin of the data, independent of the data production, and objective of its approach.

As summarized in the document, *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use* (OSWER No. 9200.1-85, EPA 540-R-08-005, January 13, 2009), EPA data validation consists of four levels of data validation, Stage 1 through Stage 4. Based on the DQOs for this Program, and as applicable, the data will be validated using the Alaska Department of Environmental Conservation's (ADEC's) Contaminated Sites Program Laboratory Data Review Checklist (September 2022). This level of validation is consistent with the Stage 2A level. The laboratories will be required to deliver data packages that meet Stage 2A requirements such that an independent party can validate the data.

The data validation will be performed by Montrose in accordance with the general guidance provided in EPA's Contract Laboratory Program *National Functional Guidelines for Organic Superfund Methods Data Review*, EPA/540/R-20-005, November 2020; Contract Laboratory Program *National Functional Guidelines for Inorganic Superfund Methods Data Review*, EPA/542/R-20-006, November 2020; *National Functional Guidelines for High Resolution Superfund Methods Data Review*, EPA/542-R-20-007, November 2020; *Guidance on Environmental Data Verification and Data Validation QA/G-8*, EPA/240/R-02/004, November 2002; *Quality Assurance/Quality Control Guidance for Removal Activities, Interim Final*, Office of Solid Waste and Emergency Response (OSWER) Directive 9360.4-01, April 1990; and ADEC's Contaminated Sites Program Laboratory Data Review Checklist, September 2022.

### **Project Schedule/Timeline Table**

A project schedule will be provided in the Site-specific Work Plan. The project schedule will include estimated start and completion dates for specific project activities and may include QA assessments that will be performed during the project.

If a sampling event is delayed, the following project participants will be notified by Montrose via electronic mail:

- Program Manager
- EPA PO

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## **WORKSHEET #15: PROJECT ACTION LIMITS, LABORATORY-SPECIFIC DETECTION/QUANTITATION LIMITS**

Target Analyte Lists (TALs), project action limits (PALs), LOQs, and QC samples are identified during the project planning process. QC acceptance criteria may vary based on the analytical method and individual laboratory SOPs. Identified TALs and PALs will be used to direct the appropriate analytical methods and laboratory limit of quantitation (LOQs) to meet project-specific DQOs. In every case, the risk-based concentration (RBC) for the analyte/compound in the media of interest will drive the decision. The goal would be for every laboratory LOQ to be at, or below, the RBC.

Laboratory LOQs and MDLs will be compared against the PALs to ensure that the requested analysis will provide adequate sensitivity for the sampling project. Some PALs may not be achievable using current analytical methods and technologies.

Site-specific TALs, analytical methods selection, and PALs will be provided in Site-specific Workplans for EPA PO to review and approve. In the absence of site-specific details, the following worksheets will be used.

## WORKSHEET #15.1: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – TARGET COMPOUND LIST (TCL) VOCs (SOIL/SEDIMENT/WASTE)

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS/MS/MSD Precision**	
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (µg/kg)	Soil/Sediment/Waste (µg/kg)	Soil/Sediment/Waste (µg/kg)	Soil %R	Soil RPD
1,1,1,2-Tetrachloroethane	630-20-6	TBD	TBD	20	10	6.2	78-125	20
1,1,1-Trichloroethane	71-55-6	TBD	TBD	25	12.5	7.8	73-130	20
1,1,2,2-Tetrachloroethane	79-34-5	TBD	TBD	2	1	0.62	70-124	20
1,1,2-Trichloroethane	79-00-5	TBD	TBD	1	0.5	0.5	78-121	20
1,1-Dichloroethane	75-34-3	TBD	TBD	25	12.5	7.8	76-125	20
1,1-Dichloroethene	75-35-4	TBD	TBD	25	12.5	7.8	70-131	20
1,1-Dichloropropene	563-58-6	TBD	TBD	25	12.5	7.8	76-125	20
1,2,3-Trichlorobenzene	87-61-6	TBD	TBD	100	50	30	66-130	20
1,2,3-Trichloropropane	96-18-4	TBD	TBD	2	1	0.62	73-125	20
1,2,3-Trichloropropane (SIMS)	96-18-4	TBD	TBD	0.25	0.125	0.0625	73-125	20
1,2,4-Trichlorobenzene	120-82-1	TBD	TBD	25	12.5	7.8	67-129	20
1,2,4-Trimethylbenzene	95-63-6	TBD	TBD	100	50	30	75-123	20
1,2-Dibromo-3-chloropropane	96-12-8	TBD	TBD	100	50	31	61-132	20
1,2-Dibromo-3-chloropropane (SIMS)	96-12-8	TBD	TBD	0.25	0.125	0.0625	61-132	20
1,2-Dibromoethane	106-93-4	TBD	TBD	1.5	0.75	0.75	78-122	20
1,2-Dibromoethane (SIMS)	106-93-4	TBD	TBD	0.125	0.0625	0.031	78-122	20
1,2-Dichlorobenzene	95-50-1	TBD	TBD	25	12.5	7.8	78-121	20
1,2-Dichloroethane	107-06-2	TBD	TBD	2	1	0.7	73-128	20
1,2-Dichloropropane	78-87-5	TBD	TBD	10	5	5	76-123	20
1,3,5-Trimethylbenzene	108-67-8	TBD	TBD	25	12.5	7.8	73-124	20

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS/MS/MSD Precision**	
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (µg/kg)	Soil/Sediment/Waste (µg/kg)	Soil/Sediment/Waste (µg/kg)	Soil %R	Soil RPD
1,3-Dichlorobenzene	541-73-1	TBD	TBD	25	12.5	7.8	77-121	20
1,3-Dichloropropane	142-28-9	TBD	TBD	10	5	3.1	77-121	20
1,4-Dichlorobenzene	106-46-7	TBD	TBD	25	12.5	7.8	75-120	20
2,2-Dichloropropane	594-20-7	TBD	TBD	25	12.5	7.8	67-133	20
2-Butanone (MEK)	78-93-3	TBD	TBD	250	125	78	51-148	20
2-Chlorotoluene	95-49-8	TBD	TBD	25	12.5	7.8	75-122	20
2-Hexanone	591-78-6	TBD	TBD	120	60	60	53-145	20
4-Chlorotoluene	106-43-4	TBD	TBD	20	10	10	72-124	20
4-Isopropyltoluene	99-87-6	TBD	TBD	80	40	40	73-127	20
4-Methyl-2-pentanone (MIBK)	108-10-1	TBD	TBD	250	125	78	65-135	20
Acetone	67-64-1	TBD	TBD	250	125	110	36-164	20
Benzene	71-43-2	TBD	TBD	12.5	6.25	3.9	77-121	20
Bromobenzene	108-86-1	TBD	TBD	25	12.5	7.8	78-121	20
Bromochloromethane	74-97-5	TBD	TBD	25	12.5	7.8	78-125	20
Bromodichloromethane	75-27-4	TBD	TBD	2	1	0.62	75-127	20
Bromoform	75-25-2	TBD	TBD	25	12.5	7.8	67-132	20
Bromomethane	74-83-9	TBD	TBD	20	10	8	53-143	20
Carbon disulfide	75-15-0	TBD	TBD	100	50	31	63-132	20
Carbon tetrachloride	56-23-5	TBD	TBD	12.5	6.25	3.9	70-135	20
Chlorobenzene	108-90-7	TBD	TBD	25	12.5	7.8	79-120	20
Chloroethane	75-00-3	TBD	TBD	200	100	62	59-139	20
Chloroform	67-66-3	TBD	TBD	6	3	3	78-123	20
Chloromethane	74-87-3	TBD	TBD	25	12.5	7.8	50-136	20



				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS/MS/MSD Precision**	
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (µg/kg)	Soil/Sediment/Waste (µg/kg)	Soil/Sediment/Waste (µg/kg)	Soil %R	Soil RPD
cis-1,2-Dichloroethene	156-59-2	TBD	TBD	25	12.5	7.8	77-123	20
cis-1,3-Dichloropropene	10061-01-5	TBD	TBD	12.5	6.25	3.9	74-126	20
Dibromochloromethane	124-48-1	TBD	TBD	5	2.5	1.5	74-126	20
Dibromomethane	74-95-3	TBD	TBD	25	12.5	7.8	78-125	20
Dichlorodifluoromethane	75-71-8	TBD	TBD	100	50	30	29-149	20
Ethylbenzene	100-41-4	TBD	TBD	25	12.5	7.8	76-122	20
Freon-113	76-13-1	TBD	TBD	100	50	31	66-136	20
Hexachlorobutadiene	87-68-3	TBD	TBD	20	10	6.2	61-135	20
Isopropylbenzene (Cumene)	98-82-8	TBD	TBD	25	12.5	7.8	68-134	20
Methylene chloride	75-09-2	TBD	TBD	100	50	31	70-128	20
Methyl-t-butyl ether	1634-04-4	TBD	TBD	100	50	31	73-125	20
Naphthalene	91-20-3	TBD	TBD	25	12.5	7.8	62-129	20
n-Butylbenzene	104-51-8	TBD	TBD	25	12.5	7.8	70-128	20
n-Propylbenzene	103-65-1	TBD	TBD	25	12.5	7.8	73-125	20
o-Xylene	95-47-6	TBD	TBD	25	12.5	7.8	77-123	20
P & M -Xylene	P & M -Xylene	TBD	TBD	50	25	15	77-124	20
sec-Butylbenzene	135-98-8	TBD	TBD	25	12.5	7.8	73-126	20
Styrene	100-42-5	TBD	TBD	25	12.5	7.8	76-124	20
tert-Butylbenzene	98-06-6	TBD	TBD	25	12.5	7.8	73-125	20
Tetrachloroethene	127-18-4	TBD	TBD	12.5	6.25	3.9	73-128	20
Toluene	108-88-3	TBD	TBD	25	12.5	7.8	77-121	20
trans-1,2-Dichloroethene	156-60-5	TBD	TBD	25	12.5	7.8	74-125	20



				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS/MS/MSD Precision**	
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (µg/kg)	Soil/Sediment/Waste (µg/kg)	Soil/Sediment/Waste (µg/kg)	Soil %R	Soil RPD
trans-1,3-Dichloropropene	10061-02-6	TBD	TBD	12.5	6.25	3.9	71-130	20
Trichloroethene	79-01-6	TBD	TBD	10	5	3.2	77-123	20
Trichlorofluoromethane	75-69-4	TBD	TBD	50	25	15	62-140	20
Vinyl acetate	108-05-4	TBD	TBD	100	50	31	50-151	20
Vinyl chloride	75-01-4	TBD	TBD	0.8	0.4	0.25	56-135	20
Xylenes (total)	1330-20-7	TBD	TBD	75	37.5	22.8	78-124	20

Notes:

\* Individual laboratory LOQs (practical quantitation limits) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

Project Action Limits (PALs) vary by matrix and data use; the PALs will be defined as part of the project planning process.

Laboratory LOQs and MDLs should be reviewed during the project planning to ensure that laboratories can achieve the project's quality objectives.

%R = percent recovery

µg/kg = microgram per kilogram

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

MDL = Method Detection Limit

MS = Matrix Spike

MSD = Matrix Spike Duplicate

NA = Not Applicable

NFG = National Functional Guidelines

RPD = Relative Percent Difference

TBD = To Be Determined

## WORKSHEET #15.2: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – TCLP VOCs (AQUEOUS)

Analyte	CAS Number	Project Action Limit	Project QL	Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS/MS/MSD Precision**	
				TCLP Leachate (mg/L)	TCLP Leachate (mg/L)	TCLP Leachate (mg/L)	Water %R	Water RPD
1,1-Dichloroethene	75-35-4	TBD	TBD	1	0.5	0.31	71-131	20
1,2-Dichloroethane	107-06-2	TBD	TBD	0.5	0.25	0.2	73-128	20
1,4-Dichlorobenzene	106-46-7	TBD	TBD	0.5	0.25	0.15	79-118	20
2-Butanone (MEK)	78-93-3	TBD	TBD	10	5	3.1	56-143	20
Benzene	71-43-2	TBD	TBD	0.4	0.2	0.12	79-120	20
Carbon tetrachloride	56-23-5	TBD	TBD	1	0.5	0.31	72-136	20
Chlorobenzene	108-90-7	TBD	TBD	0.5	0.25	0.15	82-118	20
Chloroform	67-66-3	TBD	TBD	1	0.5	0.31	79-124	20
Hexachlorobutadiene	87-68-3	TBD	TBD	1	0.5	0.31	66-134	20
Tetrachloroethene	127-18-4	TBD	TBD	1	0.5	0.31	74-129	20
Trichloroethene	79-01-6	TBD	TBD	0.5	0.25	0.15	79-123	20
Vinyl chloride	75-01-4	TBD	TBD	0.15	0.075	0.05	58-137	20

Notes:

\* Individual laboratory LOQs (practical quantitation limits) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

Project Action Limits (PALs) vary by matrix and data use; the PALs will be defined as part of the project planning process.

Laboratory LOQLs and MDLs should be reviewed during the project planning to ensure that laboratories can achieve the project's quality objectives.

-- = Analyte not reported by this method

%R = percent recovery

µg/L = microgram per liter

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

MDL = Method Detection Limit

MS = Matrix Spike

MSD = Matrix Spike Duplicate

NFG = National Functional Guidelines

RPD = Relative Percent Difference

SIM = Selected Ion Monitoring

TAL = Target Analyte List

TCLP = Toxicity characteristic leaching procedure

TBD = To Be Determined

## WORKSHEET #15.3: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – TCL SVOCs (SOIL)

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS/MS/MSD Recovery Limits**	LCS/MS/MSD Precision**
Analyte	CAS Number	Project Action Level	Project QL	Low Soil/Sediment/ Waste (µg/kg)	Low Soil/Sediment/ Waste (µg/kg)	Low Soil/Sediment/ Waste (µg/kg)	Soil %R	Soil RPD
1,2,4-Trichlorobenzene	120-82-1	TBD	TBD	0.25	0.125	0.078	34-118	20
1,2-Dichlorobenzene	95-50-1	TBD	TBD	0.25	0.125	0.078	33-117	20
1,3-Dichlorobenzene	541-73-1	TBD	TBD	1	0.5	0.3	30-115	20
1,4-Dichlorobenzene	106-46-7	TBD	TBD	0.25	0.125	0.078	31-115	20
1-Chloronaphthalene	90-13-1	TBD	TBD	0.25	0.125	0.078	48-115	20
1-Methylnaphthalene	90-12-0	TBD	TBD	0.25	0.125	0.078	40-119	20
2,4,5-Trichlorophenol	95-95-4	TBD	TBD	0.25	0.125	0.078	41-124	20
2,4,6-Trichlorophenol	88-06-2	TBD	TBD	1	0.5	0.3	39-126	20
2,4-Dichlorophenol	120-83-2	TBD	TBD	0.25	0.125	0.078	40-122	20
2,4-Dimethylphenol	105-67-9	TBD	TBD	0.5	0.25	0.125	30-127	20
2,4-Dinitrophenol	51-28-5	TBD	TBD	5	2.5	1.5	62-113	20
2,4-Dinitrotoluene	121-14-2	TBD	TBD	0.25	0.125	0.078	48-126	20
2,6-Dichlorophenol	87-65-0	TBD	TBD	0.25	0.125	0.078	41-117	20
2,6-Dinitrotoluene	606-20-2	TBD	TBD	0.25	0.125	0.078	46-124	20
2-Chloronaphthalene	91-58-7	TBD	TBD	0.25	0.125	0.078	41-114	20
2-Chlorophenol	95-57-8	TBD	TBD	0.25	0.125	0.078	34-121	20
2-Methyl-4,6-dinitrophenol	534-52-1	TBD	TBD	2	1	0.62	29-132	20
2-Methylnaphthalene	91-57-6	TBD	TBD	0.25	0.125	0.078	38-122	20
2-Methylphenol (o-Cresol)	95-48-7	TBD	TBD	0.25	0.125	0.078	32-122	20
2-Nitroaniline	88-74-4	TBD	TBD	0.25	0.125	0.078	44-127	20
2-Nitrophenol	88-75-5	TBD	TBD	0.25	0.125	0.078	36-123	20

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS/MS/MSD Recovery Limits**	LCS/MS/MSD Precision**
Analyte	CAS Number	Project Action Level	Project QL	Low Soil/Sediment/Waste (µg/kg)	Low Soil/Sediment/Waste (µg/kg)	Low Soil/Sediment/Waste (µg/kg)	Soil %R	Soil RPD
3&4-Methylphenol (p&m-Cresol)	3&4-Methylphen.	TBD	TBD	1	0.5	0.31	34-119	20
3,3-Dichlorobenzidine	91-94-1	TBD	TBD	1	0.5	0.3	22-121	20
3-Nitroaniline	99-09-2	TBD	TBD	0.5	0.25	0.15	33-119	20
4-Bromophenyl-phenylether	101-55-3	TBD	TBD	0.25	0.125	0.078	46-124	20
4-Chloro-3-methylphenol	59-50-7	TBD	TBD	0.25	0.125	0.078	45-122	20
4-Chloroaniline	106-47-8	TBD	TBD	1	0.5	0.31	17-106	20
4-Chlorophenyl-phenylether	7005-72-3	TBD	TBD	0.25	0.125	0.078	45-121	20
4-Nitroaniline	100-01-6	TBD	TBD	3	1.5	0.94	77-120	20
4-Nitrophenol	100-02-7	TBD	TBD	2	1	0.62	30-132	20
Acenaphthene	83-32-9	TBD	TBD	0.25	0.125	0.078	40-123	20
Acenaphthylene	208-96-8	TBD	TBD	0.25	0.125	0.078	32-132	20
Aniline	62-53-3	TBD	TBD	4	2	1	24-89	20
Anthracene	120-12-7	TBD	TBD	0.25	0.125	0.078	47-123	20
Azobenzene	103-33-3	TBD	TBD	0.25	0.125	0.078	39-125	20
Benzo(a)Anthracene	56-55-3	TBD	TBD	0.25	0.125	0.078	49-126	20
Benzo[a]pyrene	50-32-8	TBD	TBD	0.25	0.125	0.078	45-129	20
Benzo[b]Fluoranthene	205-99-2	TBD	TBD	0.25	0.125	0.078	45-132	20
Benzo[g,h,i]perylene	191-24-2	TBD	TBD	0.25	0.125	0.078	43-134	20
Benzo[k]fluoranthene	207-08-9	TBD	TBD	0.25	0.125	0.078	47-132	20
Benzoic acid	65-85-0	TBD	TBD	1.5	0.75	0.47	53-124	20
Benzyl alcohol	100-51-6	TBD	TBD	0.25	0.125	0.078	29-122	20
Bis(2chloro1methylethyl)Ether	108-60-1	TBD	TBD	0.25	0.125	0.078	33-131	20
Bis(2-Chloroethoxy)methane	111-91-1	TBD	TBD	2	1	0.6	36-121	20
Bis(2-Chloroethyl)ether	111-44-4	TBD	TBD	0.25	0.125	0.078	31-120	20

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS/MS/MSD Recovery Limits**	LCS/MS/MSD Precision**
Analyte	CAS Number	Project Action Level	Project QL	Low Soil/Sediment/Waste (µg/kg)	Low Soil/Sediment/Waste (µg/kg)	Low Soil/Sediment/Waste (µg/kg)	Soil %R	Soil RPD
bis(2-Ethylhexyl)phthalate	117-81-7	TBD	TBD	0.25	0.125	0.078	51-133	20
Butylbenzylphthalate	85-68-7	TBD	TBD	0.25	0.125	0.078	48-132	20
Carbazole	86-74-8	TBD	TBD	0.25	0.125	0.078	50-123	20
Chrysene	218-01-9	TBD	TBD	0.25	0.125	0.078	50-124	20
Dibenzo[a,h]anthracene	53-70-3	TBD	TBD	0.25	0.125	0.078	45-134	20
Dibenzofuran	132-64-9	TBD	TBD	0.25	0.125	0.078	44-120	20
Diethylphthalate	84-66-2	TBD	TBD	0.25	0.125	0.078	50-124	20
Dimethylphthalate	131-11-3	TBD	TBD	0.25	0.125	0.078	48-124	20
Di-n-butylphthalate	84-74-2	TBD	TBD	0.25	0.125	0.078	51-128	20
di-n-Octylphthalate	117-84-0	TBD	TBD	0.5	0.25	0.15	45-140	20
Fluoranthene	206-44-0	TBD	TBD	0.25	0.125	0.078	50-127	20
Fluorene	86-73-7	TBD	TBD	0.25	0.125	0.078	43-125	20
Hexachlorobenzene	118-74-1	TBD	TBD	0.25	0.125	0.078	45-122	20
Hexachlorobutadiene	87-68-3	TBD	TBD	0.25	0.125	0.078	32-123	20
Hexachlorocyclopentadiene	77-47-4	TBD	TBD	0.7	0.35	0.2	45-107	20
Hexachloroethane	67-72-1	TBD	TBD	0.25	0.125	0.078	28-117	20
Indeno[1,2,3-c,d] pyrene	193-39-5	TBD	TBD	0.25	0.125	0.078	45-133	20
Isophorone	78-59-1	TBD	TBD	0.25	0.125	0.078	30-122	20
Naphthalene	91-20-3	TBD	TBD	0.25	0.125	0.078	35-123	20
Nitrobenzene	98-95-3	TBD	TBD	0.25	0.125	0.078	34-122	20
N-Nitrosodimethylamine	62-75-9	TBD	TBD	0.25	0.125	0.078	23-120	20
N-Nitroso-di-n-propylamine	621-64-7	TBD	TBD	0.25	0.125	0.078	36-120	20
N-Nitrosodiphenylamine	86-30-6	TBD	TBD	0.25	0.125	0.078	38-127	20
Pentachlorophenol	87-86-5	TBD	TBD	4	2	1	25-133	20
Phenanthrene	85-01-8	TBD	TBD	0.25	0.125	0.078	50-121	20

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS/MS/MSD Recovery Limits**	LCS/MS/MSD Precision**
Analyte	CAS Number	Project Action Level	Project QL	Low Soil/Sediment/Waste (µg/kg)	Low Soil/Sediment/Waste (µg/kg)	Low Soil/Sediment/Waste (µg/kg)	Soil %R	Soil RPD
Phenol	108-95-2	TBD	TBD	0.25	0.125	0.078	34-121	20
Pyrene	129-00-0	TBD	TBD	0.25	0.125	0.078	47-127	20

Notes:

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

Project Action Limits (PALs) vary by matrix and data use; the PALs will be defined as part of the project planning process.

Laboratory LOQs and MDLs should be reviewed during the project planning to ensure that laboratories can achieve the project's quality objectives.

-- = Analyte not reported by this method

%R = percent recovery

µg/kg = microgram per kilogram

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

MS = Matrix Spike

MSD = Matrix Spike Duplicate

NFG = National Functional Guidelines

RPD = Relative Percent Difference

SIM = Selected Ion Monitoring

TBD = To Be Determined

## WORKSHEET #15.4: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – TCLP SVOCs (AQUEOUS)

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS/MS/MSD Recovery Limits**	LCS/MS/MSD Precision**
Analyte	CAS Number	Project Action Limit	Project QL	TCLP Leachate (mg/L)	TCLP Leachate (mg/L)	TCLP Leachate (mg/L)	Water %R	Water RPD
2,4,5-Trichlorophenol	95-95-4	TBD	TBD	0.01	0.005	0.0031	53-123	20
2,4,6-Trichlorophenol	88-06-2	TBD	TBD	0.01	0.005	0.0031	50-125	20
2,4-Dinitrotoluene	121-14-2	TBD	TBD	0.01	0.005	0.0031	57-128	20
2-Methylphenol (o-Cresol)	95-48-7	TBD	TBD	0.01	0.005	0.0031	30-117	20
3&4-Methylphenol (p&m-Cresol)	3&4-Methylphen.	TBD	TBD	0.02	0.01	0.0062	29-110	20
Hexachlorobenzene	118-74-1	TBD	TBD	0.01	0.005	0.0031	53-125	20
Hexachlorobutadiene	87-68-3	TBD	TBD	0.01	0.005	0.0031	22-124	20
Hexachloroethane	67-72-1	TBD	TBD	0.01	0.005	0.0031	21-115	20
Nitrobenzene	98-95-3	TBD	TBD	0.01	0.005	0.0031	45-121	20
Pentachlorophenol	87-86-5	TBD	TBD	0.05	0.025	0.015	35-138	20
Pyridine	110-86-1	TBD	TBD	0.02	0.01	0.0062	10-73	20

### Notes:

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

Project Action Limits (PALs) vary by matrix and data use; the PALs will be defined as part of the project planning process.

Laboratory LOQs and MDLs should be reviewed during the project planning to ensure that laboratories can achieve the project's quality objectives.

%R = percent recovery

µg/L = microgram per liter

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

MS/MSD = Matrix Spike/Matrix Spike Duplicate

NFG = National Functional Guidelines

RPD = relative percent difference

TBD = To Be Determined

TCLP = Toxicity characteristic leaching procedure

## WORKSHEET #15.5: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – TCL PCB (SOIL)

Analyte	CAS Number	Project Action Limit	Project QL	Achievable Laboratory Limits			Accuracy and Precision Criteria			
				Lab LOQ	Lab LOD	Lab MDL	LCS/MS/MSD Recovery Limits**			LCS/MS/MSD Precision**
				Soil/ Sediment/ Waste (µg/kg)	Soil/ Sediment/ Waste (µg/kg)	Soil/ Sediment/ Waste (µg/kg)	Soil LCS %R	Soil MS/MSD %R	Soil MS/MSD %R	Soil RPD
Aroclor-1016	12674-11-2	TBD	TBD	50	25	12.5	47-134	TBD	TBD	≤ 30
Aroclor-1221	11104-28-2	TBD	TBD	100	50	25	70-130	TBD	TBD	TBD
Aroclor-1232	11141-16-5	TBD	TBD	50	25	12.5	70-130	TBD	TBD	TBD
Aroclor-1242	53469-21-9	TBD	TBD	50	25	12.5	70-130	TBD	TBD	TBD
Aroclor-1248	12672-29-6	TBD	TBD	50	25	12.5	70-130	TBD	TBD	TBD
Aroclor-1254	11097-69-1	TBD	TBD	50	25	12.5	67-135	TBD	TBD	TBD
Aroclor-1260	11096-82-5	TBD	TBD	50	25	12.5	53-140	TBD	TBD	≤ 30

### Notes:

\* Individual laboratory LOQs (practical quantitation limits) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

Project Action Limits (PALs) vary by matrix and data use; the PALs will be defined as part of the project planning process.

Laboratory LOQs and MDLs should be reviewed during the project planning to ensure that laboratories can achieve the project's quality objectives.

%R = percent recovery

µg = microgram

µg/cm<sup>2</sup> = microgram per cubic centimeter

µg/kg = microgram per kilogram

µg/L = microgram per liter

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

MS/MSD = Matrix Spike/Matrix Spike Duplicate

NFG = National Functional Guidelines

RPD = relative percent difference

TBD = To Be Determined



## WORKSHEET #15.6: REFERENCE LIMITS AND EVALUATION TABLE – GRO BY AK 101 (SOIL)

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS/MS/MSD Recovery Limits <sup>1</sup>	LCS/MS/MSD Precision <sup>1</sup>
Analyte	CAS Number	Project Action Limit	Project QL	Soil/ Sediment/ Waste (mg/kg)	Soil/ Sediment/ Waste (mg/kg)	Soil/ Sediment/ Waste (mg/kg)	Soil %R	Soil RPD
Gasoline Range Organics (GRO)	GRO	TBD	TBD	2.5	1.25	0.75	60-120	≤ 20

Notes:

1 These QC limits are method specific. State regulation may specify LOD and PALs.  
 GRO includes analytes detected between the Retention Times of C6 and C10 alkane standards.

%R = percent recovery  
 CAS = Chemical Abstracts Service  
 LCS = Laboratory Control Sample  
 LOQ = Limit of Quantitation  
 LOD = Limit of Detection

MDL = Method Detection Limit  
 mg/kg = milligram per kilogram  
 MS/MSD = Matrix Spike/Matrix Spike Duplicate  
 PAL = Project Action Limits

RPD = relative percent difference  
 TBD = To Be Determined

## WORKSHEET #15.7: REFERENCE LIMITS AND EVALUATION TABLE – DRO, AND RRO BY AK 102/103 (SOIL)

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ )	Lab LOD	Lab MDL	LCS/MS/MSD Recovery Limits <sup>1</sup>	LCS/MS/MSD Precision <sup>1</sup>
Analyte	CAS Number	Project Action Limit	Project QL	Soil/ Sediment/ Waste (mg/kg)	Soil/ Sediment/ Waste (mg/kg)	Soil/ Sediment/ Waste (mg/kg)	Soil %R	Soil RPD
Diesel Range Organics (DRO)	DRO	TBD	TBD	20	10	9	75-125	≤ 20
Residual Range Organics (RRO)	RRO	TBD	TBD	100	50	43	60-120	≤ 20

Notes:

<sup>1</sup> These QC limits are method specific. State regulation may specify LOD and PALs.

DRO includes analytes detected between the Retention Times of C10 and C25 alkane standards. RRO includes analytes detected between the Retention Times of C25 and C36 alkane standards.

%R = percent recovery

CAS = Chemical Abstracts Service

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

MDL = Method Detection Limit

mg/kg = milligram per kilogram

MS/MSD = Matrix Spike/Matrix Spike Duplicate

PAL = Project Action Limits

RPD = relative percent difference

TBD = To Be Determined

## WORKSHEET #15.8: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – HERBICIDES (GROUNDWATER)

Analyte	CAS Number	Project Action Limit	Project QL	Achievable Laboratory Limits			Accuracy and Precision Criteria		
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**		Lab Duplicate Precision
				Groundwater (µg/L)	Groundwater (µg/L)	Groundwater (µg/L)	LCS %R	MS/MSD %R	RPD
2,4-D	94-75-7	TBD	TBD	2	1	0.7	58-128	58-128	28
2,4,5-TP (Silvex)	93-72-1	TBD	TBD	0.2	0.1	0.051	57-134	57-134	28
2,4,5-T	93-76-5	TBD	TBD	0.2	0.1	0.061	58-135	58-135	32
Dicamba	1918-00-9	TBD	TBD	0.2	0.1	0.04	63-138	63-138	34
Dinoseb	88-85-7	TBD	TBD	4	2	1	11-115	11-115	36
Dalapon	75-99-0	TBD	TBD	5	2.5	2	15-115	15-115	35
Dichloroprop	120-36-5	TBD	TBD	2	1	0.37	70-148	70-148	27
2,4-DB	94-82-6	TBD	TBD	2	1	0.77	60-126	60-126	35
MCP	93-65-2	TBD	TBD	200	100	69	55-123	55-123	33
MCPA	94-74-6	TBD	TBD	200	150	110	55-121	55-121	27
Pentachlorophenol	87-86-5	TBD	TBD	0.2	0.1	0.093	62-122	62-122	25

### Notes:

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

# The 20% RPD applies when laboratory duplicate concentrations are greater than 5x LOQ. For laboratory duplicate concentrations at or above the LOQ and less than 5x LOQ, the control limit is ±CRQL.

Limits listed above include 5x dilution performed on digestate prior to analysis.

%R = percent recovery

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

GC/ECD = Gas Chromatography Electron Capture Detector

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

µg/l = microgram per liter

MS/MSD = Matrix Spike/Matrix Spike Duplicate

NA = Not Applicable

RPD = relative percent difference

TBD = To Be Determined

## WORKSHEET #15.9: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – HERBICIDES (SOIL/SEDIMENT/WASTE)

				Achievable Laboratory Limits			Accuracy and Precision Criteria		
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**		Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	Soil/ Sediment/ Waste (µg/kg)	Soil/ Sediment/ Waste (µg/kg)	Soil/ Sediment/ Waste (µg/kg)	LCS %R	MS/MSD %R	RPD
2,4-D	94-75-7	TBD	TBD	33	17	8.4	43-124	43-124	32
2,4,5-TP (Silvex)	93-72-1	TBD	TBD	3.3	1.7	0.93	41-130	41-130	31
2,4,5-T	93-76-5	TBD	TBD	3.3	1.7	0.85	40-124	40-124	35
Dicamba	1918-00-9	TBD	TBD	3.3	1.7	0.77	32-129	32-129	34
Dinoseb	88-85-7	TBD	TBD	83	33	17	10-124	10-124	41
Dalapon	75-99-0	TBD	TBD	170	66	33	10-133	10-133	35
Dichloroprop	120-36-5	TBD	TBD	33	17	8.2	51-145	51-145	34
2,4-DB	94-82-6	TBD	TBD	33	17	8.5	42-130	42-130	34
MCP	93-65-2	TBD	TBD	3300	1700	840	34-130	34-130	34
MCPA	94-74-6	TBD	TBD	3300	2500	1600	37-124	37-124	35
Pentachlorophenol	87-86-5	TBD	TBD	3.3	1.7	0.7	45-126	45-126	32

### Notes:

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

# The 20% RPD applies when laboratory duplicate concentrations are greater than 5x LOQ. For laboratory duplicate concentrations at or above the LOQ and less than 5x LOQ, the control limit is ±CRQL.

Limits listed above include 5x dilution performed on digestate prior to analysis.

%R = percent recovery

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

GC/ECD = Gas Chromatography Electron Capture Detector

HRMS = High Resolution-Mass Spectrometry

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

µg/kg = microgram per kilogram

MS/MSD = Matrix Spike/Matrix Spike Duplicate

NA = Not Applicable

RPD = relative percent difference

TBD = To Be Determined

## WORKSHEET #15.10: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – PESTICIDES (GROUNDWATER)

Analyte	CAS Number	Project Action Limit	Project QL	Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**	Lab Duplicate Precision
				Groundwater (µg/L)	Groundwater (µg/L)	Groundwater (µg/L)	LCS/MS/MSD %R	RPD
4,4'-DDD	72-54-8	TBD	TBD	0.0375	0.0375	0.0125	56-143	20
4,4'-DDE	72-55-9	TBD	TBD	0.0375	0.0375	0.0125	57-135	20
4,4'-DDT	50-29-3	TBD	TBD	0.0375	0.0375	0.0125	51-143	20
Aldrin	309-00-2	TBD	TBD	0.0225	0.0225	0.0094	45-134	20
alpha-BHC	319-84-6	TBD	TBD	0.0225	0.0225	0.0094	54-138	20
beta-BHC	319-85-7	TBD	TBD	0.0375	0.0375	0.0125	56-136	20
cis-Chlordane	5103-71-9	TBD	TBD	0.0375	0.0375	0.0125	60-129	20
delta-BHC	319-86-8	TBD	TBD	0.0375	0.0375	0.0125	52-142	20
Dieldrin	60-57-1	TBD	TBD	0.0225	0.0225	0.0094	60-136	20
Endosulfan I	959-98-8	TBD	TBD	0.0225	0.0225	0.0094	62-126	20
Endosulfan II	33213-65-9	TBD	TBD	0.0225	0.0225	0.0094	52-135	20
Endosulfan sulfate	-317206	TBD	TBD	0.0225	0.0225	0.0094	62-133	20
Endrin	72-20-8	TBD	TBD	0.0375	0.0375	0.0125	60-138	20
Endrin aldehyde	7421-93-4	TBD	TBD	0.0225	0.0225	0.0094	51-132	20
Endrin ketone	53494-70-5	TBD	TBD	0.0225	0.0225	0.0094	58-134	20
gamma-BHC (Lindane)	58-89-9	TBD	TBD	0.0375	0.0375	0.0125	59-134	20
Heptachlor	76-44-8	TBD	TBD	0.0225	0.0225	0.0094	54-130	20
Heptachlor epoxide	1024-57-3	TBD	TBD	0.0225	0.0225	0.012	61-133	20
Methoxychlor	72-43-5	TBD	TBD	0.0225	0.0225	0.015	54-145	20

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**	Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (µg/L)	Groundwater (µg/L)	Groundwater (µg/L)	LCS/MS/MSD %R	RPD
Toxaphene	8001-35-2	TBD	TBD	2	1.5	0.62	34-134	20
trans-Chlordane	5103-74-2	TBD	TBD	0.05	0.0375	0.0125	56-136	20

Notes:

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

# The 20% RPD applies when laboratory duplicate concentrations are greater than 5x LOQ. For laboratory duplicate concentrations at or above the LOQ and less than 5x LOQ, the control limit is ±CRQL.

Limits listed above include 5x dilution performed on digestate prior to analysis.

%R = percent recovery

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

GC/ECD = Gas Chromatography Electron Capture Detector

HRMS = High Resolution-Mass Spectrometry

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

µg/l = microgram per liter

MS/MSD = Matrix Spike/Matrix Spike Duplicate

NA = Not Applicable

RPD = relative percent difference

TBD = To Be Determined

## WORKSHEET #15.11: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – PESTICIDES (SOIL/SEDIMENT/WASTE)

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**	Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment /Waste (µg/kg)	Soil/Sediment /Waste (µg/kg)	Soil/Sediment/ Waste (µg/kg)	LCS/MS/MSD %R	RPD
4,4'-DDD	72-54-8	TBD	TBD	2	1.5	0.5	56-139	20
4,4'-DDE	72-55-9	TBD	TBD	2	1.5	0.5	56-134	20
4,4'-DDT	50-29-3	TBD	TBD	6	4.5	3	50-141	20
Aldrin	309-00-2	TBD	TBD	1.5	1.125	0.37	45-136	20
alpha-BHC	319-84-6	TBD	TBD	1.5	1.125	0.37	45-137	20
beta-BHC	319-85-7	TBD	TBD	1.5	1.125	0.37	50-136	20
cis-Chlordane	5103-71-9	TBD	TBD	1.5	1.125	0.37	54-133	20
delta-BHC	319-86-8	TBD	TBD	1.5	1.125	0.37	47-139	20
Dieldrin	60-57-1	TBD	TBD	2	1.5	0.37	56-136	20
Endosulfan I	959-98-8	TBD	TBD	1.5	1.125	0.37	53-132	20
Endosulfan II	33213-65-9	TBD	TBD	2	1.5	1	53-134	20
Endosulfan sulfate	-317206	TBD	TBD	2	1.5	0.75	55-136	20
Endrin	72-20-8	TBD	TBD	10	7.5	5	57-140	20
Endrin aldehyde	7421-93-4	TBD	TBD	2	1.5	1	35-137	20
Endrin ketone	53494-70-5	TBD	TBD	5	3.75	1.25	55-136	20
gamma-BHC (Lindane)	58-89-9	TBD	TBD	1.5	1.125	0.37	49-135	20
Heptachlor	76-44-8	TBD	TBD	6	4.5	3	47-136	20
Heptachlor epoxide	1024-57-3	TBD	TBD	2	1.5	1	52-136	20
Methoxychlor	72-43-5	TBD	TBD	4	3	2	52-143	20
Toxaphene	8001-35-2	TBD	TBD	500	375	150	33-141	20

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**	Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment /Waste (µg/kg)	Soil/Sediment /Waste (µg/kg)	Soil/Sediment/ Waste (µg/kg)	LCS/MS/MSD %R	RPD
trans-Chlordane	5103-74-2	TBD	TBD	4	3	2	53-135	20

Notes:

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

# The 20% RPD applies when laboratory duplicate concentrations are greater than 5x LOQ. For laboratory duplicate concentrations at or above the LOQ and less than 5x LOQ, the control limit is ±CRQL.

Limits listed above include 5x dilution performed on digestate prior to analysis.

%R = percent recovery

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

GC/ECD = Gas Chromatography Electron Capture Detector

HRMS = High Resolution-Mass Spectrometry

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

µg/kg = microgram per kilogram

MS/MSD = Matrix Spike/Matrix Spike Duplicate

NA = Not Applicable

RPD = relative percent difference

TBD = To Be Determined



## WORKSHEET #15.12: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – DIOXINS/FURANS (GROUNDWATER)

				Achievable Laboratory Limits			Accuracy and Precision Criteria		
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**		Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (pg/L)	Groundwater (pg/L)	Groundwater (pg/L)	LCS %R	Groundwater %R	Groundwater RPD
2,3,7,8-TCDD	1746-01-6	TBD	TBD	1.25	2.5	5			
1,2,3,7,8-PeCDD	40321-76-4	TBD	TBD	5	12.5	25			
1,2,3,4,7,8-HxCDD	39227-28-6	TBD	TBD	5	12.5	25			
1,2,3,6,7,8-HxCDD	57653-85-7	TBD	TBD	5	12.5	25			
1,2,3,7,8,9-HxCDD	19408-74-3	TBD	TBD	5	12.5	25			
1,2,3,4,6,7,8-HpCDD	35822-46-9	TBD	TBD	5	12.5	25			
OCDD	3268-87-9	TBD	TBD	10	25	50			
2,3,7,8-TCDF	51207-31-9	TBD	TBD						
1,2,3,7,8-PeCDF	57117-41-6	TBD	TBD	2.5	5	10			
2,3,4,7,8-PeCDF	57117-31-4	TBD	TBD	5	12.5	25			
1,2,3,4,7,8-HxCDF	70648-26-9	TBD	TBD	5	12.5	25			
1,2,3,6,7,8-HxCDF	57117-44-9	TBD	TBD	5	12.5	25			
2,3,4,6,7,8-HxCDF	60851-34-5	TBD	TBD	5	12.5	25			
1,2,3,7,8,9-HxCDF	72918-21-9	TBD	TBD	5	12.5	25			
1,2,3,4,6,7,8-HpCDF	67562-39-4	TBD	TBD	5	12.5	25			
1,2,3,4,7,8,9-HpCDF	55673-89-7	TBD	TBD	5	12.5	25			
OCDF	39001-02-0	TBD	TBD	5	12.5	25			

Notes:

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

# The 20% RPD applies when laboratory duplicate concentrations are greater than 5x LOQ. For laboratory duplicate concentrations at or above the LOQ and less than 5x LOQ, the control limit is  $\pm$ CRQL.

Limits listed above include 5x dilution performed on digestate prior to analysis.

%R = percent recovery

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

HRGC = High Resolution Gas Chromatography

HRMS = High Resolution-Mass Spectrometry

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

Pg/L = picogram per liter

MS/MSD = Matrix Spike/Matrix Spike Duplicate

NA = Not Applicable

RPD = relative percent difference

TBD = To Be Determined

## WORKSHEET #15.13: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – DIOXINS/FURANS (SOIL/SEDIMENT/WASTE)

				Achievable Laboratory Limits			Accuracy and Precision Criteria		
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**		Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment /Waste (pg/g)	Soil/Sediment /Waste (pg/g)	Soil/Sediment /Waste (pg/g)	LCS %R	Soil/Sediment/ Waste %R	Soil/ Sediment/ Waste RPD
2,3,7,8-TCDD	1746-01-6	TBD	TBD	0.50	0.25	0.125			
1,2,3,7,8-PeCDD	40321-76-4	TBD	TBD	2.5	1.25	0.50			
1,2,3,4,7,8-HxCDD	39227-28-6	TBD	TBD	2.5	1.25	0.50			
1,2,3,6,7,8-HxCDD	57653-85-7	TBD	TBD	2.5	1.25	0.50			
1,2,3,7,8,9-HxCDD	19408-74-3	TBD	TBD	2.5	1.25	0.50			
1,2,3,4,6,7,8-HpCDD	35822-46-9	TBD	TBD	2.5	1.25	0.50			
OCDD	3268-87-9	TBD	TBD	5	2.5	1			
2,3,7,8-TCDF	51207-31-9	TBD	TBD	0.5	0.25	0.125			
1,2,3,7,8-PeCDF	57117-41-6	TBD	TBD	2.5	1.25	0.50			
2,3,4,7,8-PeCDF	57117-31-4	TBD	TBD	2.5	1.25	0.50			
1,2,3,4,7,8-HxCDF	70648-26-9	TBD	TBD	2.5	1.25	0.50			
1,2,3,6,7,8-HxCDF	57117-44-9	TBD	TBD	2.5	1.25	0.50			
2,3,4,6,7,8-HxCDF	60851-34-5	TBD	TBD	2.5	1.25	0.50			
1,2,3,7,8,9-HxCDF	72918-21-9	TBD	TBD	2.5	1.25	0.50			
1,2,3,4,6,7,8-HpCDF	67562-39-4	TBD	TBD	2.5	1.25	0.50			
1,2,3,4,7,8,9-HpCDF	55673-89-7	TBD	TBD	2.5	1.25	0.50			
OCDF	39001-02-0	TBD	TBD	5	2.5	1			

Notes:

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

# The 20% RPD applies when laboratory duplicate concentrations are greater than 5x LOQ. For laboratory duplicate concentrations at or above the LOQ and less than 5x LOQ, the control limit is  $\pm$ CRQL.

Limits listed above include 5x dilution performed on digestate prior to analysis.

%R = percent recovery

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

HRGC = High Resolution Gas Chromatography

HRMS = High Resolution-Mass Spectrometry

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

pg/g = picogram per gram

MS/MSD = Matrix Spike/Matrix Spike Duplicate

NA = Not Applicable

RPD = relative percent difference

TBD = To Be Determined

## WORKSHEET #15.14: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – PFAS (GROUNDWATER)

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**	Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (µg/L)	Groundwater (µg/L)	Groundwater (µg/L)	LCS/MS/MSD %R	RPD
Perfluorobutanoic acid	375-22-4	TBD	TBD	0.016	0.004	0.0019	40-150	30
Perfluoropentanoic acid	2706-90-3	TBD	TBD	0.008	0.002	0.00094	40-150	30
Perfluorohexanoic acid	307-24-4	TBD	TBD	0.004	0.002	0.0005	40-150	30
Perfluoroheptanoic acid	375-85-9	TBD	TBD	0.004	0.002	0.0005	40-150	30
Perfluorooctanoic acid	335-67-1	TBD	TBD	0.004	0.001	0.0005	40-150	30
Perfluorononanoic acid	375-95-1	TBD	TBD	0.004	0.002	0.00061	40-150	30
Perfluorodecanoic acid	335-76-2	TBD	TBD	0.004	0.002	0.0005	40-150	30
Perfluoroundecanoic acid	2058-94-8	TBD	TBD	0.004	0.002	0.0006	40-150	30
Perfluorododecanoic acid	307-55-1	TBD	TBD	0.004	0.002	0.0006	40-150	30
Perfluorotridecanoic acid	72629-94-8	TBD	TBD	0.004	0.002	0.00084	40-150	30
Perfluorotetradecanoic acid	376-06-7	TBD	TBD	0.004	0.002	0.0005	40-150	30
Perfluorobutanesulfonic acid	375-73-5	TBD	TBD	0.004	0.002	0.0005	40-150	30
Perfluoropentanesulfonic acid	2706-91-4	TBD	TBD	0.005	0.004	0.0011	40-150	30
Perfluorohexanesulfonic acid	355-46-4	TBD	TBD	0.004	0.002	0.0007	40-150	30
Perfluoroheptanesulfonic acid	375-92-8	TBD	TBD	0.004	0.002	0.0005	40-150	30

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**	Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (µg/L)	Groundwater (µg/L)	Groundwater (µg/L)	LCS/MS/MSD %R	RPD
Perfluorooctanesulfonic acid	1763-23-1	TBD	TBD	0.004	0.002	0.00054	40-150	30
Perfluorononanesulfonic acid	68259-12-1	TBD	TBD	0.004	0.002	0.00057	40-150	30
Perfluorodecanesulfonic acid	335-77-3	TBD	TBD	0.004	0.002	0.00064	40-150	30
Perfluorododecanesulfonic acid	79780-39-5	TBD	TBD	0.005	0.004	0.0011	40-150	30
4:2 Fluorotelomer sulfonate	757124-72-4	TBD	TBD	0.02	0.008	0.0032	40-150	30
6:2 Fluorotelomer sulfonate	27619-97-2	TBD	TBD	0.02	0.008	0.0035	40-150	30
8:2 Fluorotelomer sulfonate	39108-34-4	TBD	TBD	0.02	0.008	0.0041	40-150	30
PFOSA	754-91-6	TBD	TBD	0.004	0.002	0.00067	40-150	30
MeFOSA	31506-32-8	TBD	TBD	0.008	0.004	0.001	40-150	30
EtFOSA	4151-50-2	TBD	TBD	0.008	0.004	0.001	40-150	30
MeFOSAA	2355-31-9	TBD	TBD	0.005	0.004	0.001	40-150	30
EtFOSAA	2991-50-6	TBD	TBD	0.005	0.004	0.0013	40-150	30
MeFOSE	24448-09-7	TBD	TBD	0.04	0.02	0.0044	40-150	30
EtFOSE	1691-99-2	TBD	TBD	0.04	0.02	0.0074	40-150	30
HFPO-DA (GenX)	13252-13-6	TBD	TBD	0.004	0.002	0.001	40-150	30
ADONA	919005-14-4	TBD	TBD	0.008	0.004	0.0019	40-150	30
PFMPA	377-73-1	TBD	TBD	0.008	0.002	0.001	40-150	30

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**	Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (µg/L)	Groundwater (µg/L)	Groundwater (µg/L)	LCS/MS/MSD %R	RPD
PFMBA	863090-89-5	TBD	TBD	0.008	0.004	0.0011	40-150	30
NFDHA	151772-58-6	TBD	TBD	0.008	0.004	0.0012	40-150	30
9Cl-PF3ONS (F-53B Major)	756426-58-1	TBD	TBD	0.008	0.004	0.0014	40-150	30
11Cl-PF3OUdS (F-53B Minor)	763051-92-9	TBD	TBD	0.008	0.004	0.0018	40-150	30
PFEESA	113507-82-7	TBD	TBD	0.008	0.002	0.00078	40-150	30
3:3 Fluorotelomer carboxylate	356-02-5	TBD	TBD	0.02	0.01	0.0045	40-150	30
5:3 Fluorotelomer carboxylate	914637-49-3	TBD	TBD	0.1	0.02	0.0087	40-150	30
7:3 Fluorotelomer carboxylate	812-70-4	TBD	TBD	0.1	0.02	0.0079	40-150	30

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

# The 20% RPD applies when laboratory duplicate concentrations are greater than 5x LOQ. For laboratory duplicate concentrations at or above the LOQ and less than 5x LOQ, the control limit is ±CRQL.

Limits listed above include 5x dilution performed on digestate prior to analysis.

%R = percent recovery

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

LCMS = Liquid Chromatography-Mass Spectrometry

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

µg/L = microgram per liter

MS/MSD = Matrix Spike/Matrix Spike Duplicate

NA = Not Applicable

RPD = relative percent difference

TBD = To Be Determined

## WORKSHEET #15.15: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – PFAS (SOIL/SEDIMENT/WASTE)

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**	Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (µg/kg)	Soil/Sediment/Waste (µg/kg)	Soil/Sediment/Waste (µg/kg)	LCS/MS/MSD %R	RPD
Perfluorobutanoic acid	375-22-4	TBD	TBD	2	0.8	0.31	40-150	30
Perfluoropentanoic acid	2706-90-3	TBD	TBD	1	0.4	0.1	40-150	30
Perfluorohexanoic acid	307-24-4	TBD	TBD	1	0.4	0.1	40-150	30
Perfluoroheptanoic acid	375-85-9	TBD	TBD	1	0.4	0.1	40-150	30
Perfluorooctanoic acid	335-67-1	TBD	TBD	1	0.4	0.1	40-150	30
Perfluorononanoic acid	375-95-1	TBD	TBD	1	0.4	0.12	40-150	30
Perfluorodecanoic acid	335-76-2	TBD	TBD	1	0.4	0.1	40-150	30
Perfluoroundecanoic acid	2058-94-8	TBD	TBD	1	0.4	0.13	40-150	30
Perfluorododecanoic acid	307-55-1	TBD	TBD	1	0.4	0.1	40-150	30
Perfluorotridecanoic acid	72629-94-8	TBD	TBD	1	0.4	0.1	40-150	30
Perfluorotetradecanoic acid	376-06-7	TBD	TBD	1	0.4	0.1	40-150	30
Perfluorobutanesulfonic acid	375-73-5	TBD	TBD	1	0.4	0.1	40-150	30
Perfluoropentanesulfonic acid	2706-91-4	TBD	TBD	1	0.4	0.16	40-150	30
Perfluorohexanesulfonic acid	355-46-4	TBD	TBD	1	0.4	0.16	40-150	30
Perfluoroheptanesulfonic acid	375-92-8	TBD	TBD	1	0.4	0.15	40-150	30
Perfluorooctanesulfonic acid	1763-23-1	TBD	TBD	1	0.4	0.1	40-150	30



				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**	Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (µg/kg)	Soil/Sediment/Waste (µg/kg)	Soil/Sediment/Waste (µg/kg)	LCS/MS/MSD %R	RPD
Perfluorononanesulfonic acid	68259-12-1	TBD	TBD	1	0.4	0.18	40-150	30
Perfluorodecanesulfonic acid	335-77-3	TBD	TBD	1	0.4	0.14	40-150	30
Perfluorododecanesulfonic acid	79780-39-5	TBD	TBD	1	0.4	0.15	40-150	30
4:2 Fluorotelomer sulfonate	757124-72-4	TBD	TBD	2	1	0.3	40-150	30
6:2 Fluorotelomer sulfonate	27619-97-2	TBD	TBD	2	1	0.35	40-150	30
8:2 Fluorotelomer sulfonate	39108-34-4	TBD	TBD	2	1	0.61	40-150	30
PFOSA	754-91-6	TBD	TBD	1	0.4	0.1	40-150	30
MeFOSA	31506-32-8	TBD	TBD	1	0.4	0.14	40-150	30
EtFOSA	4151-50-2	TBD	TBD	1	0.4	0.1	40-150	30
MeFOSAA	2355-31-9	TBD	TBD	1	0.4	0.16	40-150	30
EtFOSAA	2991-50-6	TBD	TBD	1	0.4	0.2	40-150	30
MeFOSE	24448-09-7	TBD	TBD	5	2	0.64	40-150	30
EtFOSE	1691-99-2	TBD	TBD	5	2	0.83	40-150	30
HFPO-DA (GenX)	13252-13-6	TBD	TBD	2	0.8	0.29	40-150	30
ADONA	919005-14-4	TBD	TBD	2	0.8	0.34	40-150	30
PFMPA	377-73-1	TBD	TBD	1	0.4	0.11	40-150	30

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**	Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (µg/kg)	Soil/Sediment/Waste (µg/kg)	Soil/Sediment/Waste (µg/kg)	LCS/MS/MSD %R	RPD
PFMBA	863090-89-5	TBD	TBD	1	0.4	0.1	40-150	30
NFDHA	151772-58-6	TBD	TBD	2	0.8	0.24	40-150	30
9CI-PF3ONS (F-53B Major)	756426-58-1	TBD	TBD	2	1	0.44	40-150	30
11CI-PF3OUdS (F-53B Minor)	763051-92-9	TBD	TBD	2	1	0.36	40-150	30
PFEESA	113507-82-7	TBD	TBD	1	0.4	0.1	40-150	30
3:3 Fluorotelomer carboxylate	356-02-5	TBD	TBD	2.5	1	0.51	40-150	30
5:3 Fluorotelomer carboxylate	914637-49-3	TBD	TBD	13	5	1.2	40-150	30
7:3 Fluorotelomer carboxylate	812-70-4	TBD	TBD	13	5	1.3	40-150	30

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

# The 20% RPD applies when laboratory duplicate concentrations are greater than 5x LOQ. For laboratory duplicate concentrations at or above the LOQ and less than 5x LOQ, the control limit is ±CRQL.

Limits listed above include 5x dilution performed on digestate prior to analysis.

%R = percent recovery

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

LCMS = Liquid Chromatography-Mass Spectrometry

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

µg/kg = microgram per kilogram

MS/MSD = Matrix Spike/Matrix Spike Duplicate

NA = Not Applicable

RPD = relative percent difference

TBD = To Be Determined

## WORKSHEET #15.16: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – PCB CONGENERS (SOIL/SEDIMENT/WASTE)

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (pg/g)	OPR %R
PCB-77	32598-13-3	TBD	TBD	1	Method Limits
PCB-81	70362-50-4	TBD	TBD	1	Method Limits
PCB-105	32598-14-4	TBD	TBD	1	Method Limits
PCB-114	74472-37-0	TBD	TBD	1	Method Limits
PCB-118	31508-00-6	TBD	TBD	1	Method Limits
PCB-123	65510-44-3	TBD	TBD	1	Method Limits
PCB-126	57465-28-8	TBD	TBD	1	Method Limits
PCB-156/157		TBD	TBD	2	Method Limits
PCB-156	38380-08-4	TBD	TBD	-	Method Limits
PCB-157	69782-90-7	TBD	TBD	-	Method Limits
PCB-167	52663-72-6	TBD	TBD	1	Method Limits
PCB-169	32774-16-6	TBD	TBD	1	Method Limits
PCB-189	39635-31-9	TBD	TBD	1	Method Limits
PCB-1	2051-60-7	TBD	TBD	1	Method Limits
PCB-2	2051-61-8	TBD	TBD	1	Method Limits
PCB-3	2051-62-9	TBD	TBD	1	Method Limits
PCB-4	13029-08-8	TBD	TBD	1	Method Limits
PCB-10	33146-45-1	TBD	TBD	1	Method Limits
PCB-9	34883-39-1	TBD	TBD	1	Method Limits
PCB-7	33284-50-3	TBD	TBD	1	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (pg/g)	OPR %R
PCB-6	25569-80-6	TBD	TBD	1	Method Limits
PCB-5	16605-91-7	TBD	TBD	1	Method Limits
PCB-8	34883-43-7	TBD	TBD	1	Method Limits
PCB-14	34883-41-5	TBD	TBD	1	Method Limits
PCB-11	2050-67-1	TBD	TBD	1	Method Limits
PCB-13/12		TBD	TBD	2	Method Limits
PCB-13	2974-90-5	TBD	TBD	-	Method Limits
PCB-12	2974-92-7	TBD	TBD	-	Method Limits
PCB-15	2050-68-2	TBD	TBD	1	Method Limits
PCB-19	38444-73-4	TBD	TBD	1	Method Limits
PCB-30/18		TBD	TBD	2	Method Limits
PCB-30	35693-92-6	TBD	TBD	-	Method Limits
PCB-18	37680-65-2	TBD	TBD	-	Method Limits
PCB-17	37680-66-3	TBD	TBD	1	Method Limits
PCB-27	38444-76-7	TBD	TBD	1	Method Limits
PCB-24	55702-45-9	TBD	TBD	1	Method Limits
PCB-16	38444-78-9	TBD	TBD	1	Method Limits
PCB-32	38444-77-8	TBD	TBD	1	Method Limits
PCB-34	37680-68-5	TBD	TBD	1	Method Limits
PCB-23	55720-44-0	TBD	TBD	1	Method Limits
PCB-26/29		TBD	TBD	2	Method Limits
PCB-26	38444-81-4	TBD	TBD	-	Method Limits
PCB-29	15862-07-4	TBD	TBD	-	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (pg/g)	OPR %R
PCB-25	55712-37-3	TBD	TBD	1	Method Limits
PCB-31	16606-02-3	TBD	TBD	1	Method Limits
PCB-28/20		TBD	TBD	2	Method Limits
PCB-28	7012-37-5	TBD	TBD	-	Method Limits
PCB-20	38444-84-7	TBD	TBD	-	Method Limits
PCB-21/33		TBD	TBD	2	Method Limits
PCB-21	55702-46-0	TBD	TBD	-	Method Limits
PCB-33	38444-86-9	TBD	TBD	-	Method Limits
PCB-22	38444-85-8	TBD	TBD	1	Method Limits
PCB-36	38444-87-0	TBD	TBD	1	Method Limits
PCB-39	38444-88-1	TBD	TBD	1	Method Limits
PCB-38	53555-66-1	TBD	TBD	1	Method Limits
PCB-35	37680-69-6	TBD	TBD	1	Method Limits
PCB-37	38444-90-5	TBD	TBD	1	Method Limits
PCB-54	15968-05-5	TBD	TBD	1	Method Limits
PCB-50/53		TBD	TBD	2	Method Limits
PCB-50	62796-65-0	TBD	TBD	-	Method Limits
PCB-53	41464-41-9	TBD	TBD	-	Method Limits
PCB-45	70362-45-7	TBD	TBD	1	Method Limits
PCB-51	68194-04-7	TBD	TBD	1	Method Limits
PCB-46	41464-47-5	TBD	TBD	1	Method Limits
PCB-52	35693-99-3	TBD	TBD	1	Method Limits
PCB-73	74338-23-1	TBD	TBD	1	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (pg/g)	OPR %R
PCB-43	70362-46-8	TBD	TBD	1	Method Limits
PCB-69/49		TBD	TBD	2	Method Limits
PCB-69	60233-24-1	TBD	TBD	-	Method Limits
PCB-49	41464-40-8	TBD	TBD	-	Method Limits
PCB-48	70362-47-9	TBD	TBD	1	Method Limits
PCB-44/47/65		TBD	TBD	3	Method Limits
PCB-44	41464-39-5	TBD	TBD	-	Method Limits
PCB-47	2437-79-8	TBD	TBD	-	Method Limits
PCB-65	33284-54-7	TBD	TBD	-	Method Limits
PCB-59/62/75		TBD	TBD	3	Method Limits
PCB-59	74472-33-6	TBD	TBD	-	Method Limits
PCB-62	54230-22-7	TBD	TBD	-	Method Limits
PCB-75	32598-12-2	TBD	TBD	-	Method Limits
PCB-42	36559-22-5	TBD	TBD	1	Method Limits
PCB-41	52663-59-9	TBD	TBD	1	Method Limits
PCB-71/40		TBD	TBD	2	Method Limits
PCB-71	41464-64-4	TBD	TBD	-	Method Limits
PCB-40	38444-93-8	TBD	TBD	-	Method Limits
PCB-64	52663-58-8	TBD	TBD	1	Method Limits
PCB-72	41464-42-0	TBD	TBD	1	Method Limits
PCB-68	73575-52-7	TBD	TBD	1	Method Limits
PCB-57	70424-67-8	TBD	TBD	1	Method Limits
PCB-58	41464-49-7	TBD	TBD	1	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (pg/g)	OPR %R
PCB-67	73575-53-8	TBD	TBD	1	Method Limits
PCB-63	74472-34-7	TBD	TBD	1	Method Limits
PCB-61/70/74/76		TBD	TBD	4	Method Limits
PCB-61	33284-53-6	TBD	TBD	-	Method Limits
PCB-70	32598-11-1	TBD	TBD	-	Method Limits
PCB-74	32690-93-0	TBD	TBD	-	Method Limits
PCB-76	70362-48-0	TBD	TBD	-	Method Limits
PCB-66	32598-10-0	TBD	TBD	1	Method Limits
PCB-55	74338-24-2	TBD	TBD	1	Method Limits
PCB-56	41464-43-1	TBD	TBD	1	Method Limits
PCB-60	33025-41-1	TBD	TBD	1	Method Limits
PCB-80	33284-52-5	TBD	TBD	1	Method Limits
PCB-79	41464-48-6	TBD	TBD	1	Method Limits
PCB-78	70362-49-1	TBD	TBD	1	Method Limits
PCB-104	56558-16-8	TBD	TBD	1	Method Limits
PCB-96	73575-54-9	TBD	TBD	1	Method Limits
PCB-103	60145-21-3	TBD	TBD	1	Method Limits
PCB-94	73575-55-0	TBD	TBD	1	Method Limits
PCB-95	38379-99-6	TBD	TBD	1	Method Limits
PCB-100/93		TBD	TBD	2	Method Limits
PCB-100	39485-83-1	TBD	TBD	-	Method Limits
PCB-93	73575-56-1	TBD	TBD	-	Method Limits
PCB-102	68194-06-9	TBD	TBD	1	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (pg/g)	OPR %R
PCB-98	60233-25-2	TBD	TBD	1	Method Limits
PCB-88	55215-17-3	TBD	TBD	1	Method Limits
PCB-91	68194-05-8	TBD	TBD	1	Method Limits
PCB-84	52663-60-2	TBD	TBD	1	Method Limits
PCB-89	73575-57-2	TBD	TBD	1	Method Limits
PCB-121	56558-18-0	TBD	TBD	1	Method Limits
PCB-92	52663-61-3	TBD	TBD	1	Method Limits
PCB-113/90/101		TBD	TBD	3	Method Limits
PCB-113	68194-10-5	TBD	TBD	-	Method Limits
PCB-90	68194-07-0	TBD	TBD	-	Method Limits
PCB-101	37680-73-2	TBD	TBD	-	Method Limits
PCB-83	60145-20-2	TBD	TBD	1	Method Limits
PCB-99	38380-01-7	TBD	TBD	1	Method Limits
PCB-112	74472-36-9	TBD	TBD	1	Method Limits
PCB-108/119/86/97/125/87		TBD	TBD	6	Method Limits
PCB-108	70362-41-3	TBD	TBD	-	Method Limits
PCB-119	56558-17-9	TBD	TBD	-	Method Limits
PCB-86	55312-69-1	TBD	TBD	-	Method Limits
PCB-97	41464-51-1	TBD	TBD	-	Method Limits
PCB-125	74472-39-2	TBD	TBD	-	Method Limits
PCB-87	38380-02-8	TBD	TBD	-	Method Limits
PCB-117	68194-11-6	TBD	TBD	1	Method Limits



				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (pg/g)	OPR %R
PCB-116/85		TBD	TBD	2	Method Limits
PCB-116	18259-05-7	TBD	TBD	-	Method Limits
PCB-85	65510-45-4	TBD	TBD	-	Method Limits
PCB-110	38380-03-9	TBD	TBD	1	Method Limits
PCB-115	74472-38-1	TBD	TBD	1	Method Limits
PCB-82	52663-62-4	TBD	TBD	1	Method Limits
PCB-111	39635-32-0	TBD	TBD	1	Method Limits
PCB-120	68194-12-7	TBD	TBD	1	Method Limits
PCB-107/124		TBD	TBD	2	Method Limits
PCB-107	70424-68-9	TBD	TBD	-	Method Limits
PCB-124	70424-70-3	TBD	TBD	-	Method Limits
PCB-109	74472-35-8	TBD	TBD	1	Method Limits
PCB-106	70424-69-0	TBD	TBD	1	Method Limits
PCB-122	76842-07-4	TBD	TBD	1	Method Limits
PCB-127	39635-33-1	TBD	TBD	1	Method Limits
PCB-155	33979-03-2	TBD	TBD	1	Method Limits
PCB-152	68194-09-2	TBD	TBD	1	Method Limits
PCB-150	68194-08-1	TBD	TBD	1	Method Limits
PCB-136	38411-22-2	TBD	TBD	1	Method Limits
PCB-145	74472-40-5	TBD	TBD	1	Method Limits
PCB-148	74472-41-6	TBD	TBD	1	Method Limits
PCB-151/135		TBD	TBD	2	Method Limits
PCB-151	52663-63-5	TBD	TBD	-	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (pg/g)	OPR %R
PCB-135	52744-13-5	TBD	TBD	-	Method Limits
PCB-154	60145-22-4	TBD	TBD	1	Method Limits
PCB-144	68194-14-9	TBD	TBD	1	Method Limits
PCB-147/149		TBD	TBD	2	Method Limits
PCB-147	68194-13-8	TBD	TBD	-	Method Limits
PCB-149	38380-04-0	TBD	TBD	-	Method Limits
PCB-134	52704-70-8	TBD	TBD	1	Method Limits
PCB-143	68194-15-0	TBD	TBD	1	Method Limits
PCB-139/140		TBD	TBD	2	Method Limits
PCB-139	56030-56-9	TBD	TBD	-	Method Limits
PCB-140	59291-64-4	TBD	TBD	-	Method Limits
PCB-131	61798-70-7	TBD	TBD	1	Method Limits
PCB-142	41411-61-4	TBD	TBD	1	Method Limits
PCB-132	38380-05-1	TBD	TBD	1	Method Limits
PCB-133	35694-04-3	TBD	TBD	1	Method Limits
PCB-165	74472-46-1	TBD	TBD	1	Method Limits
PCB-146	51908-16-8	TBD	TBD	1	Method Limits
PCB-161	74472-43-8	TBD	TBD	1	Method Limits
PCB-153/168		TBD	TBD	2	Method Limits
PCB-153	35065-27-1	TBD	TBD	-	Method Limits
PCB-168	59291-65-5	TBD	TBD	-	Method Limits
PCB-141	52712-04-6	TBD	TBD	1	Method Limits
PCB-130	52663-66-8	TBD	TBD	1	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (pg/g)	OPR %R
PCB-137	35694-06-5	TBD	TBD	1	Method Limits
PCB-164	74472-45-0	TBD	TBD	1	Method Limits
PCB-163/138/129		TBD	TBD	3	Method Limits
PCB-163	74472-44-9	TBD	TBD	-	Method Limits
PCB-138	35065-28-2	TBD	TBD	-	Method Limits
PCB-129	55215-18-4	TBD	TBD	-	Method Limits
PCB-160	41411-62-5	TBD	TBD	1	Method Limits
PCB-158	74472-42-7	TBD	TBD	1	Method Limits
PCB-128/166		TBD	TBD	2	Method Limits
PCB-128	38380-07-3	TBD	TBD	-	Method Limits
PCB-166	41411-63-6	TBD	TBD	-	Method Limits
PCB-159	39635-35-3	TBD	TBD	1	Method Limits
PCB-162	39635-34-2	TBD	TBD	1	Method Limits
PCB-188	74487-85-7	TBD	TBD	1	Method Limits
PCB-179	52663-64-6	TBD	TBD	1	Method Limits
PCB-184	74472-48-3	TBD	TBD	1	Method Limits
PCB-176	52663-65-7	TBD	TBD	1	Method Limits
PCB-186	74472-49-4	TBD	TBD	1	Method Limits
PCB-178	52663-67-9	TBD	TBD	1	Method Limits
PCB-175	40186-70-7	TBD	TBD	1	Method Limits
PCB-187	52663-68-0	TBD	TBD	1	Method Limits
PCB-182	60145-23-5	TBD	TBD	1	Method Limits
PCB-183	52663-69-1	TBD	TBD	1	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (pg/g)	OPR %R
PCB-185	52712-05-7	TBD	TBD	1	Method Limits
PCB-174	38411-25-5	TBD	TBD	1	Method Limits
PCB-177	52663-70-4	TBD	TBD	1	Method Limits
PCB-181	74472-47-2	TBD	TBD	1	Method Limits
PCB-171/173		TBD	TBD	2	Method Limits
PCB-171	52663-71-5	TBD	TBD	-	Method Limits
PCB-173	68194-16-1	TBD	TBD	-	Method Limits
PCB-172	52663-74-8	TBD	TBD	1	Method Limits
PCB-192	74472-51-8	TBD	TBD	1	Method Limits
PCB-180/193		TBD	TBD	2	Method Limits
PCB-180	35065-29-3	TBD	TBD	-	Method Limits
PCB-193	69782-91-8	TBD	TBD	-	Method Limits
PCB-191	74472-50-7	TBD	TBD	1	Method Limits
PCB-170	35065-30-6	TBD	TBD	1	Method Limits
PCB-190	41411-64-7	TBD	TBD	1	Method Limits
PCB-202	2136-99-4	TBD	TBD	1	Method Limits
PCB-201	40186-71-8	TBD	TBD	1	Method Limits
PCB-204	74472-52-9	TBD	TBD	1	Method Limits
PCB-197	33091-17-7	TBD	TBD	1	Method Limits
PCB-200	52663-73-7	TBD	TBD	1	Method Limits
PCB-198/199		TBD	TBD	2	Method Limits
PCB-198	68194-17-2	TBD	TBD	-	Method Limits
PCB-199	52663-75-9	TBD	TBD	-	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (pg/g)	OPR %R
PCB-196	42740-50-1	TBD	TBD	1	Method Limits
PCB-203	52663-76-0	TBD	TBD	1	Method Limits
PCB-195	52663-78-2	TBD	TBD	1	Method Limits
PCB-194	35694-08-7	TBD	TBD	1	Method Limits
PCB-205	74472-53-0	TBD	TBD	1	Method Limits
PCB-208	52663-77-1	TBD	TBD	1	Method Limits
PCB-207	52663-79-3	TBD	TBD	1	Method Limits
PCB-206	40186-72-9	TBD	TBD	1	Method Limits
PCB-209	2051-24-3	TBD	TBD	1	Method Limits

Notes:

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

# The 20% RPD applies when laboratory duplicate concentrations are greater than 5x LOQ. For laboratory duplicate concentrations at or above the LOQ and less than 5x LOQ, the control limit is  $\pm$ CRQL.

Limits listed above include 5x dilution performed on digestate prior to analysis.

%R = percent recovery

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

HRGC = High Resolution Gas Chromatography

HRMS = High Resolution-Mass Spectrometry

LCS = Laboratory Control Sample

RL = Reporting Limit

MDL = Method Detection Limit

mg/kg = milligram per kilogram

MS/MSD = Matrix Spike/Matrix Spike Duplicate

NA = Not Applicable

RPD = relative percent difference

TBD = To Be Determined

## WORKSHEET #15.17: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – PCB CONGENERS (GROUNDWATER)

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (pg/g)	OPR %R
PCB-77	32598-13-3	TBD	TBD	10	Method Limits
PCB-81	70362-50-4	TBD	TBD	10	Method Limits
PCB-105	32598-14-4	TBD	TBD	10	Method Limits
PCB-114	74472-37-0	TBD	TBD	10	Method Limits
PCB-118	31508-00-6	TBD	TBD	10	Method Limits
PCB-123	65510-44-3	TBD	TBD	10	Method Limits
PCB-126	57465-28-8	TBD	TBD	10	Method Limits
PCB-156/157		TBD	TBD	20	Method Limits
PCB-156	38380-08-4	TBD	TBD	-	Method Limits
PCB-157	69782-90-7	TBD	TBD	-	Method Limits
PCB-167	52663-72-6	TBD	TBD	10	Method Limits
PCB-169	32774-16-6	TBD	TBD	10	Method Limits
PCB-189	39635-31-9	TBD	TBD	10	Method Limits
PCB-1	2051-60-7	TBD	TBD	10	Method Limits
PCB-2	2051-61-8	TBD	TBD	10	Method Limits
PCB-3	2051-62-9	TBD	TBD	10	Method Limits
PCB-4	13029-08-8	TBD	TBD	10	Method Limits
PCB-10	33146-45-1	TBD	TBD	10	Method Limits
PCB-9	34883-39-1	TBD	TBD	10	Method Limits
PCB-7	33284-50-3	TBD	TBD	10	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (pg/g)	OPR %R
PCB-6	25569-80-6	TBD	TBD	10	Method Limits
PCB-5	16605-91-7	TBD	TBD	10	Method Limits
PCB-8	34883-43-7	TBD	TBD	10	Method Limits
PCB-14	34883-41-5	TBD	TBD	10	Method Limits
PCB-11	2050-67-1	TBD	TBD	10	Method Limits
PCB-13/12		TBD	TBD	20	Method Limits
PCB-13	2974-90-5	TBD	TBD	-	Method Limits
PCB-12	2974-92-7	TBD	TBD	-	Method Limits
PCB-15	2050-68-2	TBD	TBD	10	Method Limits
PCB-19	38444-73-4	TBD	TBD	10	Method Limits
PCB-30/18		TBD	TBD	20	Method Limits
PCB-30	35693-92-6	TBD	TBD	-	Method Limits
PCB-18	37680-65-2	TBD	TBD	-	Method Limits
PCB-17	37680-66-3	TBD	TBD	10	Method Limits
PCB-27	38444-76-7	TBD	TBD	10	Method Limits
PCB-24	55702-45-9	TBD	TBD	10	Method Limits
PCB-16	38444-78-9	TBD	TBD	10	Method Limits
PCB-32	38444-77-8	TBD	TBD	10	Method Limits
PCB-34	37680-68-5	TBD	TBD	10	Method Limits
PCB-23	55720-44-0	TBD	TBD	10	Method Limits
PCB-26/29		TBD	TBD	20	Method Limits
PCB-26	38444-81-4	TBD	TBD	-	Method Limits
PCB-29	15862-07-4	TBD	TBD	-	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (pg/g)	OPR %R
PCB-25	55712-37-3	TBD	TBD	10	Method Limits
PCB-31	16606-02-3	TBD	TBD	10	Method Limits
PCB-28/20		TBD	TBD	20	Method Limits
PCB-28	7012-37-5	TBD	TBD	-	Method Limits
PCB-20	38444-84-7	TBD	TBD	-	Method Limits
PCB-21/33		TBD	TBD	20	Method Limits
PCB-21	55702-46-0	TBD	TBD	-	Method Limits
PCB-33	38444-86-9	TBD	TBD	-	Method Limits
PCB-22	38444-85-8	TBD	TBD	10	Method Limits
PCB-36	38444-87-0	TBD	TBD	10	Method Limits
PCB-39	38444-88-1	TBD	TBD	10	Method Limits
PCB-38	53555-66-1	TBD	TBD	10	Method Limits
PCB-35	37680-69-6	TBD	TBD	10	Method Limits
PCB-37	38444-90-5	TBD	TBD	10	Method Limits
PCB-54	15968-05-5	TBD	TBD	10	Method Limits
PCB-50/53		TBD	TBD	20	Method Limits
PCB-50	62796-65-0	TBD	TBD	-	Method Limits
PCB-53	41464-41-9	TBD	TBD	-	Method Limits
PCB-45	70362-45-7	TBD	TBD	10	Method Limits
PCB-51	68194-04-7	TBD	TBD	10	Method Limits
PCB-46	41464-47-5	TBD	TBD	10	Method Limits
PCB-52	35693-99-3	TBD	TBD	10	Method Limits
PCB-73	74338-23-1	TBD	TBD	10	Method Limits



				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (pg/g)	OPR %R
PCB-43	70362-46-8	TBD	TBD	10	Method Limits
PCB-69/49		TBD	TBD	20	Method Limits
PCB-69	60233-24-1	TBD	TBD	-	Method Limits
PCB-49	41464-40-8	TBD	TBD	-	Method Limits
PCB-48	70362-47-9	TBD	TBD	10	Method Limits
PCB-44/47/65		TBD	TBD	30	Method Limits
PCB-44	41464-39-5	TBD	TBD	-	Method Limits
PCB-47	2437-79-8	TBD	TBD	-	Method Limits
PCB-65	33284-54-7	TBD	TBD	-	Method Limits
PCB-59/62/75		TBD	TBD	30	Method Limits
PCB-59	74472-33-6	TBD	TBD	-	Method Limits
PCB-62	54230-22-7	TBD	TBD	-	Method Limits
PCB-75	32598-12-2	TBD	TBD	-	Method Limits
PCB-42	36559-22-5	TBD	TBD	10	Method Limits
PCB-41	52663-59-9	TBD	TBD	10	Method Limits
PCB-71/40		TBD	TBD	20	Method Limits
PCB-71	41464-64-4	TBD	TBD	-	Method Limits
PCB-40	38444-93-8	TBD	TBD	-	Method Limits
PCB-64	52663-58-8	TBD	TBD	10	Method Limits
PCB-72	41464-42-0	TBD	TBD	10	Method Limits
PCB-68	73575-52-7	TBD	TBD	10	Method Limits
PCB-57	70424-67-8	TBD	TBD	10	Method Limits
PCB-58	41464-49-7	TBD	TBD	10	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (pg/g)	OPR %R
PCB-67	73575-53-8	TBD	TBD	10	Method Limits
PCB-63	74472-34-7	TBD	TBD	10	Method Limits
PCB-61/70/74/76		TBD	TBD	40	Method Limits
PCB-61	33284-53-6	TBD	TBD	-	Method Limits
PCB-70	32598-11-1	TBD	TBD	-	Method Limits
PCB-74	32690-93-0	TBD	TBD	-	Method Limits
PCB-76	70362-48-0	TBD	TBD	-	Method Limits
PCB-66	32598-10-0	TBD	TBD	10	Method Limits
PCB-55	74338-24-2	TBD	TBD	10	Method Limits
PCB-56	41464-43-1	TBD	TBD	10	Method Limits
PCB-60	33025-41-1	TBD	TBD	10	Method Limits
PCB-80	33284-52-5	TBD	TBD	10	Method Limits
PCB-79	41464-48-6	TBD	TBD	10	Method Limits
PCB-78	70362-49-1	TBD	TBD	10	Method Limits
PCB-104	56558-16-8	TBD	TBD	10	Method Limits
PCB-96	73575-54-9	TBD	TBD	10	Method Limits
PCB-103	60145-21-3	TBD	TBD	10	Method Limits
PCB-94	73575-55-0	TBD	TBD	10	Method Limits
PCB-95	38379-99-6	TBD	TBD	10	Method Limits
PCB-100/93		TBD	TBD	20	Method Limits
PCB-100	39485-83-1	TBD	TBD	-	Method Limits
PCB-93	73575-56-1	TBD	TBD	-	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (pg/g)	OPR %R
PCB-102	68194-06-9	TBD	TBD	10	Method Limits
PCB-98	60233-25-2	TBD	TBD	10	Method Limits
PCB-88	55215-17-3	TBD	TBD	10	Method Limits
PCB-91	68194-05-8	TBD	TBD	10	Method Limits
PCB-84	52663-60-2	TBD	TBD	10	Method Limits
PCB-89	73575-57-2	TBD	TBD	10	Method Limits
PCB-121	56558-18-0	TBD	TBD	10	Method Limits
PCB-92	52663-61-3	TBD	TBD	10	Method Limits
PCB-113/90/101		TBD	TBD	30	Method Limits
PCB-113	68194-10-5	TBD	TBD	-	Method Limits
PCB-90	68194-07-0	TBD	TBD	-	Method Limits
PCB-101	37680-73-2	TBD	TBD	-	Method Limits
PCB-83	60145-20-2	TBD	TBD	10	Method Limits
PCB-99	38380-01-7	TBD	TBD	10	Method Limits
PCB-112	74472-36-9	TBD	TBD	10	Method Limits
PCB-108/119/86/97/125/87		TBD	TBD	60	Method Limits
PCB-108	70362-41-3	TBD	TBD	-	Method Limits
PCB-119	56558-17-9	TBD	TBD	-	Method Limits
PCB-86	55312-69-1	TBD	TBD	-	Method Limits
PCB-97	41464-51-1	TBD	TBD	-	Method Limits
PCB-125	74472-39-2	TBD	TBD	-	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (pg/g)	OPR %R
PCB-87	38380-02-8	TBD	TBD	-	Method Limits
PCB-117	68194-11-6	TBD	TBD	10	Method Limits
PCB-116/85		TBD	TBD	20	Method Limits
PCB-116	18259-05-7	TBD	TBD	-	Method Limits
PCB-85	65510-45-4	TBD	TBD	-	Method Limits
PCB-110	38380-03-9	TBD	TBD	10	Method Limits
PCB-115	74472-38-1	TBD	TBD	10	Method Limits
PCB-82	52663-62-4	TBD	TBD	10	Method Limits
PCB-111	39635-32-0	TBD	TBD	10	Method Limits
PCB-120	68194-12-7	TBD	TBD	10	Method Limits
PCB-107/124		TBD	TBD	20	Method Limits
PCB-107	70424-68-9	TBD	TBD	-	Method Limits
PCB-124	70424-70-3	TBD	TBD	-	Method Limits
PCB-109	74472-35-8	TBD	TBD	10	Method Limits
PCB-106	70424-69-0	TBD	TBD	10	Method Limits
PCB-122	76842-07-4	TBD	TBD	10	Method Limits
PCB-127	39635-33-1	TBD	TBD	10	Method Limits
PCB-155	33979-03-2	TBD	TBD	10	Method Limits
PCB-152	68194-09-2	TBD	TBD	10	Method Limits
PCB-150	68194-08-1	TBD	TBD	10	Method Limits
PCB-136	38411-22-2	TBD	TBD	10	Method Limits
PCB-145	74472-40-5	TBD	TBD	10	Method Limits
PCB-148	74472-41-6	TBD	TBD	10	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (pg/g)	OPR %R
PCB-151/135		TBD	TBD	20	Method Limits
PCB-151	52663-63-5	TBD	TBD	-	Method Limits
PCB-135	52744-13-5	TBD	TBD	-	Method Limits
PCB-154	60145-22-4	TBD	TBD	10	Method Limits
PCB-144	68194-14-9	TBD	TBD	10	Method Limits
PCB-147/149		TBD	TBD	20	Method Limits
PCB-147	68194-13-8	TBD	TBD	-	Method Limits
PCB-149	38380-04-0	TBD	TBD	-	Method Limits
PCB-134	52704-70-8	TBD	TBD	10	Method Limits
PCB-143	68194-15-0	TBD	TBD	10	Method Limits
PCB-139/140		TBD	TBD	20	Method Limits
PCB-139	56030-56-9	TBD	TBD	-	Method Limits
PCB-140	59291-64-4	TBD	TBD	-	Method Limits
PCB-131	61798-70-7	TBD	TBD	10	Method Limits
PCB-142	41411-61-4	TBD	TBD	10	Method Limits
PCB-132	38380-05-1	TBD	TBD	10	Method Limits
PCB-133	35694-04-3	TBD	TBD	10	Method Limits
PCB-165	74472-46-1	TBD	TBD	10	Method Limits
PCB-146	51908-16-8	TBD	TBD	10	Method Limits
PCB-161	74472-43-8	TBD	TBD	10	Method Limits
PCB-153/168		TBD	TBD	20	Method Limits
PCB-153	35065-27-1	TBD	TBD	-	Method Limits
PCB-168	59291-65-5	TBD	TBD	-	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (pg/g)	OPR %R
PCB-141	52712-04-6	TBD	TBD	10	Method Limits
PCB-130	52663-66-8	TBD	TBD	10	Method Limits
PCB-137	35694-06-5	TBD	TBD	10	Method Limits
PCB-164	74472-45-0	TBD	TBD	10	Method Limits
PCB-163/138/129		TBD	TBD	30	Method Limits
PCB-163	74472-44-9	TBD	TBD	-	Method Limits
PCB-138	35065-28-2	TBD	TBD	-	Method Limits
PCB-129	55215-18-4	TBD	TBD	-	Method Limits
PCB-160	41411-62-5	TBD	TBD	10	Method Limits
PCB-158	74472-42-7	TBD	TBD	10	Method Limits
PCB-128/166		TBD	TBD	20	Method Limits
PCB-128	38380-07-3	TBD	TBD	-	Method Limits
PCB-166	41411-63-6	TBD	TBD	-	Method Limits
PCB-159	39635-35-3	TBD	TBD	10	Method Limits
PCB-162	39635-34-2	TBD	TBD	10	Method Limits
PCB-188	74487-85-7	TBD	TBD	10	Method Limits
PCB-179	52663-64-6	TBD	TBD	10	Method Limits
PCB-184	74472-48-3	TBD	TBD	10	Method Limits
PCB-176	52663-65-7	TBD	TBD	10	Method Limits
PCB-186	74472-49-4	TBD	TBD	10	Method Limits
PCB-178	52663-67-9	TBD	TBD	10	Method Limits
PCB-175	40186-70-7	TBD	TBD	10	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (pg/g)	OPR %R
PCB-187	52663-68-0	TBD	TBD	10	Method Limits
PCB-182	60145-23-5	TBD	TBD	10	Method Limits
PCB-183	52663-69-1	TBD	TBD	10	Method Limits
PCB-185	52712-05-7	TBD	TBD	10	Method Limits
PCB-174	38411-25-5	TBD	TBD	10	Method Limits
PCB-177	52663-70-4	TBD	TBD	10	Method Limits
PCB-181	74472-47-2	TBD	TBD	10	Method Limits
PCB-171/173		TBD	TBD	20	Method Limits
PCB-171	52663-71-5	TBD	TBD	-	Method Limits
PCB-173	68194-16-1	TBD	TBD	-	Method Limits
PCB-172	52663-74-8	TBD	TBD	10	Method Limits
PCB-192	74472-51-8	TBD	TBD	10	Method Limits
PCB-180/193		TBD	TBD	20	Method Limits
PCB-180	35065-29-3	TBD	TBD	-	Method Limits
PCB-193	69782-91-8	TBD	TBD	-	Method Limits
PCB-191	74472-50-7	TBD	TBD	10	Method Limits
PCB-170	35065-30-6	TBD	TBD	10	Method Limits
PCB-190	41411-64-7	TBD	TBD	10	Method Limits
PCB-202	2136-99-4	TBD	TBD	10	Method Limits
PCB-201	40186-71-8	TBD	TBD	10	Method Limits
PCB-204	74472-52-9	TBD	TBD	10	Method Limits
PCB-197	33091-17-7	TBD	TBD	10	Method Limits
PCB-200	52663-73-7	TBD	TBD	10	Method Limits

				Achievable Laboratory Limits	Accuracy and Precision Criteria
				Lab RL	Ongoing Precision Recovery Limits**
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (pg/g)	OPR %R
PCB-198/199		TBD	TBD	20	Method Limits
PCB-198	68194-17-2	TBD	TBD	-	Method Limits
PCB-199	52663-75-9	TBD	TBD	-	Method Limits
PCB-196	42740-50-1	TBD	TBD	10	Method Limits
PCB-203	52663-76-0	TBD	TBD	10	Method Limits
PCB-195	52663-78-2	TBD	TBD	10	Method Limits
PCB-194	35694-08-7	TBD	TBD	10	Method Limits
PCB-205	74472-53-0	TBD	TBD	10	Method Limits
PCB-208	52663-77-1	TBD	TBD	10	Method Limits
PCB-207	52663-79-3	TBD	TBD	10	Method Limits
PCB-206	40186-72-9	TBD	TBD	10	Method Limits
PCB-209	2051-24-3	TBD	TBD	10	Method Limits

Notes:

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

# The 20% RPD applies when laboratory duplicate concentrations are greater than 5x LOQ. For laboratory duplicate concentrations at or above the LOQ and less than 5x LOQ, the control limit is  $\pm$ CRQL.

Limits listed above include 5x dilution performed on digestate prior to analysis.

%R = percent recovery

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

HRGC = High Resolution Gas Chromatography

HRMS = High Resolution-Mass Spectrometry

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

pg/g = picogram per gram

MS/MSD = Matrix Spike/Matrix Spike Duplicate

NA = Not Applicable

RPD = relative percent difference

TBD = To Be Determined



## WORKSHEET #15.18: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – INORGANICS (GROUNDWATER)

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**	Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	Groundwater (µg/l)	Groundwater (µg/l)	Groundwater (µg/l)	LCS/MS/MSD %R	RPD
Arsenic	7440-38-2	TBD	TBD	10	5	3.1	84-116	20
Barium	7440-39-3	TBD	TBD	3	1.5	0.94	86-114	20
Cadmium	7440-43-9	TBD	TBD	2	1	0.62	87-115	20
Chromium	7440-47-3	TBD	TBD	10	5	3.1	85-116	20
Cyanide	57-12-5	TBD	TBD	0.01	0.006	0.003	90-110	20
Lead	7439-92-1	TBD	TBD	1	0.5	0.31	70-124	20
Mercury	7439-97-6	TBD	TBD	0.5	0.25	0.18	80-120	20
Silver	7440-22-4	TBD	TBD	2	1	0.62	85-116	20

### Notes:

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

# The 20% RPD applies when laboratory duplicate concentrations are greater than 5x LOQ. For laboratory duplicate concentrations at or above the LOQ and less than 5x LOQ, the control limit is ±CRQL.

Limits listed above include 5x dilution performed on digestate prior to analysis.

%R = percent recovery

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

ICP-AES = Inductively Coupled Plasma-Atomic Emission Spectroscopy

ICP-MS = Inductively Coupled Plasma-Mass Spectrometry

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

µg/L = microgram per liter

MS/MSD = Matrix Spike/Matrix Spike Duplicate

NA = Not Applicable

RPD = relative percent difference

TBD = To Be Determined

## WORKSHEET #15.19: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – INORGANICS (SOIL/SEDIMENT/WASTE)

				Achievable Laboratory Limits			Accuracy and Precision Criteria	
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits**	Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	Soil/Sediment/Waste (mg/kg)	Soil/Sediment/Waste (mg/kg)	Soil/Sediment/Waste (mg/kg)	LCS/MS/MSD %R	RPD
Arsenic	7440-38-2	TBD	TBD	0.31	1	0.75	82-118	20
Barium	7440-39-3	TBD	TBD	0.3	0.094	0.225	86-116	20
Cadmium	7440-43-9	TBD	TBD	0.2	0.062	0.15	84-116	20
Chromium	7440-47-3	TBD	TBD	1	0.31	0.75	83-119	20
Cyanide	57-12-5	TBD	TBD	0.12	0.072	0.036	75-118	30
Lead	7439-92-1	TBD	TBD	0.2	0.062	0.15	84-118	20
Mercury	7439-97-6	TBD	TBD	0.2	0.07	0.15	74-126	20
Selenium	7782-49-2	TBD	TBD	2	0.62	1.5	80-119	20
Silver	7440-22-4	TBD	TBD	0.5	0.15	0.375	83-118	20

### Notes:

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

# The 20% RPD applies when laboratory duplicate concentrations are greater than 5x LOQ. For laboratory duplicate concentrations at or above the LOQ and less than 5x LOQ, the control limit is  $\pm$ CRQL.

Limits listed above include 5x dilution performed on digestate prior to analysis.

%R = percent recovery

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

ICP-AES = Inductively Coupled Plasma-Atomic Emission Spectroscopy

ICP-MS = Inductively Coupled Plasma-Mass Spectrometry

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

mg/kg = milligram per kilogram

MS/MSD = Matrix Spike/Matrix Spike Duplicate

NA = Not Applicable

RPD = relative percent difference

TBD = To Be Determined

## WORKSHEET #15.20: PROJECT ACTION LIMITS AND ACHIEVABLE LABORATORY LIMITS\* – INORGANICS (TCLP)

				Achievable Laboratory Limits			Accuracy and Precision Criteria <sup>1</sup>	
				Lab LOQ	Lab LOD	Lab MDL	LCS and MS Recovery Limits	Lab Duplicate Precision
Analyte	CAS Number	Project Action Limit	Project QL	TCLP Leachate (mg/L)	TCLP Leachate (mg/L)	TCLP Leachate (mg/L)	LCS %R	TCLP Leachate by ICP-MS RPD
Arsenic	7440-38-2	TBD	TBD	20	10	6.2	84-116	20
Barium	7440-39-3	TBD	TBD	6	3	1.88	86-114	20
Cadmium	7440-43-9	TBD	TBD	4	2	1.2	87-115	20
Chromium	7440-47-3	TBD	TBD	20	10	6.2	85-116	20
Lead	7439-92-1	TBD	TBD	2	1	0.62	88-115	20
Mercury <sup>1</sup>	7439-97-6	TBD	TBD	0.8	0.4	0.28	70-124	20
Selenium	7782-49-2	TBD	TBD	40	20	12.4	80-120	20
Silver	7440-22-4	TBD	TBD	4	2	1.24	85-116	20

### Notes:

\* Individual laboratory limit of quantitation (LOQs) and method detection limits (MDLs) will vary.

\*\* MS/MSDs will be based on statistically derived limits and will vary between laboratories. In the absence of laboratory limits, use NFG guidelines, if applicable.

1 Mercury is analyzed by Cold Vapor Atomic Absorption rather than by ICP-AES or ICP-MS.

# The 20% RPD applies when laboratory duplicate concentrations are greater than 5x LOQ. For laboratory duplicate concentrations at or above the LOQ and less than 5x LOQ, the control limit is ±CRQL.

-- = Analyte not performed by this method

%R = percent recovery

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

CRQL = Contract Required Quantitation Limit

ICP-AES = Inductively Coupled Plasma-Atomic Emission Spectroscopy

ICP-MS = Inductively Coupled Plasma-Mass Spectrometry

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

LOD = Limit of Detection

MDL = Method Detection Limit

MS/MSD = Matrix Spike/Matrix Spike Duplicate

mg/L = milligram per liter

RPD = relative percent difference

TBD = To Be Determined

TCLP = Toxicity characteristic leaching procedure

## **WORKSHEET #17 & 18: SAMPLING DESIGN, RATIONALE, LOCATIONS, AND METHODS**

### ***Sampling Design***

The sampling design, rationale, locations and methods are described in the Site-specific Work Plan. Each site involving environmental field sampling requires a site-specific sampling design and rationale, which specifies data collection activities and QA/QC measures specific to the site. The Work Plan presents the rationale for each field activity planned for the field investigation; and specifically, the sampling design and rationale in terms of the matrices to be sampled, analyses planned along with their respective concentration levels, sampling locations (including QC, critical, and background samples), the estimated number of samples to be collected, and sampling frequency (if recurring sampling rounds are planned). This information is crucial to plan approval and should be closely related to previously discussed DQOs. A Site-specific Work Plan will be prepared for each site and should describe the following:

- The physical boundaries for the area under study, including maps or diagrams.
- The environmental media populations to be represented by the data.
- The time period being represented by the collected data.
- The descriptions and basis for dividing the site into sampling areas (e.g., decision units, exposure units) that support site DQOs.
- The basis for the numbers and placement of samples within sampling areas.
- If sampling locations are known, descriptions of how actual sample positions will be located once in the field (include maps or diagrams).
- If a sample cannot be collected where planned, the decision process for changing the location.
- If sample locations will be determined in the field, the decision process for doing so.
- Contingencies in the event that field conditions are different than expected and could have an effect on the sampling design.

To the extent possible based on available information, the Work Plan should also include the following:

- Brief history of the property use;
- Proposed reuse/redevelopment, if known;
- Identification of the applicable state standards being used (commercial/industrial, residential, or recreational);
- Direction of groundwater flow and source or reference for groundwater flow direction, if available;
- Number of samples to be collected;
- Type of samples to be collected;
- Location of samples to be collected (may specify “TBD at the discretion of the Program Manager”) and rationale for sample locations;
- Table showing samples to be collected, media, analyses, field QC/laboratory QC samples, and total number of samples for each medium;
- Site location map;
- Site features map (showing all site features, including buildings, former building locations, loading docks, concrete slabs, former transformers, locations of known spills, known and existing monitoring wells, grass, and waste piles).

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## ***Sampling Locations and Methods***

Sampling locations, analytical methods, and associated SOP references may be presented in a tabular format, as well as the rationale for the sample locations. Sampling locations for many sites are pre-determined and can be displayed on a site plan. The following information should be included:

- Sample IDs with depths (if known)
- Sample matrix (for example, *soil, sediment, or groundwater*)
- QC Sample Type (for example, *field duplicate, MS/MSD, or trip blanks*)
- Analyte (for example, *lead*) or Analytical Group (for example, *VOCs or PCBs*)
- Rationale (objective or reason for location, for example, *upgradient well*)
- Sampling SOPs (incorporated by reference)

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## **WORKSHEET #19 & 30: SAMPLE CONTAINERS, PRESERVATION, AND HOLD TIMES**

Worksheet #19 & 30 (combined herein for convenience) tabulates the sample containers and preservation requirements for each analysis and matrix type based on SW-846 Chapter 3 (Inorganics) and Chapter 4 (Organics) requirements. Technical holding times for sample preparation and analysis are also listed in these worksheets.

Except for VOCs and GRO in soil, sample preparation methods are not listed. To include the numerous organic and inorganic preparation methods would needlessly add to the complexity of this worksheet. VOC preparation method SW-846 5035A includes sampling and preservation requirements and is referenced in this worksheet.

The Field Team Leader will be responsible for the acceptance and inspection of sample containers.

Analytical Group (Concentration Level)	Matrix	Analytical Method	Containers (number, size, type per sample)	Preservation Requirements (chemical, temperature, light protected)	Technical Hold Time (Sample Preparation)	Technical Hold Time (Analysis)
VOCs (Low/Med)	Soil	SW-846 5035A/ 8260C/D	Three 5-gram EnCore (or equivalent) samplers <u>and</u> <u>Percent Solids vial below</u>	Iced to ≤6°C, methanol preservative	NA	14 days from collection
Percent solids for soil VOCs only	Soil	NA	One 40-mL VOA vial, one 4-oz glass jar, or 10-gram core tube.	Iced to ≤6°C, not frozen or frozen to < -7 °C	NA	NA
VOCs (Low/Med) <i>Field Preserved</i>	Soil	SW-846 5035A/ 8260C/D	5-gram soil cores extruded (e.g., using a Terra-Core sampler) into two 40-mL amber VOA vials with NaHSO <sub>4</sub> and a stir bar plus one 40-mL VOA vial with MeOH	Iced to ≤6°C, methanol preservative	Transfer soil cores to VOA vials containing preservatives in the field	14 days from collection
VOCs (Trace/Low)	Water	SW-846 8260C/D	Three 40-mL amber glass VOA vials	HCl pH<2, Iced to ≤6°C, not frozen	None	14 days from collection
VOCs (Trace/Low)	Water	SW-846 8260C/D	Three 40-mL amber glass VOA vials, PTFE septum lid	Iced to ≤6°C, not frozen (sample collected in un- preserved VOA vial if sample effervesces in presence of HCl)	None	14 days from collection
GRO	Soil	SW-846 5035/AK101	One 4-oz glass amber wide mouth jar	Iced to ≤6°C, not frozen, methanol preservative	None	28 days from collection
Percent solids for soil GRO only	Soil	NA	One 40-mL VOA vial, dry with no headspace	Iced to ≤6°C, not frozen	None	None
GRO	Water	SW-846 8015C/D	Three 40-mL amber glass VOA vials, PTFE septum lid	HCl pH<2, Iced to ≤6°C, not frozen	None	14 days from collection
SVOCs (Low)	Soil	SW-846 8270D/E	One 4-oz glass wide mouth jar	Iced to ≤6°C, not frozen	14 days (sampling to extraction)	40 days to analysis of extract
SVOCs (Low)	Water	SW-846 8270D/E	Two 1-L amber glass with PTFE-lined lid	Iced to ≤6°C, not frozen	7 days from sampling to extraction	40 days to analysis of extract
PAHs by SIM (Trace)	Soil	SW-846 8270D/E	One 8-oz glass wide mouth jar with PTFE-lined lid	Iced to ≤6°C, not frozen	14 days (sampling to extraction)	40 days to analysis of extract.

Analytical Group (Concentration Level)	Matrix	Analytical Method	Containers (number, size, type per sample)	Preservation Requirements (chemical, temperature, light protected)	Technical Hold Time (Sample Preparation)	Technical Hold Time (Analysis)
PAHs by SIM (Trace)	Water	SW-846 8270D/E	Two 1-L amber glass with PTFE-lined lid	Iced to ≤6°C, not frozen	7 days from sampling to extraction	40 days to analysis of extract.
OC Pesticides (Low)	Soil	SW-846 8081B	One 8-oz glass wide mouth jar with PTFE-lined lid	Iced to ≤6°C, not frozen	14 days (sampling to extraction)	40 days (to analysis of extract)
OC Pesticides (Low)	Water	SW-846 8081B	Two 1-L amber glass with PTFE-lined lid	Iced to ≤6°C, not frozen	7 days from sampling to extraction	40 days (to analysis of extract)
PCBs as Aroclors (Low)	Soil	SW-846 8082A	One 8-oz glass wide mouth jar with PTFE-lined lid	Iced to ≤6°C, not frozen	365 days (sampling to extraction)	40 days to analysis of extract (recommended)
PCBs as Aroclors (Low)	Water	SW-846 8082A	Two 1-L amber glass with PTFE-lined cap	Iced to ≤6°C, not frozen	365 days from sampling to extraction	40 days to analysis of extract (recommended)
Herbicides (Low)	Soil	SW-846 8151A	One 8-oz glass wide mouth jar with PTFE-lined lid	Iced to ≤6°C, not frozen	14 days (sampling to extraction)	40 days (extraction to analysis)
Herbicides (Low)	Water	SW-846 8151A	Two 1-L amber glass with PTFE-lined lid	Iced to ≤6°C, not frozen	7 days from sampling to extraction	40 days (to analysis of extract)
DRO and/or RRO	Soil	AK102/AK103	One 4-oz AMBER glass wide mouth jar with Teflon®-lined lid	Iced to ≤6°C, not frozen	14 days (sampling to extraction)	40 days (to analysis of extract)
DRO and/or RRO	Water	AK102/AK103	Two 250-mL amber glass jars with PTFE-lined lid	Iced to ≤6°C, not frozen	14 days from sampling to extraction	40 days (to analysis of extract)
PFAS (verify against new method development)	Water	SW-846 Method 8327 or EPA 537.1 (drinking water)	Three 250 mL HDPE or polypropylene container with unlined HDPE or polypropylene cap <i>Double the volume for S/D</i>	We follow sampling and preservation considerations discussed in ITRC's <i>Sampling Precautions and Laboratory Methods for Per- and Polyfluoroalkyl Substances (PFAS)</i> (ITRC, August 2020).		



Analytical Group (Concentration Level)	Matrix	Analytical Method	Containers (number, size, type per sample)	Preservation Requirements (chemical, temperature, light protected)	Technical Hold Time (Sample Preparation)	Technical Hold Time (Analysis)
PFAS (verify against new method development)	Soil	SW-846 Method 8327	HDPE, glass, or polypropylene sample bottles with Teflon® - free caps, provided by the laboratory	We follow sampling and preservation considerations discussed in ITRC's <i>Sampling Precautions and Laboratory Methods for Per- and Polyfluoroalkyl Substances (PFAS)</i> (ITRC, August 2020).		
Dioxins/ Furans	Solid	SW-846 Method 8290A	One 4-oz glass amber wide mouth jar	Iced to ≤6°C, not frozen, and kept in the dark	30 days from sampling to extraction	45 days (to analysis of extract)
Dioxins/ Furans	Aqueous	SW-846 Method 8290A	Two 1-L amber glass with Teflon lined lid	Iced to ≤6°C, not frozen, and kept in the dark if residual chlorine present, add 80 mg sodium thiosulfate per liter water; if pH>9, adjust to pH of 7 to 9 with sulfuric acid	30 days from sampling to extraction	45 days (to analysis of extract)
ICP-AES Metals (Low) or ICP-MS Metals (Trace)	Soil	SW-846 6010C/D SW-846 6020A/B	One 4-oz glass wide mouth jar <i>No extra volume needed for S/D</i>	Iced to ≤6°C, not frozen	None	6 months
ICP-AES Metals (Low) or ICP-MS Metals (Trace)	Water	SW-846 6010C/D EPA 200.7/ 200.8	One 500-ml HDPE bottle <i>Double the volume for S/D</i>	HNO <sub>3</sub> to pH<2, Iced to ≤6°C, not frozen	None	6 months
Dissolved Metals by ICP- AES (Low) or ICP-MS (Trace)	Water (field filtered)	SW-846 6010C/D EPA 200.7/ 200.8	One 500-ml HDPE bottle <i>Double the volume for S/D</i>	Sample must be filtered through 0.45 micron filter prior to preserving with HNO <sub>3</sub> to pH<2, Iced to ≤6°C, not frozen	None	6 months
Dissolved Metals by ICP- AES (Low) or ICP-MS (Trace)	Water (not field filtered)	SW-846 6010C/D EPA 200.7/ 200.8	One 500-ml HDPE <i>Double the volume for S/D</i>	Iced to ≤6°C, not frozen	None	6 months
Mercury (Low)	Soil	SW-846 7471B	One 4-oz glass wide mouth jar <i>No extra volume needed for S/D</i>	None	None	28 days

Analytical Group (Concentration Level)	Matrix	Analytical Method	Containers (number, size, type per sample)	Preservation Requirements (chemical, temperature, light protected)	Technical Hold Time (Sample Preparation)	Technical Hold Time (Analysis)
Mercury (Low)	Water	SW-846 7470A	One 250-ml HDPE bottle <i>Double the volume for S/D</i>	HNO <sub>3</sub> to pH<2, Iced to ≤6°C, not frozen	None	28 days
Total Cyanide	Soil	SW-846 9012A/B	One 4-oz glass wide mouth jar <i>No extra volume needed for S/D</i>	Iced to ≤6°C, not frozen	None	14 days
Total Cyanide (Low)	Water	SW-846 9012A/B	One 1-L HDPE bottle <i>Double the volume for S/D</i>	NaOH pH>12, Iced to ≤6°C, not frozen	None	14 days
TCLP VOC	Soil	SW-846 1311/ 8260C/D	One 4-oz jar with PTFE-lined septum lid	Iced to ≤6°C, not frozen	14 days (sampling to TCLP ZHE extraction)	14 days (TCLP extraction to analysis)
TCLP Organic extractables: SVOC, Pesticide, Herbicide (any or all)	Soil	SW-846 1311/ 8270D/E, 8081B, 8151A	One 8-oz. wide mouth glass jar	Iced to ≤6°C, not frozen	14 days (sampling to TCLP extraction) and 7 days (TCLP extraction to organic extraction for SVOCs, pesticides, or herbicides)	40 days (organic extraction to analysis)
TCLP Metals including mercury	Soil	SW-846 1311/ 6010C/D and 7470A	One 8-oz. wide mouth glass jar	Iced to ≤6°C, not frozen	Mercury: 28 days (sampling to TCLP extraction); Other metals: 180 days (sampling to TCLP extraction)	Mercury: 28 days (TCLP extraction to analysis); Other metals: 180 days (TCLP extraction to analysis)
Asbestos	Soil	PLM using EPA 600/R-93/116 (or equivalent) including preparation by milling similar to procedures in CARB 435	One 1-Liter plastic bag	None	None	None
Asbestos	Bulk	EPA 600/R- 93/116	Per subcontractor SOP	None	None	None

Analytical Group (Concentration Level)	Matrix	Analytical Method	Containers (number, size, type per sample)	Preservation Requirements (chemical, temperature, light protected)	Technical Hold Time (Sample Preparation)	Technical Hold Time (Analysis)
Lead-based paint	Paint chips	SW-846 7000B	Resealable baggie or centrifuge tubes	None	None	None

Notes:

- Container requirements in this table are based on the CLP Samplers Guide and/or SW846 Chapters 3 and 4 and are considered sufficient volumes for most laboratories. Sample volumes needed by laboratories may vary depending on equipment for preparation methods used by the individual laboratories. Volumes presented in this table should be considered maximum sample amounts needed by the laboratory and include sufficient sample for re-extraction/re-digestion if needed.
- Volumes for TCLP analyses in this table are adequate for soil matrices; however, waste materials with lower densities may require additional volume. Consult with the Chemist.
- Technical holding times for TCLP parameters are based on EPA SW-846 holding times rather than CLP holding times. If amber containers are not available for VOCs or other organic samples, protect the sample from light. All bottle ware is to be QC grade with Certificates of Analysis.
- VOA vials for soils are tared and require weighing in the field to the nearest 0.01 gram.
- Field sampling for asbestos-containing material (ACM) will follow Asbestos Hazard Emergency Response Act (AHERA) sampling protocols. Bulk samples of suspected ACM and LBP will include enough volume to accurately represent these materials.

AHERA = Asbestos Hazard Emergency  
Response Act

ASTM = American Society for Testing Materials

BFB = Bromofluorobenzene

CARB = California Air Resources Board

DRO = Diesel-Range Organic

GRO = Gasoline-Range Organic

HCl = hydrochloric acid

HDPE = high-density polyethylene

HNO<sub>3</sub> = nitric acid

ICP-AES = Inductively Coupled Plasma-Atomic  
Emission Spectrometer

ICP-MS = Inductively Coupled Plasma-Mass  
Spectrometer

L = liter

MeOH = methanol

mL = milliliter

NA = Not Applicable

NaHSO<sub>4</sub> = sodium bisulfate

OC = Organochlorine

oz. = ounce

PAH = Polynuclear Aromatic Hydrocarbon

PCB = Polychlorinated Biphenyl

PFAS = Per- and Polyfluoroalkyl Substances

PLM = Polarized Light Microscopy

PTFE = Polytetrafluoroethylene

QC = quality control

S/D = Sample/Duplicate

SIM = selected ion monitoring

SVOC = Semivolatile Organic Compound

TCLP = Toxicity Characteristic Leaching  
Procedure

VOA = Volatile Organic Analysis

VOC = Volatile Organic Compound

ZHE = Zero Headspace Extractor

## WORKSHEET #20: FIELD QC SUMMARY

Much of the information in this table is common to all projects. However, the numbers and types of Field QC samples will be selected during the project planning based on the project's data quality objectives (DQOs) and documented in the associated Work Plan.

Matrix	Analytical Group	Analytical Method	No. of Field Samples	No. of Field Duplicate Pairs	No. of MS/MSD	No. of Ambient Field Blanks	No. of <sup>2</sup> Equipment Blanks	No. of Trip Blanks	No. of PE Samples	Total No. of Samples to Laboratory
Soil	VOCs	SW-846 5035A+ 8260C/D	TBD	1 per 10	1 per 20	0	1 per day	1 per cooler with VOC samples	TBD	TBD
Water	VOCs	SW-846 5030+ 8260C/D	TBD	1 per 10	1 per 20	1 per day	1 per day	1 per cooler with VOC samples	TBD	TBD
Soil	GRO	AK101	TBD	1 per 10	1 per 20	0	1 per day	1 per cooler with GRO samples	TBD	TBD
Water	GRO	AK101	TBD	1 per 10	1 per 20	1 per day	1 per day	1 per cooler with GRO samples	TBD	TBD
Soil	DRO and RRO	AK102/103	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Water	DRO and RRO	AK102/103	TBD	1 per 10	1 per 20	1 per day	1 per day	0	TBD	TBD
Soil	SVOCs	SW-846 8270D/E	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Water	SVOCs	SW-846 8270D/E	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Soil	PAHs by SIM	SW-846 8270D/E	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Water	PAHs by SIM	SW-846 8270D/E	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Soil	OC Pesticides	SW-846 8081B	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Water	OC Pesticides	SW-846 8081B	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Soil	PCBs (Aroclors)	SW-846 8082A	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Water	PCBs (Aroclors)	SW-846 8082A	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Soil	Herbicides	SW-846 8151A	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD

Matrix	Analytical Group	Analytical Method	No. of Field Samples	No. of Field Duplicate Pairs	No. of MS/MSD	No. of Ambient Field Blanks	No. of <sup>2</sup> Equipment Blanks	No. of Trip Blanks	No. of PE Samples	Total No. of Samples to Laboratory
Water	Herbicides	SW-846 8151A	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Soil	PFAS	SW-846 Method 8327	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Water	PFAS	SW-846 Method 8327 or EPA 537.1 (drinking water)	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Soil	Dioxins/Furans	SW-846 Method 8290A	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Water	Dioxins/Furans	SW-846 Method 8290A	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Soil	Metals	SW-846 6010C/D or 6020A/B	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Water	Metals	SW-846 6010C/D, 6020A/B, EPA 200.7, EPA 200.8	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Soil	Mercury	EPA 7471B	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Water	Mercury	EPA 7470A	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Soil	Cyanide	EPA 9012A/B	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Water	Cyanide	EPA 9012A/B	TBD	1 per 10	1 per 20	0	1 per day	0	TBD	TBD
Solid	TCLP analyses	SW-846 1311+ SW-846 8260C/D+, 8270D/E+, 8081B+, 6010C/D+, 7470A	TBD	0	0	0	0	0	0	TBD

**Notes:**

- Analytical methods and the numbers and types of Field QC samples will be selected during the site scoping process and documented in the site-specific sampling designs. The numbers of field QC samples listed in this table may not be needed depending on the type of sampling equipment used. Equipment blanks would not be required if dedicated sampling equipment is used.
- Equipment rinsate blanks will be collected for non-dedicated sampling equipment.  
DRO and RRO can be extracted from the same 1-L sample bottle.

DRO = Diesel-Range Organic  
 GRO = Gasoline-Range Organic  
 L = liter  
 MS/MSD = Matrix Spike/ Matrix Spike Duplicate  
 OC = Organochlorine

PAH = Polynuclear Aromatic Hydrocarbon  
 PCB = Polychlorinated Biphenyl  
 PFAS = Per-and Polyfluoroalkyl Substances  
 PE = Performance Evaluation

QC = quality control  
 RRO = residual range organics  
 SIM = selected ion monitoring  
 SVOC = Semivolatile Organic Compound

TBD = To Be Determined  
 TCLP = Toxicity Characteristic Leaching Procedure  
 VOC = Volatile Organic Compound

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## WORKSHEET #21: FIELD SOPS

SOPs are generally divided into task or activity-specific categories, such as sample collection, field screening instruments, field screening kits/methods, and monitoring well installation SOPs.

### Contaminated Sites/Brownfields in the State of Alaska

If the project is in the State of Alaska, the ADEC's Division of Spill Prevention and Response Contaminated Sites Program's *Field Sampling Guidance (January 2022)* will be followed. If required by Alaska state regulations, driller should be licensed in Alaska. Drilling core logging and well installation should be overseen by a licensed geologist or qualified professional. These field SOPs are published and can be found here:

<https://dec.alaska.gov/spar/csp/guidance-forms/>

Additionally, ASTM D6063-11 "Standard Guide for Sampling of Drums and Similar Containers by Field Personnel" may be utilized and can be found here:

<https://www.astm.org/d6063-11r18.html>

In the absence of state designated SOPs, Montrose Environmental Field SOPs, which are included as **Appendix B**, will be used for field operations.

SOPs used for fieldwork will be referenced in the Site-specific Work Plan. Any modification to these SOPs will be documented in the Work Plan. The combination of this QAPP and the Site-specific work Plan will provide planning documentation for field sampling methods, sample handling procedures, and QA/QC procedures for the successful execution of the project. As needed, additional SOPs may be incorporated into Work Plans, including SOPs developed for EPA regions, state agencies, and other federal agencies such as U.S. Army Corps of Engineers. Any SOPs used to develop a Work Plan will be attached to the Work Plan or cited as a reference.

If an asbestos, lead-based paint, mold or PCB survey or sampling is required, Montrose will potentially subcontract these services to complete the assessment. SOPs for such surveys/sampling will be provided by the subcontractor and maintained in the Montrose project file and available upon request. All on-site subcontracted personnel will comply with the site-specific Health and Safety Plan (HASP) requirements and will hold applicable certification and be current in all training requirements. Montrose personnel will oversee any required subcontractors.

## WORKSHEET #22: FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION

Common types of field monitoring equipment are listed in the table below. However, this list is neither prescriptive nor comprehensive. Site-specific equipment and procedures are included in the Work Plan.

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Resp. Person	SOP Reference
pH Probe	Calibrate daily using at least two auto- calibration standard solutions	NA	NA	NA	Daily before use and when drift is identified or suspected, or readings are unstable	pH reads $\pm 0.2$ Standards of 4.0, 7.0, or 10.0 depending on which two solutions are used.	Clean probe with deionized water and recalibrate. Do not use if unable to calibrate properly.	Field Team Leader	TBD
Specific Conductance probe	Calibrate daily using auto-calibration standard solutions	NA	NA	NA	Daily before use and when drift is identified or suspected, or readings are unstable	Conductivity is $\mu\text{S} \pm 3\%$ of standard solution.	Clean probe with deionized water and recalibrate. Do not use if unable to calibrate properly.	Field Team Leader	TBD
Oxidation-reduction potential	Calibrate daily using auto-calibration standard solutions	NA	NA	NA	Daily before use and when drift is identified or suspected, or readings are unstable	Within Calibration Range	Clean probe with deionized water and recalibrate. Do not use if unable to calibrate properly.	Field Team Leader	TBD
Dissolved Oxygen, Temperature, and turbidity probes	NA for DO and temperature; Calibrate daily using auto-calibration standard solutions	NA	During calibration of instrument, check temperature against ambient.	NA	Daily before use and when drift is identified or suspected, or readings are unstable	Calibrate at saturation with acceptance criteria of $\pm 0.3 \text{ mg DO/L}$ Std = 11-40 NTU, $< \pm 8\%$ Std = 41-100 NTU, $< \pm 6.5\%$ Std > 100 NTU, $< \pm 5\%$	Clean probe with deionized water and recalibrate. Do not use if unable to calibrate properly.	Field Team Leader	TBD



Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Resp. Person	SOP Reference
Multi-gas Meter	Calibrate for organic vapors using isobutylene; LEL, O <sub>2</sub> , H <sub>2</sub> S, and carbon monoxide using mixed gas	Charge battery. Allow complete discharge of battery before recharging	Self-Test	NA	Daily before use and as needed during day	NA	If instrument cannot be calibrated, replaced with another unit.	Field Team Leader	TBD
Photoionization detector	Calibrate for organic vapors using isobutylene at 100 ppm	Charge battery. Allow complete discharge of battery before recharging	Self-Test	NA	Daily before use and as needed during day	NA	If instrument cannot be calibrated, replaced with another unit.	Field Team Leader	TBD
Petro FLAG TPH Analyzer	Calibrate for TPH using reagents of known concentrations to create an acceptable instrument performance curve	Clean vials after each reading, discard scratched or damaged vials	Self-test with vials of known concentrations to generate acceptable instrument performance curve	NA	Daily before use and as needed during day	Within Calibration Range	If instrument cannot be calibrated, replaced with another unit.	Field Team Leader	TBD
Chlorine Halogen test kit	NA	NA	NA	Confirm positive indication by performing tests on substances of known concentrations	Daily before use and as needed during day	NA	If positive indication cannot be confirmed, replace test kit	Field Team Leader	TBD
Groundwater sampling pumps and tubing (as applicable)	NA	NA	NA	Inspect pumps, tubing and connections.	Regularly	Maintain in good working order as per manufacturer manuals	Replace items	Field Team Leader	TBD

## Notes:

 μS = microSiemens  
 DO = Dissolved Oxygen

 H<sub>2</sub>S = Hydrogen Sulfide  
 LEL = Lower Explosive Limit

 mg DO/L = Milligrams Dissolved  
 Oxygen Per Liter

 NA = Not Applicable  
 NTU = Nephelometric Turbidity  
 Units

 O<sub>2</sub> = Oxygen  
 SOP = Standard Operating  
 Procedure

 Std = Standard  
 TBD = To be determined  
 Procedure



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## WORKSHEET #23: ANALYTICAL SOPS

As part of the analytical subcontracting process, the QAM will specify analytical methods to be used by subcontracted laboratories. All analytical laboratories must be accredited for the selected analytical method by a National Environmental Laboratory Accreditation Program (NELAP) accredited laboratory or a state-accredited laboratory within EPA Region 10.

The primary laboratory selected for this program is SGS North America Inc. (SGS), located in Anchorage, AK. Other laboratories (including Pace Analytical and ALS Global) may be selected as part of this program. The accreditation information for SGS is included in the project file and will be made available upon request. The accreditation and laboratory QA Manager contact information for additional laboratories will be added to the project file as applicable and will also be made available upon request.

Individual laboratory analytical SOPs and QAMs will be made available upon request.

## WORKSHEET #24: ANALYTICAL INSTRUMENT CALIBRATION

Analytical instruments must be calibrated according to the method-specific criteria. The selected laboratory's QAM must contain their analytical instrumentation calibration procedures, be kept in project files, and made available upon request.

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
GC/MS (VOCs)	SW-846 8260C/D	As specified by method	As specified by method	Instrument maintenance, standard, inspection, recalibration	Laboratory Analyst	TBD
GC/MS (SVOCs and PAH by SIM)	SW-846 8270D/E	As specified by method	As specified by method	Instrument maintenance, standard, inspection, recalibration	Laboratory Analyst	TBD
GC/ECD (OC pesticides)	SW-846 8081B	As specified by method	As specified by method	Instrument maintenance, standard, inspection, recalibration	Laboratory Analyst	TBD
HRGC/HRMS (PCB Congeners)	EPA 1668	As specified by method	As specified by method	Instrument maintenance, standard, inspection, recalibration	Laboratory Analyst	TBD
GC/ECD (PCBs)	SW-846 8082A	As specified by method	As specified by method	Instrument maintenance, standard, inspection, recalibration	Laboratory Analyst	TBD
GC/ECD (Herbicides)	External Standard: SW-846 8151A	As specified by method	As specified by method	Instrument maintenance, standard, inspection, recalibration	Laboratory Analyst	TBD
GC/FID (GRO)	External Standard: AK101	As specified by method	As specified by method	Instrument maintenance, standard, inspection, recalibration	Laboratory Analyst	TBD
GC/FID (DRO/RRO)	External Standard: AK102/103	As specified by method	As specified by method	Instrument maintenance, standard, inspection, recalibration	Laboratory Analyst	TBD
LC/MS/MS (PFAS)	SW-846 Method 8327 or EPA 537.1 (drinking water)	As specified by method	As specified by method	Instrument maintenance, standard, inspection, recalibration	Laboratory Analyst	TBD
HRGC/HRMS (Dioxins/Furans)	SW-846 8290	As specified by method	As specified by method	Instrument maintenance, standard, inspection, recalibration	Laboratory Analyst	TBD

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
ICP-AES (Metals)	SW-846 6010C/D EPA 200.7	As specified by method	As specified by method	Instrument maintenance, standard, inspection, recalibration	Laboratory Analyst	TBD
ICP-MS (Metals)	SW-846 6020A/B EPA 200.8	As specified by method	As specified by method	Instrument maintenance, standard, inspection, recalibration	Laboratory Analyst	TBD
Cold Vapor (Mercury)	SW-846 7470A/7471B EPA 245.1	As specified by method	As specified by method	Instrument maintenance, standard, inspection, recalibration	Laboratory Analyst	TBD
Spectrometric (Cyanide)	SW-846 9012A/B	As specified by method	As specified by method	Instrument maintenance, standard, inspection, recalibration	Laboratory Analyst	TBD

**Notes:**

DRO = Diesel-Range Organics

GC/ECD = Gas Chromatograph/Electron Capture Detector

GC/FID = Gas Chromatograph/Flame Ionization Detector

GC/MS = Gas Chromatograph/Mass Spectrometer

GRO = Gasoline-Range Organics

ICP-AES = Inductively Coupled Plasma-Atomic Emission Spectrometer

ICP-MS = Inductively Coupled Plasma- Mass Spectrometer

PFAS = Per-and Polyfluoro

PAH = Polynuclear Aromatic Hydrocarbon alkyl Substances

PCB = Polychlorinated Biphenyl

SIM = selected ion monitoring

SVOC = Semivolatile Organic Compound

RRO = Residual Range Organics

TBD = To be determined

VOC = Volatile Organic Compound

## WORKSHEET #25: ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION

Analytical instruments must be maintained regularly to meet method-specific calibration acceptance criteria. The selected laboratory's QA manual must contain their analytical instrumentation maintenance procedures, be kept in project files, and made available upon request.

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
GC/MS (VOCs)	Replace septa, clean injection port, clip and replace column	SW-846 8260C/D EPA 524.2, EPA 624.1	Leak test, column and injection port inspection, source insulator integrity	As specified by method	<u>Per method criteria:</u> Passing BFB tunes, ICAL, and CCVs. Passing internal standards response.	Perform maintenance, check standards, recalibrate	Laboratory Analyst	TBD
GC/MS (SVOCs)	Replace septa, clean injection port, clip and replace column	SW-846 8270C/D EPA 525.2, EPA 625.1	Leak test, column and injection port inspection, source insulator integrity	As specified by method	<u>Per method criteria:</u> Passing DFTPP, ICAL, and CCVs. Passing internal standards response.	Perform maintenance, check standards, recalibrate	Laboratory Analyst	TBD
GC/ECD (OC pesticides)	Replace septa, clean injection port, clip and replace column	Passing Calibrations: SW-846 8081B, EPA 508.1, EPA 608.3	Leak test, column and injection port inspection	As specified by method	<u>Per method criteria:</u> Passing DDT and endrin breakdowns. Passing ICAL and CCVs.	Perform maintenance, check standards, recalibrate	Laboratory Analyst	TBD
GC/ECD (PCBs)	Replace septa, clean injection port, clip and replace column	Passing Calibrations: SW-846 8082A, EPA 608.3	Leak test, column and injection port inspection	As specified by method	<u>Per method criteria:</u> Passing ICAL and CCVs	Perform maintenance, check standards, recalibrate	Laboratory Analyst	TBD
GC/ECD (Herbicides)	Replace septa, clean injection port, clip and replace column	Passing Calibrations: SW-846 8151A, EPA 615	Leak test, column and injection port inspection	As specified by method	<u>Per method criteria:</u> Passing ICAL and CCVs	Perform maintenance, check standards, recalibrate	Laboratory Analyst	TBD
GC/FID (GRO/DRO/RRO)	Replace septa, clean injection port, clip and replace column	Passing calibrations: SW-846 8015C/D	Leak test, column and injection port inspection	As specified by method	<u>Per method criteria:</u> Passing ICAL and CCVs	Perform maintenance, check standards, recalibrate	Laboratory Analyst	TBD

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
LC/MS/MS (PFAS)	Replace septa, clean injection port, clip and replace column	Passing calibrations: SW-846 Method 8327 or EPA 537.1 (drinking water)	Leak test, column and injection port inspection	As specified by method	<u>Per method criteria:</u> Passing ICAL and CCVs	Perform maintenance, check standards, recalibrate	Laboratory Analyst	TBD
ICP-AES (Metals)	Torch, nebulizer, spray chamber, autosampler, pump tubing	SW-846 6010C/D, EPA 200.7	Check connections, flush lines, clean nebulizer	As specified by method	<u>Per method criteria:</u> Passing ICAL and CCVs	Perform maintenance, check standards, recalibrate	Laboratory Analyst	TBD
ICP-MS (Metals)	Torch, nebulizer, spray chamber, autosampler, pump tubing	SW-846 6010C/D, EPA 200.8	Check connections, flush lines, clean nebulizer	As specified by method	<u>Per method criteria:</u> Passing tune, ICAL, and CCVs	Perform maintenance, check standards, recalibrate	Laboratory Analyst	TBD
CVAA (Mercury)	Pump tubing, absorption cell and lens cleaning	SW-846 7470A/7471B, EPA 245.1, EPA 245.2	Check connections, flush sample lines	As specified by method	<u>Per method criteria:</u> Passing ICAL and CCVs	Perform maintenance, check standards, recalibrate	Laboratory Analyst	TBD
Automated Spectrophotometer (Cyanide)	Pump, tubing, maintenance	SW-846 9012B, EPA 335.4	Clean or replace tubing, check connections	As specified by method	<u>Per method criteria:</u> Passing ICAL and CCVs	Perform maintenance, check standards, recalibrate	Laboratory Analyst	TBD
HRGC/HRMS (Dioxins/Furans)	Replace septa, clean injection port, clip and replace column	SW-846 8290A, EPA 1613B	Leak test, column and injection port inspection, source insulator integrity	As specified by method	<u>Per method criteria:</u> Passing ICAL and CCVs	Perform maintenance, check standards, recalibrate	Laboratory Analyst	TBD
HRGC/HRMS (Chlorinated biphenyl congeners)	Replace septa, clean injection port, clip and replace column	EPA 1668C	Leak test, column and injection port inspection, source insulator integrity	As specified by method	<u>Per method criteria:</u> Passing ICAL and CCVs	Perform maintenance, check standards, recalibrate	Laboratory Analyst	TBD

## Notes:

BFB = 4-Bromofluorobenzene  
CCV = Continuing Calibration Verification  
CVAA = Cold Vapor Atomic Absorption  
DDT = dichlorodiphenyltrichloroethane  
DFTPP = decafluorotriphenyl/phosphine  
DRO = Diesel-Range Organics  
EPA = U.S. Environmental Protection Agency  
GC/ECD = Gas Chromatograph/Electron Capture  
Detector

GC/FID = Gas Chromatograph/Flame Ionization Detector  
GC/MS = Gas Chromatograph/Mass Spectrometer  
GRO = Gasoline-Range Organics  
HRGC/HRMS = High Resolution Gas Chromatograph/High  
Resolution Mass Spectrometer  
ICAL = Initial Calibration  
ICP-AES = Inductively Coupled Plasma-Atomic Emission  
Spectrometer

ICP-MS = Inductively Coupled Plasma- Mass Spectrometer  
OC = Organochlorine  
PCB = Polychlorinated Biphenyl  
PFAS = Per-and Polyfluoroalkyl Substances  
SOP = Standard Operating Procedure  
SVOC = Semivolatile Organic Compound  
RRO = Residual Range Organics  
TBD = To be determined  
VOC = Volatile Organic Compound

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## WORKSHEET #26 & 27: SAMPLE HANDLING, CUSTODY, AND DISPOSAL

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

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To maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory, the field sampling team will generate a chain of custody (COC) form for each cooler containing samples for shipment. Figure 26-1 presents an example COC form. The COC may be more than one page long and list all field samples submitted for analysis in a shipping container (cooler) including field blanks (trip, equipment, and ambient blanks). The COC will be placed in a plastic zippered bag and the plastic bag will be taped to the inside lid of the container. Each time the samples are transferred, the signatures of the persons relinquishing and receiving the samples, as well as the date and time of cooler sealing/transfer and laboratory receipt, will be documented on the COC.

A transfer of samples from the field team to a laboratory courier will be documented by signatures of the persons relinquishing and receiving the samples, as well as the date and time of sample transfer. The transfer from the field team to a carrier (FedEx, UPS, etc.) and from the carrier to the laboratory will be documented by the carrier's airbill records, eliminating the need for the carrier to sign the COC.

Within the laboratory, the person responsible for sample receipt must sign and date the COC form; verify that custody seals are intact on shipping containers; compare samples received against those listed on the COC form; examine all samples for possible shipping damage, leakage, and improper sampler preservation; note on the COC record that specific samples were damaged; notify sampling personnel as soon as possible so that appropriate samples may be resampled; verify that sample holding times have not been exceeded; maintain laboratory COC documentation; and place the samples in appropriate laboratory storage. The laboratory is required to include a copy of the COC and airbill (if applicable) as part of the laboratory's data package. Items requiring custody procedures include field samples and data files that can include field books, logs, and laboratory reports. An item is considered in custody if it is:

- In a person's possession
- In view of the person after being in their possession
- Sealed in a manner that it cannot be tampered with after having been in physical possession

The COC record should include, at a minimum, the following:

- Project name
- Types of analysis or analyses to be performed
- Sample identification
- Sample media information
- Type of sample (grab or composite)
- Sample collection date and time
- Names and signatures of samplers
- Signatures of any individuals with control over samples
- Laboratory contact information
- Montrose's contact information
- Designated QC samples
- Number of containers

A sample label is affixed to each sample container. The sample label must, at a minimum, contain the sample number, project number, unique identification or station number, identification of sampler, date and time of sample collection; sample designation as grab or composite, preservative(s), and analysis/fraction.

Custody seals (see Figure 26-2) are used to determine whether any tampering has occurred during transport of samples. These signed and dated seals will be placed at the junction between the lid and the main body of the cooler by the person responsible for packing the cooler. There also may be occasions when custody seals will be affixed to bottle lids. If the coolers or jars are opened before receipt at the laboratory, the custody seals will not be intact. Samples will be placed in coolers or other containers with sufficient ice and packing material to keep sample containers from shifting and breaking during transport. A temperature indicator bottle containing tap water will be placed in the iced cooler so that the laboratory can document cooler temperature upon receipt.

The field team will make every attempt to ship samples on the same day the samples are collected, if practical. When it is not possible to ship the samples on the day of collection, the field team will store the samples in refrigerators designated for sample storage at the site or in coolers. If the samples are stored in coolers and the sample preservation requirements include refrigeration, ice will be used to keep the samples cold. The coolers or refrigerators will be secured in either a locked room or compartment or otherwise sealed to prevent tampering until the samples are transferred to an overnight carrier or courier.

Unless previous screening results, site knowledge, or other information indicate the samples are hazardous, all samples collected and shipped for analysis will be treated as environmental samples. Samples, whether classified as hazardous or as environmental samples, will be shipped in compliance with applicable regulations. The United States Department of Transportation (DOT) and the International Air Transport Association (IATA) establish specific regulations governing the packaging of hazardous and environmental samples for shipment. These regulations include specifications for packing materials, shipping containers, and shipping labels. Based on the best available knowledge of the samples being collected, all samples will be shipped in accordance with these regulations.

## **Sample Identification Procedures**

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Samples collected at the site must be uniquely labeled. All samples will be identified with a label attached directly to the container (see Figure 26-3). Sample information will be entered onto labels which can be adhered to sample containers. Sample container labels should include the following information:

1. Sample identifier (assigned by samplers);
2. Date sample was collected (MM/DD/YYYY);
3. Time sample was collected (in military time) [00:000] ;
4. Preservative(s), if any (specify "None" if sample is not preserved);
5. Analysis/fraction.



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

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The designated sample custodian(s) and staff are responsible for samples received at the laboratory. In addition to receiving samples, the sample receipt staff is also responsible for documentation of sample receipt and storage before and after sample analysis. Summaries of the minimal laboratory receipt procedures are:

- Upon receipt, sign, date, and document the time of sample receipt on the airbills or other shipping manifests received from the couriers.
- Sign the COC, assuming custody of the samples. If a COC is not received with a set of samples, the laboratory will immediately notify the QA Manager, Field Team Leader, and/or Program Manager.
- Inspect the sample cooler for integrity and then document the following information:
  - Air carrier or courier and whether the samples were shipped, or hand delivered (copies of the airbills are maintained).
  - Confirmation of presence of intact custody seals.
  - Sample temperature (whether ambient or chilled) and actual temperature of the temperature indicator bottle.
  - Presence of leaking or broken containers and indication of chemical preservation.
- Verify that the holding time is not exceeded. If a sample has exceeded holding time, the laboratory will immediately notify the QA Manager, Field Team Leader, and/or Program Manager.
- Match the sample container information (e.g., sample label) with the COC, and any other pertinent sample information. The sample custodian then verifies sample identity to ensure that all information is correct. Any inconsistencies are resolved with the QA Manager, Field Team Leader, and/or Program Manager, and corrective action measures are resolved and documented before sample analysis proceeds.

Samples submitted to laboratories will be stored at  $\leq 6^{\circ}\text{C}$  (not frozen) for a minimum of 60 days following the completion of analyses and/or issue of final reports. Laboratories are also responsible for the proper management and disposal of all sample residuals and extracts, following all applicable federal, state, and local laws; rules; and regulations.

### ***Environmental Analysis Request/Chain of Custody***

[illegible]

**CUSTODY SEAL**

Person Collecting Sample \_\_\_\_\_ Sample No. \_\_\_\_\_

(signature)

Date Collected \_\_\_\_\_ Time Collected \_\_\_\_\_

Project: \_\_\_\_\_ Task: \_\_\_\_\_

Sample I.D.: \_\_\_\_\_

Analysis: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Sample Date: \_\_\_\_\_ Initials: \_\_\_\_\_

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## **WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION**

Samples may be analyzed under a variety of analytical methods. Method selection and project-specific measurement performance criteria (MPC) will be based on site-specific DQOs. The MPC listings in the worksheets in this section are based on the current analytical methods. Laboratory analyses will be expected to meet these minimum MPCs.

If site-specific DQOs cannot be met using the MPC listed in these worksheets, more stringent MPC criteria will be developed for the site by the QA Manager as part of the analytical technical specifications.

## WORKSHEET #28.1: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION – VOCS BY GC/MS

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Method Blank (MB)	1 per 12-hour period	Method criteria same as Project-Specific MPC Lab SOPs vary by method #	Investigate the source of contamination and eliminate the problem before proceeding with further analysis. (Corrective actions are required only if the samples contain the same contaminant at concentrations exceeding the MPC levels.) CA includes: <ul style="list-style-type: none"> <li>• Reanalyze the samples if sufficient sample volume remains.</li> <li>• Flag (qualify) the sample result.</li> <li>• Document the problem in the case narrative.</li> </ul>	Analyst	SW-846 8260C/D and TO-15: analyte concentrations < LOQ EPA 524.2 and EPA 624.1: analyte concentrations < LOQ
Trip Blank	1 per cooler containing VOC samples	No criteria specified in method or SOPs	Investigate sources of trip blank contamination after method blank actions are applied and considering field blank contamination. CA includes: <ul style="list-style-type: none"> <li>• Review potential laboratory or field sources of contaminants (including type of water used to make the trip blank).</li> <li>• Once identified, QA Manager or Chemist should share findings with program management and the field team.</li> <li>• Discuss trip blank contamination in EPA deliverables and any impacts on data quality.</li> </ul>	Program Manager, Field Samplers, QA Manager, and Chemist	All analyte concentrations < LOQ

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Equipment and Ambient Field Blanks	1 per day	No criteria specified in method or SOPs	Investigate sources of field blank contamination after method blank actions are applied and considering trip blank contamination. CA includes: <ul style="list-style-type: none"> <li>Review potential laboratory or field sources of contaminants (including type of water used to make the field blank).</li> <li>Once source is identified, QA Manager or Chemist should share findings with program management and the field team.</li> <li>Discuss trip blank contamination in EPA deliverables and any impacts on data quality.</li> </ul>	Program Manager, Field Samplers, QA Manager, and Chemist	All analyte concentrations < LOQ
TCLP/SPLP LEB	1 per TCLP extraction batch	Analysis of LEB required but no method acceptance criteria	None; report results in laboratory data package	Analyst	SW-846 8260C/D: Analysis of LEB required but no MPC
Laboratory Control Sample (LCS)	1 per analysis or methanol extraction batch	laboratory must develop statistically- derived laboratory limits.	Investigate reason for poor LCS recovery. Eliminate problem before proceeding with further analysis. CA includes: <ul style="list-style-type: none"> <li>If low spike recovery, reanalyze samples under compliant LCS, if sufficient sample volumes are available.</li> <li>For any low or high LCS outliers, flag (qualify) any analytes in samples from the affected batch.</li> <li>Document the problem in the case narrative.</li> </ul>	Analyst and Prep Analyst	Other methods: %R within statistically derived laboratory limits
Field Duplicate	1 per 10 field samples of the same matrix	No method or SOP criteria specified	If MPC is not met for the field duplicate results >4x LOQ, a careful examination of the sampling techniques, sample matrix, and analytical method and other analytical QC criteria will be conducted to identify the root cause of the high RPD and the usability of the data.	Field Samplers and Chemist	RPD ≤30% (water and air) RPD ≤50% (soil)

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Surrogates (DMCs)	Each field and QC sample	Statistically derived laboratory control limits	Investigate reason for poor surrogate recovery. CA includes: <ul style="list-style-type: none"> <li>Reanalyze sample to confirm the problem is with the sample matrix and not the analysis. Report both sets of results if the reanalysis confirms the initial analysis.</li> <li>Otherwise, report only the compliant analysis. Document surrogate outliers on the CLP Form 2 equivalent and in the case narrative.</li> </ul>	Analyst	%R within statistically derived laboratory control limits
Internal Standards (IS)	Each field and QC sample	IS Area in the sample within -50% to +100% of the IS area in the opening CCV  For TO-15: within ±40 percent of the mean area response of the IS in the most recent valid calibration.	Investigate reason for poor IS performance. If failure is due to instrument performance, the problem must be identified, corrected, and the sample must be reanalyzed. CA includes: <ul style="list-style-type: none"> <li>Reanalyze sample and if upon reanalysis the IS area in the sample is still not within limits, report both the initial and reanalysis in the data package to document matrix interference.</li> <li>Document surrogate outliers on Form 8 and in the case narrative</li> </ul>	Analyst	IS area in the sample within -50% to +100% of the IS area in the opening CCV.  For TO-15: within ±40 percent of the mean area response of the IS in the most recent valid calibration.
Cooler Temperature Indicator	One per cooler	≤6°C (not frozen)	Laboratory to notify QA Manager and confirm whether to proceed with analysis. Resampling may be required.	Laboratory Sample Custodian/ QA Manager	≤6°C (not frozen)

Notes:

# Laboratory SOPs are retained on file.

%R = percent recovery

CCV = Continuing Calibration Verification

CLP = Contract Laboratory Program

DMC = Deuterated Monitoring Compound

GC/MS = Gas Chromatography/Mass Spectrometry

LEB = Leachate Extraction Blank

MCL = Maximum Contaminant Level

MPC = Measurement Performance Criteria

QA = Quality Assurance

QC = Quality Control

RPD = relative percent difference

SOP = Standard Operating Procedure

SPLP = Synthetic Precipitation Leaching Procedure

TCLP = Toxicity Characteristic Leaching Procedure

VOC = Volatile Organic Compound

## WORKSHEET #28.2: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION – SVOCs INCLUDING PAHS BY GC/MS

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Method Blank (MB)	1 per extraction batch	Method criteria same as Project-Specific MPC Lab SOPs vary by method #	Investigate the source of contamination and eliminate the problem before proceeding with further analysis. (Corrective actions are required only if the samples contain the same contaminant at concentrations exceeding the MPC levels.) CA includes: <ul style="list-style-type: none"> <li>Re-extract and reanalyze the samples if sufficient sample volume remains.</li> <li>Flag (qualify) the sample result.</li> <li>Document the problem in the case narrative.</li> </ul>	Analyst/Prep Analyst	SW-846 8270D/E: analyte concentrations < LOQ EPA 525.2 and EPA 625.1: analyte concentrations < LOQ
Equipment blanks and Lot Blanks	1 per day per type of sampling equipment or 1 per lot of wipes	No criteria specified in method or SOPs	Investigate sources of equipment blank or lot blank contamination after method blank actions are applied and considering other sources of blank contamination. CA includes: <ul style="list-style-type: none"> <li>Review potential laboratory or field sources of contaminants (including type of water or solvents used to make the field blank).</li> <li>Once source is identified, QA Manager or Chemist should share findings with program management and the field team.</li> <li>Discuss equipment blank or lot blank contamination in EPA deliverables and any impacts on data quality.</li> </ul>	Program Manager, Field Samplers, QA Manager, and Chemist	All analyte concentrations < LOQ
TCLP/SPLP LEB	1 per TCLP extraction batch	Analysis of LEB required but no method acceptance criteria	None; report results in laboratory data package	Analyst	SW-846 8270D/E: Analysis of LEB required but no MPC

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Laboratory Control Sample (LCS)	1 per analysis or extraction batch	None listed; laboratory must develop statistically derived laboratory limits.	Investigate reason for poor LCS recovery. Eliminate problem before proceeding with further analysis. CA includes: <ul style="list-style-type: none"> <li>If low spike recovery, re-extract and reanalyze samples under compliant LCS, if sufficient sample volumes are available.</li> <li>For any low or high LCS outliers, flag (qualify) any analytes in samples from the affected batch. Document the problem in the case narrative.</li> </ul>	Analyst and Prep Analyst	%R within statistically derived laboratory limits
Field Duplicate	1 per 10 field samples of the same matrix	No method or SOP criteria specified	If MPC is not met for the field duplicate results >4x LOQ, a careful examination of the sampling techniques, sample matrix, and analytical method and other analytical QC criteria will be conducted to identify the root cause of the high RPD and the usability of the data.	Field Samplers and Chemist	RPD ≤30% (water) RPD ≤50% (soil)
Surrogates (DMCs)	Each field and QC sample	Statistically derived laboratory control limits	Investigate reason for poor surrogate recovery. CA includes: <ul style="list-style-type: none"> <li>Re-extract the sample to confirm the problem is with the sample matrix and not the extraction. Report both sets of results if the re-extraction confirms the initial analysis. Otherwise, report only the compliant analysis.</li> <li>Document surrogate outliers on Form 2 and in the case narrative.</li> </ul>	Analyst	%R within statistically derived laboratory control limits



QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Internal Standards (IS)	Each field and QC sample	IS Area in the sample within -50% to +100% of the IS area in the opening CCV	Investigate reason for poor IS performance. If failure is due to instrument performance, the problem must be identified, corrected, and the sample must be reanalyzed. <ul style="list-style-type: none"> <li>CA includes:</li> <li>Reanalyze sample and if upon reanalysis the IS area in the sample is still not within limits, report both the initial and reanalysis in the data package to document matrix interference.</li> <li>Document surrogate outliers on Form 8 and in the case narrative.</li> </ul>	Analyst	IS area in the sample within -50% to +100% of the IS area in the opening CCV
Cooler Temperature Indicator	One per cooler	≤6°C (not frozen)	Laboratory to notify QA Manager and confirm whether to proceed with analysis. Resampling may be required.	Laboratory Sample Custodian/ QA Manager	≤6°C (not frozen)

**Notes:**

# Laboratory SOPs are retained on file.

%R = percent recovery

CCV = Continuing Calibration Verification

DMC = Deuterated Monitoring Compound

GC/MS = Gas Chromatography/Mass Spectrometry

LEB = Leachate Extraction Blank

MCL = Maximum Contaminant Level

MPC = Measurement Performance Criteria

PAH = Polycyclic Aromatic Hydrocarbons

QA = Quality Assurance

QC = Quality Control

RPD = relative percent difference

SOP = Standard Operating Procedure

SPLP = Synthetic Precipitation Leaching Procedure

SVOC = Semivolatile Organic Compound

TCLP = Toxicity Characteristic Leaching Procedure

VOC = Volatile Organic Compound

## WORKSHEET #28.3: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION – OC PESTICIDES AND HERBICIDES BY GC/ECD

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Method Blank (MB)	1 per extraction batch	Method criteria same as Project-Specific MPC / SOPs vary by laboratory #	Investigate the source of contamination and eliminate the problem before proceeding with further analysis. (Corrective actions are required only if the samples contain the same contaminant at concentrations exceeding the MPC levels.) CA includes: <ul style="list-style-type: none"> <li>Re-extract and reanalyze the samples if sufficient sample volume remains.</li> <li>Flag (qualify) the sample result.</li> <li>Document the problem in the case narrative.</li> </ul>	Analyst/Prep Analyst	SW-846 8081B and SW-846 8151A: analyte concentrations <LOQ
Equipment blanks and Lot Blanks	1 per day per type of sampling equipment or 1 per lot of wipes	No criteria specified in method or SOPs	Investigate sources of equipment blank or lot blank contamination after method blank actions are applied and considering other sources of blank contamination. CA includes: <ul style="list-style-type: none"> <li>Review potential laboratory or field sources of contaminants (including type of water or solvents used to make the field blank).</li> <li>Once source is identified, QA Manager or Chemist should share findings with program management and the field team.</li> <li>Discuss equipment blank or lot blank contamination in EPA deliverables and any impacts on data quality.</li> </ul>	Program Manager, Field Samplers, QA Manager, and Chemist	All analyte concentrations < LOQ
TCLP/SPLP LEB	1 per TCLP extraction batch	Analysis of LEB required but no method acceptance criteria	None; report results in laboratory data package	Analyst	SW-846 8260C/D: Analysis of LEB required but no MPC

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Laboratory Control Sample (LCS)	1 per extraction batch	SW-846 8081A (OC pesticides) and SW-846 8151A (herbicides): None listed; laboratory must develop statistically derived laboratory limits. EPA 508.1: 70-130%R <i>/ SOPs vary by laboratory #</i>	Investigate reason for poor LCS recovery. Eliminate problem before proceeding with further analysis. CA includes: <ul style="list-style-type: none"> <li>If low spike recovery, reanalyze samples under compliant LCS, if sufficient sample volumes are available.</li> <li>For any low or high LCS outliers, flag (qualify) any analytes in samples from the affected batch. Document the problem in the case narrative.</li> </ul>	Analyst and Prep Analyst	SW-846 8151A (herbicides): Refer to Worksheet 15.
Field Duplicate	1 per 10 field samples of the same matrix	No method or SOP criteria specified	If MPC is not met for the field duplicate results >4x LOQ, a careful examination of the sampling techniques, sample matrix, and analytical method and other analytical QC criteria will be conducted to identify the root cause of the high RPD and the usability of the data.	Field Samplers and Chemist	RPD ≤30% (water) RPD ≤50% (soil)
Matrix Spike (MS)	1 per 20 samples of the same matrix, or one per extraction batch	SW-846 8081A (OC pesticides) and SW-846 8151A (herbicides): None listed; laboratory must develop statistically derived laboratory limits. EPA 508.1: 70-130%R <i>/ SOPs vary by laboratory #</i>	<i>The MPC only applies when the sample concentration is &lt; 4x the spike added concentration.</i> No Laboratory CAs required. (Data validator will qualify data based on %R outliers.)	Analyst/Prep Analyst	SW-846 8151A (herbicides): within statistically derived laboratory limits <i>NOTE: The MPC only applies when the sample concentration is &lt; 4x the spike added concentration.</i>
Matrix Spike Duplicate (MSD)	1 per 20 samples of the same matrix, or one per extraction batch	Spike %Rs - same as for MS above Other methods: None listed; laboratory must develop statistically derived laboratory limits. <i>/ SOPs vary by laboratory #</i>	No required Laboratory CAs. Data validator will qualify data based on RPD exceedances.	Analyst/Prep Analyst	Spike %Rs - same as for MS above  RPDs within statistically derived laboratory limits

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Surrogates	Each field and QC sample	None listed; laboratory must develop statistically derived laboratory limits. <i>/ SOPs vary by laboratory #</i>	Investigate reason for poor surrogate recovery. CA includes:  Reanalyze and/or re-extract sample to confirm the problem is with the sample matrix and not the extraction. Report both sets of results if the re- extraction confirms the initial analysis.  Otherwise, report only the compliant analysis. Document surrogate outliers on Form 2 and in the case narrative.	Analyst	%R within statistically derived laboratory control limits
Dual column confirmation	Performed if analytes are detected	Other methods: 40% RPD <i>/ SOPs vary by laboratory #</i>	Report sample concentrations and RPDs on Form 10 for each reported analyte. No CA requirement.	Analyst	RPD <40%
Cooler Temperature Indicator	One per cooler	≤6°C (not frozen)	Laboratory to notify QA Manager and confirm whether to proceed with analysis. Resampling may be required.	Laboratory Sample Custodian/ QAM	≤6°C (not frozen)

**Notes:**

# Laboratory SOPs are retained on file.

%R = percent recovery

 GC/ECD = Gas Chromatography/ Electron Capture  
 Detector

LEB = Leachate Extraction Blank

LOQ Limit of Quantitation

MCL = Maximum Contaminant Level

MPC = Measurement Performance Criteria

MS = Matrix Spike

OC = Organochlorine

RPD = relative percent difference

QA = Quality Assurance

QC = Quality Control

SOP = Standard Operating Procedure

SPLC = Synthetic Precipitation Leaching Procedure

TCLP = Toxicity Characteristic Leaching Procedure

## WORKSHEET #28.4: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION – PCBS AS AROCLORS BY GC/ECD

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Method Blank (MB)	1 per extraction batch	Method criteria same as Project-Specific MPC <i>/ SOPs vary by laboratory #</i>	Investigate the source of contamination and eliminate the problem before proceeding with further analysis. (Corrective actions are required only if the samples contain the same contaminant at concentrations exceeding the MPC levels.) CA includes: <ul style="list-style-type: none"> <li>Reanalyze the samples if sufficient sample volume remains.</li> <li>Flag (qualify) the sample result. Document the problem in the case narrative.</li> </ul>	Analyst/Prep Analyst	SW-846 8082A: analyte concentrations <LOQ  EPA 608.3: analyte concentrations <LOQ
Equipment blanks and Lot Blanks	1 per day per type of sampling equipment or 1 per lot of wipes	No criteria specified in method or SOPs	Investigate sources of equipment blank or lot blank contamination after method blank actions are applied and considering other sources of blank contamination. CA includes: <ul style="list-style-type: none"> <li>Review potential laboratory or field sources of contaminants (including type of water or solvents used to make the field blank).</li> <li>Once source is identified, QA Manager or Chemist should share findings with program management and the field team.</li> <li>Discuss equipment blank or lot blank contamination in EPA deliverables and any impacts on data quality.</li> </ul>	Program Manager, Field Samplers, QA Manager, and Chemist	All analyte concentrations < LOQ

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Laboratory Control Sample (LCS)	1 per extraction batch	None listed. <i>/ SOPs vary by laboratory #</i>	Investigate reason for poor LCS recovery. Eliminate problem before proceeding with further analysis.  CA includes: <ul style="list-style-type: none"> <li>If low spike recovery, reanalyze samples under compliant LCS, if sufficient sample volumes are available.</li> <li>For any low or high LCS outliers, flag (qualify) any analytes in samples from the affected batch.</li> <li>Document the problem in the case narrative.</li> </ul>	Analyst and Prep Analyst	%R within statistically derived laboratory limits
Field Duplicate	1 per 10 field samples of the same matrix	No method or SOP criteria specified	If MPC is not met for the field duplicate results >4x LOQ, a careful examination of the sampling techniques, sample matrix, and analytical method and other analytical QC criteria will be conducted to identify the root cause of the high RPD and the usability of the data.	Field Samplers and Chemist	RPD ≤30% (water) RPD ≤50% (soil)
Matrix Spike (MS)	1 per 20 samples of the same matrix, or one per extraction batch	SW-846 8082A: None listed; laboratory must develop statistically derived laboratory limits. EPA 608.3: none listed <i>/ SOPs vary by laboratory #</i>	The MPC only applies when the sample concentration is <4x the spike added concentration. No Laboratory CAs required. (Data validator will qualify data based on %R outliers.)	Analyst/Prep Analyst	%R within statistically derived laboratory limits
Matrix Spike Duplicate (MSD)	1 per 20 samples of the same matrix, or one per extraction batch	Spike %Rs - same as for MS above None listed; laboratory must develop statistically- derived laboratory limits. <i>/ SOPs vary by laboratory #</i>	No required Laboratory CAs. Data validator will qualify data based on RPD exceedances.	Analyst/Prep Analyst	Spike %Rs - same as for MS above  RPDs within statistically derived laboratory limits

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Surrogates	Each field and QC sample	Statistically derived laboratory control limits	Investigate reason for poor surrogate recovery. CA includes: <ul style="list-style-type: none"> <li>Reanalyze and/or re-extract sample to confirm the problem is with the sample matrix and not the extraction. Report both sets of results if the re-extraction confirms the initial analysis. Otherwise, report only the compliant analysis.</li> <li>Document surrogate outliers on the CLP Form 2 and in the case narrative.</li> </ul>	Analyst	%R within statistically derived laboratory control limits
Dual column confirmation	Performed if analytes are detected	40% RPD <i>/ SOPs vary by laboratory #</i>	Report sample concentrations and RPDs on Form 10 for each reported analyte. No CA requirement.	Analyst	RPD <40%
Cooler Temperature Indicator	One per cooler	≤6°C (not frozen)	Laboratory to notify QA Manager and confirm whether to proceed with analysis. Resampling may be required.	Laboratory Sample Custodian/ QA Manager	≤6°C (not frozen)

## Notes:

# Laboratory SOPs are retained on file.

%R = percent recovery

CRQL = Contract Required Quantitation Limit

CLP = Contract Laboratory Program

 GC/ECD = Gas Chromatography/ Electron Capture  
 Detector

MPC = Measurement Performance Criteria

MS = Matrix Spike

PCB = Polychlorinated Biphenyl

QA = Quality Assurance

QC = Quality Control

## WORKSHEET #28.5: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION – GRO, DRO, AND RRO BY GC/FID

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Method Blank (MB)	1 per extraction batch	Method criteria same as Project-Specific MPC / SOPs vary by laboratory #	Investigate the source of contamination and eliminate the problem before proceeding with further analysis. (Corrective actions are required only if the samples contain the same contaminant at concentrations exceeding the MPC levels.) CA includes: <ul style="list-style-type: none"> <li>Reanalyze the samples if sufficient sample volume remains.</li> <li>Flag (qualify) the sample result.</li> <li>Document the problem in the case narrative.</li> </ul>	Analyst	SW-846 8015A: analyte concentrations < LOQ
Trip Blank	1 per cooler containing GRO samples	No criteria specified in method or SOPs	Investigate sources of trip blank contamination after method blank actions are applied and considering field blank contamination. CA includes: <ul style="list-style-type: none"> <li>Review potential laboratory or field sources of contaminants (including type of water used to make the trip blank).</li> <li>Once identified, QA Manager or Chemist should share findings with program management and the field team.</li> <li>Discuss trip blank contamination in EPA deliverables and any impacts on data quality.</li> </ul>	Program Manager, Field Samplers, QA Manager, and Chemist	Analyte concentrations < LOQ



QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Equipment blank (or Ambient Field Blanks)	1 per day per type of non-dedicated sampling equipment	No criteria specified in method or SOPs	Investigate sources of field blank contamination after method blank actions are applied and considering trip blank contamination. CA includes: <ul style="list-style-type: none"> <li>Review potential laboratory or field sources of contaminants (including type of water used to make the field blank).</li> <li>Once source is identified, QA Manager or Chemist should share findings with program management and the field team.</li> <li>Discuss blank contamination in EPA deliverables and any impacts on data quality.</li> </ul>	Program Manager, Field Samplers, QA Manager, and Chemist	Analyte concentrations < LOQ
Laboratory Control Sample (LCS)	1 per extraction batch	60-120% GRO 75-125% DRO 60-120% RRO / SOPs vary by laboratory #	Investigate reason for poor LCS recovery. Eliminate problem before proceeding with further analysis. CA includes: <ul style="list-style-type: none"> <li>If low spike recovery, reanalyze samples under compliant LCS, if sufficient sample volumes are available.</li> <li>For any low or high LCS outliers, flag (qualify) sample concentrations from the affected batch.</li> <li>Document the problem in the case narrative.</li> </ul>	Analyst and Prep Analyst	%R within statistically derived laboratory limits
Field Duplicate	1 per 10 field samples of the same matrix	No method or SOP criteria specified	If MPC is not met for the field duplicate results >4x LOQ, a careful examination of the sampling techniques, sample matrix, and analytical method and other analytical QC criteria will be conducted to identify the root cause of the high RPD and the usability of the data.	Field Samplers and Chemist	RPD ≤30% (water) RPD ≤50% (soil)
Matrix Spike (MS)	1 per 20 samples of the same matrix, or one per extraction batch	AK101/AK102/AK103: 60-120% GRO 75-125 DRO 60-140% RRO / SOPs vary by laboratory #	<i>The MPC only applies when the sample concentration is &lt;4x the spike added concentration.</i> No Laboratory CAs required. (Data validator will qualify data based on %R outliers.)	Analyst/Prep Analyst	AK101/AK102/AK103 within statistically- derived laboratory limits

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Matrix Spike Duplicate (MSD)	1 per 20 samples of the same matrix, or one per extraction batch	Spike %Rs - same as for MS above 60-120% GRO 75-125 DRO 60-140% RRO / SOPs vary by laboratory #	No required Laboratory CAs. Data validator will qualify data based on RPD exceedances.	Analyst/Prep Analyst	Spike %Rs - same as for MS above  RPDs within limits
Surrogates	Each field and QC sample	50-150% Recovery for BFB field surrogate (GRO) 60-120% (DRO/RRO)	Investigate reason for poor surrogate recovery. CA includes: <ul style="list-style-type: none"> <li>Reanalyze and/or re-extract sample to confirm the problem is with the sample matrix and not the extraction. Report both sets of results if the re-extraction confirms the initial analysis. Otherwise, report only the compliant analysis.</li> <li>Document surrogate outliers on Form 2 and in the case narrative.</li> </ul>	Analyst	%R within method control limits
Cooler Temperature Indicator	One per cooler	≤6°C (not frozen)	Laboratory to notify QA Manager and confirm whether to proceed with analysis. Resampling may be required.	Laboratory Sample Custodian/ QA Manager	≤6°C (not frozen)

Notes:

# Laboratory SOPs are retained on file.

%R = percent recovery

DRO = Diesel Range Organic

 GC/FID = Gas Chromatography/Flame Ionization  
 Detector

GRO = Gasoline Range Organic

MCL = Maximum Contaminant Level

MPC = Measurement Performance Criteria

MS = Matrix Spike

QA = Quality Assurance

QC = Quality Control

RRO = Residual Range Organics

RPD = relative percent difference

SOP = Standard Operating Procedure

VOC = Volatile Organic Compound

## WORKSHEET #28.6: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION – INORGANICS (METALS, MERCURY, AND CYANIDE)

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Method Blank (MB)	1 per digestion batch	Method criteria same as Project-Specific MPC <i>/ SOPs vary by laboratory #</i>	Investigate the source of contamination and eliminate the problem before proceeding with further analysis. (Corrective actions are required only if the samples contain the same contaminant at concentrations exceeding the MPC levels.) CA includes: <ul style="list-style-type: none"> <li>• Reanalyze the samples if sufficient sample volume remains.</li> <li>• Flag (qualify) the sample result.</li> <li>• Document the problem in the case narrative.</li> </ul>	Analyst	Blank analyte concentrations < ½ LOQ
TCLP/SPLP LEB	1 per TCLP or SPLP extraction batch	Analysis of LEB required but no method acceptance criteria	None; report results in laboratory data package	Analyst	SW-846 6010C/D, SW-846 7470A: Analysis of LEB required but no MPC
Equipment Blank	1 per day per type of non- dedicated sampling equipment	No criteria specified in method or SOPs	Investigate sources of field blank contamination after method blank actions are applied and considering trip blank contamination. CA includes: <ul style="list-style-type: none"> <li>• Review potential laboratory or field sources of contaminants (including type of water used to make the field blank).</li> <li>• Once source is identified, QA Manager or Chemist should share findings with program management and the field team.</li> <li>• Discuss blank contamination in EPA deliverables and any impacts on data quality.</li> </ul>	Program Manager, Field Samplers, QA Manager, and Chemist	Analyte concentrations <LOQ

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Laboratory Control Sample (LCS)	1 per digestion batch	Laboratory must develop statistically derived laboratory limits. <i>/ SOPs vary by laboratory #</i>	Investigate reason for poor LCS recovery. Eliminate problem before proceeding with further analysis. CA includes: <ul style="list-style-type: none"> <li>If low spike recovery, reanalyze samples under compliant LCS, if sufficient sample volumes are available.</li> <li>For any low or high LCS outliers, flag (qualify) sample concentrations from the affected batch. Document the problem in the case narrative.</li> </ul>	Analyst and Prep Analyst	%R within statistically derived laboratory limits
Field Duplicate	1 per 10 field samples of the same matrix	No method or SOP criteria specified	If MPC is not met for the field duplicate results >4x LOQ, a careful examination of the sampling techniques, sample matrix, and analytical method and other analytical QC criteria will be conducted to identify the root cause of the high RPD and the usability of the data.	Field Samplers and Chemist	RPD ≤30% (water) RPD ≤50% (soil)
Matrix Spike (MS) and post- digestion spike (PDS)	1 per 20 samples of the same matrix, or one per extraction batch	None listed; laboratory must develop statistically derived laboratory limits. <i>/ SOPs vary by laboratory #</i>	Laboratory CA required if %Rs outside of QC limits: Perform a post-digestion spike (PDS) and flag sample results in the digestion batch. (Data validator will qualify sample data based on spike recovery outliers for the MS and PDS.)	Analyst/Prep Analyst	% R within statistically derived laboratory limits
Laboratory Duplicate (D)	1 per 20 samples or one for each extraction batch	None listed; laboratory must develop statistically derived laboratory limits. <i>/ SOPs vary by laboratory #</i>	Laboratory CA is to flag sample results for analytes for which the MPC are not met.	Analyst/Prep Analyst	RPD within statistically derived laboratory limits
Cooler Temperature Indicator	One per cooler	≤6°C (not frozen)	Laboratory to notify QA Manager and confirm whether to proceed with analysis. Resampling may be required.	Laboratory Sample Custodian/ QA Manager	≤6°C (not frozen)

## Notes:

- 1 Acceptance criteria for LCSs and MSs are included under the appropriate method in Section 15.  
# Laboratory SOPs are retained on file.

%R = percent recovery

LEB = Leachate Extraction Blank

LOQ = Limit of Quantitation

MPC = Measurement Performance Criteria

QA = Quality Assurance

QC = Quality Control

RPD = relative percent difference

SOP = Standard Operating Procedure

SPLC = Synthetic Precipitation Leaching Procedure

TCLP = Toxicity Characteristic Leaching Procedure

## WORKSHEET #28.7: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION – DIOXINS/FURANS HRGC/HRMS

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Method Blank (MB)	1 per extraction batch	Method criteria same as Project-Specific MPC  Lab SOPs vary by method #	Investigate the source of contamination and eliminate the problem before proceeding with further analysis. (Corrective actions are required only if the samples contain the same contaminant at concentrations exceeding the MPC levels.) CA includes: <ul style="list-style-type: none"> <li>Re-extract and reanalyze the samples if sufficient sample volume remains.</li> <li>Flag (qualify) the sample result.</li> <li>Document the problem in the case narrative.</li> </ul>	Analyst/Prep Analyst	Analyte concentrations <1/2 LOQ except for OCDD and OCDF which are allowed concentrations of <3x LOQ
Equipment blanks	1 per day per type of non-dedicated sampling equipment	No criteria specified in method or SOPs	Investigate sources of equipment blank contamination after method blank actions are applied and considering other sources of blank contamination. CA includes: <ul style="list-style-type: none"> <li>Review potential laboratory or field sources of contaminants (including type of water or solvents used to make the field blank).</li> <li>Once source is identified, QA Manager or Chemist should share findings with program management and the field team.</li> <li>Discuss equipment blank contamination in EPA deliverables and any impacts on data quality.</li> </ul>	Program Manager, Field Samplers, QA Manager, and Chemist	All analyte concentrations < LOQ

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Laboratory Control Sample (LCS)	1 per extraction batch	Method criteria same as Project-Specific MPC	Investigate reason for poor LCS recovery. Eliminate problem before proceeding with further analysis. CA includes: <ul style="list-style-type: none"> <li>If low spike recovery, re-extract and reanalyze samples under compliant LCS, if sufficient sample volumes are available.</li> <li>For any low or high LCS outliers, flag (qualify) any analytes in samples from the affected batch. Document the problem in the case narrative.</li> </ul>	Analyst and Prep Analyst	%R must meet criteria in HRSM02.1 Exhibit D, Table 5
Laboratory Control Sample Duplicate (LCSD)	1 per extraction batch	Method criteria same as Project-Specific MPC	Re-extraction or reanalysis not required for RPD outlier between the LCS and LCSD. CA includes: <ul style="list-style-type: none"> <li>For any high RPDs, flag (qualify) the analyte in samples from the affected batch.</li> <li>Document the problem in the case narrative.</li> </ul>	Analyst and Prep Analyst	30%RPD
Field Duplicate	1 per 10 field samples of the same matrix	No method or SOP criteria specified	If MPC is not met for the field duplicate results >4x LOQ, a careful examination of the sampling techniques, sample matrix, and analytical method and other analytical QC criteria will be conducted to identify the root cause of the high RPD and the usability of the data.	Field Samplers and Chemist	RPD ≤30% (water) RPD ≤50% (soil)

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Labeled compounds	Each field and QC sample	Limits specified in the method HRSM02.1	Investigate reason for poor recovery. CA includes: <ul style="list-style-type: none"> <li>Re-extract the sample to confirm the problem is with the sample matrix and not the extraction. Report both sets of results if the re-extraction confirms the initial analysis. Otherwise, report only the compliant analysis.</li> <li>Document surrogate outliers on the Forms and in the case narrative.</li> </ul>	Analyst	Within limits specified in the method HRSM02.1
Cooler Temperature Indicator	One per cooler	≤6°C (not frozen)	Laboratory to notify QA Manager and confirm whether to proceed with analysis. Resampling may be required.	Laboratory Sample Custodian/ QAM	≤6°C (not frozen)

**Notes:**

# Laboratory SOPs are retained on file.

%R = percent recovery

HRGC = High Resolution Gas Chromatography

HRMS = High Resolution Mass Spectrometry

LCS = Laboratory Control Sample

LOQ = Limit of Quantitation

MPC = Measurement Performance Criteria

OCDD = Octachlorinated dibenzo-p-dioxin

OCDF = Octachlorinated dibenzofuran

QA = Quality Assurance

QC = Quality Assurance

RPD = relative percent difference

SOP = Standard Operating Procedure



## WORKSHEET #28.8: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION – CHLORINATED BIPHENYL CONGENERS BY HRGC/HRMS

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Method Blank (MB)	1 per extraction batch	Method criteria same as Project-Specific MPC Lab SOPs vary by method #	Investigate the source of contamination and eliminate the problem before proceeding with further analysis. (Corrective actions are required only if the samples contain the same contaminant at concentrations exceeding the MPC levels.) CA includes: <ul style="list-style-type: none"> <li>Re-extract and reanalyze the samples if sufficient sample volume remains.</li> <li>Flag (qualify) the sample result.</li> <li>Document the problem in the case narrative.</li> </ul>	Analyst/Prep Analyst	HRSM02.1: concentrations for the 12 WHO toxic CBC congeners < LOQ
Equipment blanks	1 per day per type of non-dedicated sampling equipment	No criteria specified in method or SOPs	Investigate sources of equipment blank contamination after method blank actions are applied and considering other sources of blank contamination. CA includes: <ul style="list-style-type: none"> <li>Review potential laboratory or field sources of contaminants (including type of water or solvents used to make the equipment blank).</li> <li>Once source is identified, QA Manager or Chemist should share findings with program management and the field team.</li> <li>Discuss equipment blank contamination in EPA deliverables and any impacts on data quality.</li> </ul>	Program Manager, Field Samplers, QA Manager, and Chemist	All analyte concentrations < LOQ

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Laboratory Control Sample (LCS)	1 per extraction batch	Method criteria same as Project-Specific MPC	Investigate reason for poor LCS recovery. Eliminate problem before proceeding with further analysis. CA includes: <ul style="list-style-type: none"> <li>If low spike recovery, re-extract and reanalyze samples under compliant LCS, if sufficient sample volumes are available.</li> <li>For any low or high LCS outliers, flag (qualify) any analytes in samples from the affected batch. Document the problem in the case narrative.</li> </ul>	Analyst and Prep Analyst	%R must meet criteria in HRSM02.1Table 5
Laboratory Control Sample Duplicate (LCSD)	1 per extraction batch	Method criteria same as Project-Specific MPC	Re-extraction or reanalysis not required for RPD outlier between the LCS and LCSD. CA includes: <ul style="list-style-type: none"> <li>For any high RPDs, flag (qualify) the analyte in samples from the affected batch.</li> <li>Document the problem in the case narrative.</li> </ul>	Analyst and Prep Analyst	30% RPD
Field Duplicate	1 per 10 field samples of the same matrix	No method or SOP criteria specified	If MPC is not met for the field duplicate results >4x LOQ, a careful examination of the sampling techniques, sample matrix, and analytical method and other analytical QC criteria will be conducted to identify the root cause of the high RPD and the usability of the data.	Field Samplers and Chemist	RPD ≤30% (water) RPD ≤50% (soil)

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action (CA)	Title/position of person Responsible for Corrective Action	Project-Specific MPC
Labeled congeners	Each field and QC sample	Limits specified in the method HRSM02.1	Investigate reason for poor recovery. CA includes: <ul style="list-style-type: none"> <li>Re-extract the sample to confirm the problem is with the sample matrix and not the extraction. Report both sets of results if the re-extraction confirms the initial analysis. Otherwise, report only the compliant analysis.</li> <li>Document surrogate outliers on the Forms and in the case narrative.</li> </ul>	Analyst	Within limits specified in the method HRSM02.1
Cooler Temperature Indicator	One per cooler	≤6°C (not frozen)	Laboratory to notify QA Manager and confirm whether to proceed with analysis. Resampling may be required.	Laboratory Sample Custodian/ QA Manager	≤6°C (not frozen)

Notes:  
 # Laboratory SOPs are retained on file.

%R = percent recovery  
 CBC = Chlorinated Biphenyl Congener  
 HRGC = High Resolution Gas Chromatography  
 HRMS = High Resolution Mass Spectrometry

LOQ = Limit of Quantitation  
 MPC = Measurement Performance Criteria  
 QA = Quality Assurance  
 QC = Quality Control

RPD = Relative percent difference  
 SOP = Standard Operating Procedure  
 WHO = World Health Organization

## WORKSHEET #29: PROJECT DOCUMENTS AND RECORDS

### Sample Collection and Field Records

Record	Generation	Verification	Storage Location/Archival
Field Notebook: daily observations and notes, personnel on site, tailgate meetings, communications with EPA or state agency representatives, unusual incidents, recording of sample collection dates and times including parameters, preservation, and sketch of sampling locations and/or GPS coordinates, etc.	Field Team Member	Field Team Leader	Site File
Site Maps	Field Team Member	Field Team Leader	Site File
Soil boring/coring logs: soil lithology, sample depth, groundwater depth, and other observations.	Field Team Member	Field Team Leader	Site File
Water Quality Readings: pH, temperature, dissolved oxygen (DO), turbidity, and oxidation-reduction potential (ORP).	Field Team Member	Field Team Leader	Site File
Monitoring Instrument Readings including calibration records (PID, FID, CGI/O <sub>2</sub> , radiation detectors, etc.)	Field Team Member	Field Team Leader	Site File
Data usability assessments	Field Team Member	QA Manager	Site File
Field Screening Reports	Field Team Member	Field Team Leader	Site File
Data analyses	Laboratory analyst	Laboratory QA Manager	Laboratory data package
Instrument maintenance records	Laboratory analyst	Laboratory QA Manager	Laboratory
Field surveys	Field Team Member	Field Team Leader	Site File
COC	Field Team Member	Field Team Leader	Laboratory data package
Custody seals	Field Team Member	Laboratory sample custodian	Laboratory data package
Airbill	Field Team Member	Field Team Leader	Site File

Notes:

CGI/O<sub>2</sub> = Combustible Gas Indicator/ Oxygen

COC = Chain-of-Custody

FID = Flame Ionization Detector

GIS = Geographical Information System

GPS = Global Positioning System

PID = Photoionization Detector

XRF = X-Ray Fluorescence

### Project Assessments

Record	Generation	Verification	Storage Location/Archival
Field Audit Checklists (for field operations, logbooks, etc.)	Field Team Leader	QA Manager	Site file
Data validation reports	Data Validator	QA Manager	Site file
Trip reports	Field Team Member	Field Team Leader	Site file
Progress Reports	Field Team Leader	PM	Site file

### Laboratory Records\*

Record	Generation	Verification	Storage Location/Archival
Laboratory data packages	Laboratory Personnel	Laboratory QA Manager	Site file

**Notes:**

POC = Point of Contact

PM = Program Manager

QA = Quality Assurance

\* Laboratory records include the following:

- Sample Receipt/Condition Reports
- Field Chain-of-Custodies (COCs)
- Internal Chains-of-Custody (COCs)
- Laboratory Information Management System (LIMS) login information
- Extraction bench sheets
- Instrument run logs
- Standards preparation records and traceability records (including certificates)
- Instrument Calibration and Maintenance records
- Non-Conformance Records
- Communication records (emails, phone logs)
- Quality Control (QC) sample reports
- Laboratory data qualifiers
- Electronic Data Deliverables
- Case narrative
- Sample Cross-reference table
- Quality Assurance/Quality Control (QA/QC) forms
- Method Detection Limit/Reporting Limit (MDL/LOQ) studies
- Laboratory Accreditations/Certifications
- Quality Assurance Manual
- Analytical Standard Operating Procedures (SOPs)
- Sample Disposal Records
- Control Charts

## WORKSHEET #31, 32 & 33: ASSESSMENTS, CORRECTIVE ACTION & QA MANAGEMENT REPORTS

### Assessments

Assessment Type	Responsible Party & Organization	Number/Frequency/ Estimated dates	Assessment Deliverable	Deliverable Due Date
Review of QAPP/Work Plan with Field Staff	Field Team Leader	Each sample event	NA	NA
QC of Daily Field Reporting and Field Forms/logbooks and review against Work Plan requirements	Field Team Leader	Each sample event	NA	NA
Daily Tailgate Safety Meeting	Field Team Leader	At the beginning of each sample event	NA	NA
Logbook Audit	QA Manager	Each sample event	Email/memorandum to project file	30 days after review
Laboratory Report Deliverables – verification of data package completeness, analytical compliance, and data correctness (also see Worksheet #37)	Laboratory QA Manager	Each sample delivery group	Laboratory Data Package	30 days after sample receipt
Data validation review for all project data - Assess problems with samples or analysis, laboratory performance, sampling issues resulting in rejected or qualified data, field blank contamination. (Also see Worksheet #35/36)	Data Validator	Each sample delivery group	QA Report	45 days after Laboratory Data Package receipt
Data Validation (also see Worksheet #35/36)	Data Validator	Each sample delivery group	QA Report	45 days after Laboratory Data Package receipt
Management reviews	QA Manager	annual	QA Management memorandum	30 days after review

NA = not applicable

## Assessment Response and Corrective Action

Assessment Type	Responsibility for Responding to Assessment Findings	Assessment Response Documentation	Timeframe for Response	Responsibility for Implementing Corrective Action	Responsible for Monitoring Corrective Action Implementation
Logbook audit	Field Team Leader	Email/memorandum to project file	10 days of findings	Field Team Leader	QA Manager
Data Validation	Laboratory PM	Revised Laboratory Data Package/QA Report	10 days of findings	Laboratory QA Manager	Laboratory PM
Management reviews	Project PM	QA Management memorandum	10 days of findings	Project PM	QA Manager

## QA Management Reports

Type of Report	Frequency (daily, weekly, monthly, quarterly, annually, etc.)	Projected Delivery	Person(s) Responsible for Report Preparation (Name, Title, Organization)	Report Recipient(s) (Title and Organization)
Annual quality report	Annual	Within 1 month of contract anniversary dates	QA Manager	EPA PO and Grantee PM

Notes:  
 EPA = U.S. Environmental Protection Agency  
 FTL = Field Team Leader  
 PM = Program Manager  
 QA = Quality Assurance  
 QAPP = Quality Assurance Program Plan

## WORKSHEET #35: DATA VERIFICATION PROCEDURES

This worksheet documents procedures used to verify project data and applies to both field and laboratory records. Data verification is a completeness check to confirm that all required activities were conducted, all specified records are present, and the contents of the records are complete. Verification is often performed at more than one step by more than one person.

Records Reviewed	Required Documents	Process Description	Responsible Person (Organization)
Field or Personal Logbook	QAPP, Field Documentation SOP	Verify that: <ul style="list-style-type: none"> <li>Daily entries are completed for each day of field activities.</li> <li>All planned samples including field QC samples were collected.</li> <li>All sample locations are documented in the logbook.</li> <li>Meteorological data were included for each day of field activities.</li> <li>Any changes/exceptions from the site-specific plans are documented.</li> <li>Field instruments were calibrated, and field monitoring was performed, and results are documented.</li> </ul>	Field Team Leader
COCs Sample bottle labels	Sample Handling and Custody SOP, CLP Sampler's Guide, EPA R3-specific requirements	Verify that all data elements for the COCs are present and correct. Verify consistency with the field logbook and that appropriate sample volumes have been collected. Verify that all required signatures and dates are present, including those of reviewers. Check for transcription errors.	Field Team Leader
Analytical Data Packages	QAPP, COC	Verify that: <ul style="list-style-type: none"> <li>All applicable data elements in Worksheet 34 data elements are included in the data package.</li> <li>All field sample results are reported and laboratory results are complete.</li> <li>Sample condition upon receipt was noted, and any missing/broken sample containers were noted and reported.</li> <li>Project Quantitation Limits are less than or equal to the project action limits as specified in the site-specific DQOs and sampling plans.</li> <li>Verify that necessary signatures and dates are present.</li> </ul>	Laboratory PM
Data Validation Deliverables	QAPP, COC	Verify that the report consists of the following for all field samples submitted to the laboratory: <ul style="list-style-type: none"> <li>Data validation report (PDF)</li> <li>Sample Summary Report with data validation qualifiers</li> </ul>	Data Validator
Audit reports, Corrective Action reports	QAPP	Verify that all planned audits were conducted. Examine audit reports. For any deficiencies noted, verify that corrective action was implemented according to the plan.	QA Manager



Notes:

CLP = Contract Laboratory Program

COC = Chain-of-Custody

EDD = Electronic Data Deliverable

EPA = U.S. Environmental Protection Agency

PDF = Portable Data Format

QC = Quality Control

QA = Quality Assurance

QAPP = Quality Assurance Program Plan

SOP = Standard Operating Procedure

## WORKSHEET #36: DATA VALIDATION PROCEDURES

This worksheet documents procedures that will be used to validate project data. Data validation is an analyte and sample-specific process for evaluating compliance with contract requirements, methods/SOPs, and MPC. The scope of data validation needs to be defined during project planning because it affects the type and level of documentation required for both field and laboratory activities. The data validation levels described below use terminology contained in *Guidance for Labeling Externally Validated Laboratory Data for Superfund Use*, EPA 540-R-08-005, which was developed to promote the use of consistent terminology by external data reviewer to describe the scope and content of data review activities.

Analytical data packages will undergo data validation at a level commensurate with the project's needs, which will be determined during the project planning phase and specified in the site-specific plans and data quality objectives. The data will be validated using guidance from ADEC's Contaminated Sites Program Laboratory Data Review Checklist (September 2022). This level of validation is consistent with the Stage 2A Validation, defined in the list below.

If the project objectives or the DQOs change, the level of validation may also change. Data validation levels may include the following:

- Stage 1 Validation is a verification and validation based only on completeness and compliance of sample receipt condition checks.
- Stage 2A Validation is a verification and validation based on completeness and compliance checks of sample receipt conditions and only sample-related QC results.
- Stage 2B is verification and validation based on completeness and compliance checks of sample receipt conditions and both sample-related and instrument-related QC results.
- Stage 3 Validation is a verification and validation based on completeness and compliance checks of sample receipt conditions, both sample-related and instrument-related QC results, and recalculation checks.
- Stage 4 Validation is a verification and validation based on completeness and compliance checks of sample receipt conditions, both sample-related and instrument-related QC results, recalculation checks, and the review of actual instrument outputs.

The recommended minimum baseline checks conducted for each stage of analytical data verification and validation are described in more detail in *Guidance for Labeling Externally Validated Laboratory Data for Superfund Use*, EPA 540-R-08-005

Using higher stages of analytical verification and validation does not typically result in higher data quality. However, the quality of the analytical data becomes more transparent as more stages of verification and validation are conducted. As a result, the usability of the analytical data for its intended use becomes more apparent.

The validation "stages" referenced above specify which data elements are reviewed, which allows a staged approach to data validation. Additionally, the following guidance documents may be used for data validation:

- **Organic Data for CLP SOW SFAM01.1:** *National Functional Guidelines for Organic Superfund Methods Data Review*. EPA 540-R-20-005 (EPA, November 2020)
- **Inorganic Data for CLP SOW SFAM01.1:** *National Functional Guidelines for Inorganic Superfund Methods Data Review*. EPA 540-R-20-006 (EPA, November 2020)
- **Dioxin/Furan and PCB Congener Data for CLP SOW HRSM02.1:** *National Functional Guidelines for High Resolution Superfund Methods Data Review*. EPA 542-R-20-007 (EPA, November 2020)

For sites entering State-specific cleanup programs, State-produced guidance should be consulted to identify potential State-required data validation requirements.

## WORKSHEET #37: DATA USABILITY ASSESSMENT

Data usability assessments will be performed in general accordance with EPA guidance QA/G-9R, *Data Quality Assessment, A Reviewer's Guide* (EPA/240/B-06/002) (EPA February 2006) and *Guidance for Data Usability in Risk Assessment* [Publication No. 9285.7-05FS (EPA, September 1992)], as appropriate. This worksheet documents procedures that will be used to perform the data usability assessment (DUA). The DUA is performed at the conclusion of data collection activities using the outputs from data verification and data validation (i.e., data of known and documented quality). It is the data interpretation phase, which involves a qualitative and quantitative evaluation of environmental data to determine if the site data are of the right type, quality, and quantity to support the decisions that need to be made. It involves a retrospective evaluation of the systematic planning process and participation by key members of the project team. The DUA evaluates whether underlying assumptions used during systematic planning are supported, sources of uncertainty have been accounted for and are acceptable, data are representative of the population of interest, and the results can be used as intended, with the acceptable level of confidence.

Project personnel who may be involved with the DUA include the Program Manager, Field Team Leader, and QA Manager. An overview of steps included in the DUA is as follows:

- **Step 1: Review the project's objectives and sampling design:** This includes reviewing the data quality objectives (DQOs) and MPC to make sure they are still applicable. The sampling design should be consistent with stated DQOs.
- **Step 2: Review the data verification and data validation reports:** Graphs, maps, and tables can be prepared to summarize the data. Deviations from activities planned in the site-specific plans should be considered including samples not collected (potential data gaps), holding time exceedances, damaged samples, impact of non-compliant PE sample results, and SOP deviations. The implications of unacceptable QC sample results should be assessed.
- **Step 3: Verify the assumptions of the selected statistical method:** Verify whether underlying assumptions for the selected statistical methods are valid. Common assumptions include the distributional form of the data, independence of the data, dispersion characteristics, homogeneity, etc. Depending on the robustness of the statistical method, minor deviations from assumptions usually are not critical to statistical analysis and data interpretation. If serious deviations from assumptions are discovered, then another statistical method may need to be selected.
- **Step 4: Implement the statistical method:** Implement the statistical procedures, if specified in site-specific plans, for analyzing the data and review underlying assumptions. For decision project that involve hypothesis testing (e.g., "concentrations of lead in groundwater are below the action level") consider the consequences for selecting the incorrect alternative; for estimation projects (e.g., establishing a boundary for surface soil contamination), consider the tolerance for uncertainty in measurements.
- **Step 5: Document data usability and draw conclusions:** Determine whether the data can be used as intended, considering any deviations and corrective actions. Discuss whether DQOs were achieved based on comparison with the site data quality indicators (DQI). Assess the performance of the sampling design and identify limitations on data use. Update the conceptual site model and

document conclusions. Prepare a DUA report or include the data usability summary in the final site report. The DUA can be in the form of text and/or a table.

DQIs and DUAs are described in more detail below.

DQIs are commonly referred to as “PARCCS parameters” and include measurements of precision, accuracy, representativeness, comparability, completeness, and sensitivity. The MPCs in this QAPP establish minimum limits for some of these PARCC parameters. The DUA will reconcile site-specific DQOs with the results of the data collection, including validated analytical results. DQIs aid in the evaluation process and are described in the following subsections.

## Precision

Precision is a measure of the reproducibility of sample results. Two of the most used estimates of precision are the RPD for cases in which only two measurements are available, and the percent relative standard deviation (%RSD) when three or more measurements are available. This is especially useful in normalizing environmental measurements to determine acceptability ranges for precision because it effectively corrects for the wide variability in sample analyte concentrations.

RPD: Precision is frequently represented as the RPD between concentrations of an analyte in laboratory duplicates, field duplicates, MSDs, and LCSDs. RPD is mathematically expressed by the formula:

$$RPD = \frac{|C_1 - C_2|}{((C_1 + C_2)/2)} \times 100$$

Where:

C1 = First measurement value

C2 = Second measurement value

**RSD:** Precision, when represented as the %RSD between more than two replicate measurements, is calculated by dividing the standard deviation of the measurements by the mean value for the measurements ( $\bar{x}$ ) then multiplying by 100. For example, the precision between calibration standard Relative Response Factors (RRFs) is evaluated using the %RSD between a minimum of five replicates. %RSD is mathematically expressed by the formula:

$$\%RSD = \frac{SD}{\bar{x}} \times 100$$

The mathematical formula for SD is:

$$SD = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{(n - 1)}} \times 100$$

Where:

$x_i$  = each individual value used to calculate the mean

$\bar{x}$  = the mean of  $n$  values

$n$  = the total number of values

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## Accuracy/Bias

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Accuracy is a measure of how close a measured result is to the true value. Accuracy control limits are established by the analysis of laboratory control samples (LCS) from analyte-free water and solid matrices. The LCS is subjected to all sample preparation and analytical steps. The percent recovery (%R) of each analyte is entered into a database and, when a large enough data set is acquired, statistical control limits are established for each analyte. These statistical control limits are often updated on an annual or semiannual basis, depending on the method. LCS recoveries are used for batch control; if a low LCS recovery is encountered, the corrective action might be to reanalyze or re-extract/reanalyze the field samples in that batch.

The percent recovery (%R) for spiked field sample analysis (e.g., matrix spike) provides a tool for evaluating how well the method worked for the respective matrix. The %R is used to assess a reported result for analytical accuracy and high or low bias. For MS or MSD recoveries outside control limits, batch reanalyses are not usually required unless specified in the analytical method. LCS, LCSD, MS, or MSD outliers will be noted in the case narrative accompanying the sample results.

Percent recovery (%R) is mathematically expressed by the formula:

$$\% R = \frac{(SSR - SR)}{SA} \times 100$$

Where:

SR = Spiked sample result  
SR = Sample result  
SA = Spike added

Accuracy and bias for organic calibrations is evaluated using the percent difference (%D), which measures the degree of agreement between the RRF or calibration factor (CF) for the continuing calibration verification (CCV) standard against the initial calibration (ICAL) curve average RRF or average CF. The percent difference (%D) of a CCV from the reference value (ICAL) and is used by the laboratory to document the acceptability of the continuing calibration.

The %D is calculated by expressing, as a percentage, the difference between the original value and new value relative to the original value. Unlike RPD and RSD, %D may be positive or negative. This method for precision measurement can be expressed by the formula:

$$\%D = \frac{RRF_c - \text{Mean } RRF_i}{\text{Mean } RRF_i} \times 100$$

Where:

RRF<sub>c</sub> = RRF or CF from current CCV  
Mean RRF<sub>i</sub> = Sample result

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## Completeness

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Completeness is defined as a measure of the amount of valid data obtained from an event and/or investigation compared to the total amount that was obtained. Sitewide completeness goals account for all aspects of sample handling, from collection through data reporting. The level of completeness can be affected by loss or breakage of samples during transport and analysis, as well as external problems that prohibit collection of the sample. Validation qualifiers will be used to assess analytical completeness. When evaluating analytical completeness, usable results include non-qualified and estimated (J-qualified) data; data qualified as rejected (R) are unusable. The general formula used to determine percent completeness is as follows:

$$Completeness = \frac{A}{B} \times 100$$

Where:

A = Number of usable data points

B = Total number of data points collected

The formula for sampling completeness is:

$$Sampling\ Completeness = \frac{Number\ of\ locations\ sampled}{Number\ of\ planned\ sample\ locations} \times 100$$

The formula for analytical completeness is:

$$VOC\ Analytical\ Completeness = \frac{Number\ of\ usable\ data\ points}{Expected\ number\ of\ usable\ data\ points} \times 100$$

The following table lists the completeness goals for the project. If the completeness goal is not met because of controllable circumstances, then the samples will be recollected and reanalyzed, as necessary, to meet the completeness objective. If the completeness goal is not met due to uncontrollable circumstances such as inaccessible sample points, matrix interferences, etc., then the deficiency will be evaluated, and resampling may not be required.

## Project Completeness Goals

Task	Subtask	Completeness Goal
Sampling	Sample Collection	95%
Field Measurements	Conductivity	100% of applicable collected samples
	pH/Turbidity/Dissolved Oxygen/ Oxidation-Reduction Potential/Volatile Organic Compounds	100% of applicable collected samples
	LEL/Organic Vapors/TPH/ Chlorinated Substances	100% of applicable collected samples
Analytical Measurements	All Laboratory Analyses	95% of analytes

## Representativeness

Representativeness is the degree to which sampling data accurately and precisely represent site conditions and depends on sampling and analytical variability and the variability of environmental media at the site. Data representativeness is accomplished by properly designing the Work Plan and conceptual site model, implementing the approved Site-specific Work Plan, following SOPs for sample collection, and by using analytical methods that are appropriate for the intended data uses.

## Comparability

Comparability is the degree to which the quality characteristics of one data set compare to another. Comparability of data sets generated for this project will be obtained through the implementation of standard sampling and analysis procedures, by the use of traceable reference materials for laboratory standards, and by expressing the results in comparable concentration units, and for soil samples, comparing dry weight adjusted results.

## Sensitivity

Sensitivity is the ability of the method or analytical instrument to detect target analytes at the concentration of interest. For acceptable sensitivity, quantitative measurement performance criteria need to be determined during the project planning stage to ensure that the quantitation limits can be routinely achieved for each matrix, analytical parameter, and concentration level. The concentration of the lowest calibration standard establishes the lower limits of the analytical instrument calibration range and LOQs are based on this concentration level. To provide adequate analytical sensitivity, EPA recommends that the sample LOQ be 3 to 10 times less than the PAL established for the site.

## Assessment of Data Usability

The DUA goes beyond validation in that it evaluates the achievement of the DQOs based on a review of the validated analytical data and site DQIs as established in the QAPP or modified by the Site-specific Work Plan. The DUA will note any changes to the DQOs necessitated by the data not meeting usability criteria.



## ***Sampling and Analysis Activities Evaluation***

The first step of the DUA will include a review of the sampling and analysis activities in comparison to the activities proposed in the Work Plan. Data limitations [i.e., results that are qualified as estimated (J/UJ) or rejected (R)] will be documented in the DUA.

### ***Achievement of DQIs***

The second step of DUA assesses the achievement of site-specific DQIs. Validated sample results will be compared to these DQIs and is a critical component of the DUA process. Deviations from planned performance will be documented and evaluated to determine whether corrective action is necessary. Potential corrective actions will range from resampling and/or sample reanalysis, to qualification or exclusion of the data for use. (If corrective action is not possible, the DUA will note any data limitations with regard to achieving the DQOs.)

As part of this step of the DUA assessment, the investigation team will need to make decisions on the use of qualified data for individual sample results and locations. Data usability decisions will be made based on this assessment for the intended purpose. The DUA will describe the uncertainty (e.g., bias, imprecision) of the qualified results. Cumulative QC exceedances may require technical judgment to determine the overall effect on the usability of the data. Decisions about usability of qualified data for use in risk assessment will be based on the referenced EPA documents, which allows for the use of estimated values.

### ***Achievement of DQOs***

The third step in the data usability process concerns achievement of the site DQOs. Once the data set has been assessed to be of known quality, data limitations have been documented, and overall result applicability/usability for its intended purpose has been determined, the final data assessment can be initiated by considering the answers to the following types of questions:

- Are the data adequate to determine the extent to which hazardous substances have migrated or to what extent they are expected to migrate from potential hazardous substance source areas?
- Do the data collected adequately characterize the nature and extent of potential hazardous substance source areas at the site?
- Are the data statistically adequate to allow evaluation on a per chemical and per media basis?
- Do the data collected allow assessment of hydrogeologic factors, which may influence contaminant migration/distribution?
- Is the sample set sufficient to develop site-specific removal and disposal treatment methodologies?
- Have sufficient data been collected to evaluate how factors, including physical characteristics of the site and climate and water table fluctuations, affect contaminant fate and transport?
- Have sufficient data been collected to determine the toxicity, environmental fate, and other significant characteristics of each hazardous substance present?
- Has an adequate amount of information been gathered to determine groundwater characteristics

and current and potential groundwater uses for locations close to the site?

- Is the data set sufficient to evaluate the potential extent and risk of future releases of hazardous substances, which may remain as residual contamination at the source facility?

The project team will need to formulate solutions if data gaps are found as a result of problems, biases, or trends in the analytical data, or if conditions exist that were not anticipated in the development of the DQOs. It is particularly important that each data usability evaluation specifically assess and document any limitations on the use of the data that may result from a failure to achieve the site DQOs.

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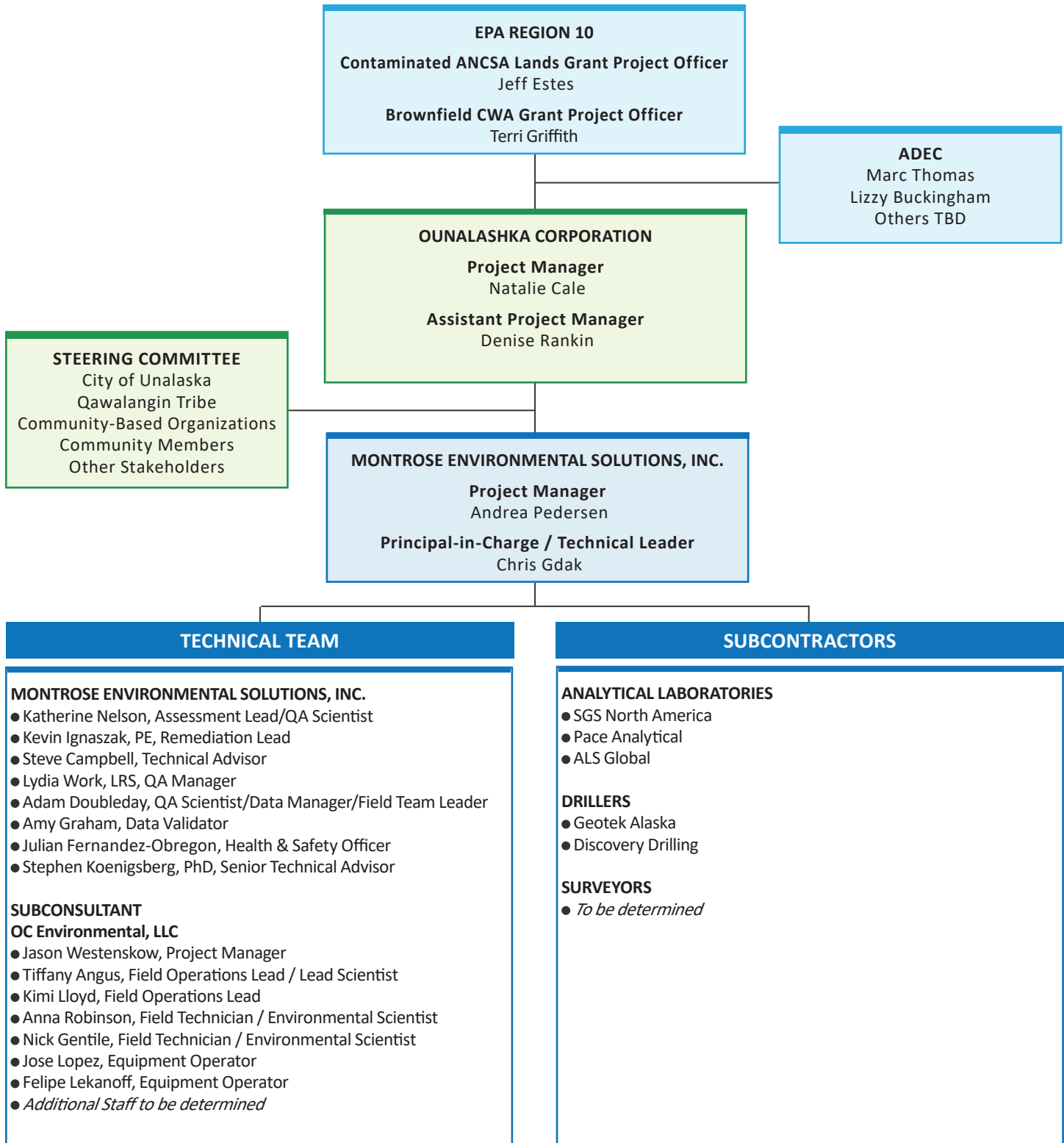
## Appendix A

### Program Organization Chart

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# APPENDIX A

## Program Organization Chart



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## Appendix B

### Montrose Field SOPs

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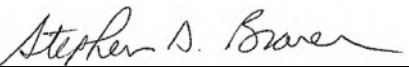
**FIELD DOCUMENTATION PROCEDURES**  
**(Standard Operating Procedure 001)**

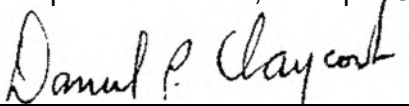
**Revision No: 2**

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Original Date: November 10, 2008

SOP Approval:  Date: 03/31/2023  
Stephen D. Brower, Principal Geoscientist

SOP Approval:  Date: 03/31/2023  
Daniel P. Claycomb, Principal Geoscientist

**FIELD DOCUMENTATION PROCEDURES**  
**(Standard Operating Procedure 001)**

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# FIELD DOCUMENTATION PROCEDURES (Standard Operating Procedure 001)

## 1.0 PURPOSE

This standard operating procedure (SOP) describes the requirements associated with documenting field investigation and remediation activities. The procedures described in this SOP are applicable to field logbooks, sample labels, Chain-of-Custody (COC) Records, and field form documentation.

## 2.0 GENERAL CONSIDERATIONS

Proper documentation of field activities is a crucial part of the field investigation/remediation process. Documentation shall be maintained to:

- Document investigation and remediation activities.
- Trace the possession and handling of samples from time of collection through submittal to the laboratory.
- Adequately document sample locations.
- Identify field personnel and their responsibilities (among other important information).
- Real-time recording.

Field documentation procedures are important from both a technical and a legal perspective.

## 3.0 PROCEDURES

### 3.1 Field Logbook

Each Field Team conducting sampling activities shall maintain a field logbook to document the activities performed by the Field Team each day that field work is conducted. At a minimum, the following information shall be recorded daily in the field logbook:

- Name and location of the site.
- Date(s) of sample collection event or field activity.
- Names of Field Team members and responsibilities.
- Time of arrival to the site and departure from the site.
- Times of relevant activities performed at the site.
- Weather conditions and relevant changes during the performance of site activities.
- Pertinent field observations. **Note:** Only objective field observations shall be recorded in the field logbook. Subjective observations such as opinions and speculations shall not be recorded in the field logbook.
- Daily summary of equipment preparation and calibration procedures.
- Time of collection of each sample.
- Record the numbers and types of samples collected and sample identification numbers in chronological order.
- A description of sampling methodology and procedures by reference to the project control documents.
- An identification of the analytical methods that are being requested, the laboratory location, and how the samples are being sent (*i.e.*, FedEx®, laboratory courier).
- Record of project-related phone calls and/or contact with individuals at the site.
- Management or disposal of investigation-derived waste.
- Photo logs (if applicable) shall include:
  - Photo number



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- Location of photo
- Brief description of photo
- Global Positioning System (GPS) coordinates, if applicable.
- Document decontamination procedures and frequency and associated equipment.

The above procedures/protocols are not typically discussed in recent regulatory guidance concerning field investigation activities because they were addressed in detail during early policy development periods of the environmental industry. Some examples of the early publications that address field documentation are listed below.

- “A Compendium of Superfund Field Operations Methods”
- “Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA”
- “Guidance for Performing Preliminary Assessments Under CERCLA”
- “Guidance for Performing Site Inspections Under CERCLA”
- “Compliance-Focused Environmental Management System - Enforcement Agreement Guidance”

A summary of the key elements of field documentation procedures described in these and other pertinent documents is provided below.

- Logbooks shall be bound.
- Each page of the logbook shall be consecutively numbered.
- Entries into the logbook shall be chronological – a time notation should introduce each entry.
- Logbook entries shall be made in indelible ink (e.g., Rite in the Rain, Power Tank [Uniball]).
- Data shall be recorded directly and legibly in the field logbook.
- Corrections in a logbook shall be lined out (a single line strike-through), initialed and dated.
- Avoid leaving any blank line(s) between logbook entries. Cross out any lines intentionally left blank with a single line strike-through, initial and date.
- Cross out any blank areas that exist with a single line strike-through, initial and date.
- Multiple blank lines may be crossed out using a single diagonal line, initial and date.
- The Field Team member keeping the logbook must sign and date each page of the logbook.

Field documentation is a crucial element of field activities. Therefore, Field Team members shall strictly adhere to logbook entry protocol. Field logbook entries shall include the information requested in the project control documents and shall be recorded in a manner consistent with this procedure.

In addition to field logbooks, electronic hardware can be employed in the field to complement the logbook records and to expedite the distribution and dissemination of field-recorded information. Computers and other electronic devices shall not replace the use of a field logbook.

### **3.2 Sample Labels**

When feasible, sample containers should be pre-labeled prior to sample collection and the labels protected from the sample matrix with a clear tape covering (unless the sample container requires a tare weight, such as a Terra Core® kit or if weatherproof labels are used). Sample labels shall include the following information (NJ DEP, 2005):

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- Unique well or sample identification.
- Parameter(s) to be analyzed.
- Date and time of collection.
- Sampler's initials.
- Preservative(s), if any.
- Site name or location.

### **3.3 Chain-of-Custody Documentation**

The COC Record is intended to be a legal record of possession of samples from the time of collection to laboratory analysis (US EPA, 2014). The COC shall be initiated in the field by the sampling personnel at the time of sample collection and bear the name of the person responsible for the secure and appropriate handling of the samples (US EPA, 2014).

The Field Team Leader shall maintain the COC during sample collection activities. The minimum information required for COC documentation includes the following:

- Name and location of the site.
- Name and affiliation of Samplers.
- Sample identification number.
- Date and time of sample collection.
- Matrix and type of sample collected (e.g., grab, composite).
- Number of containers per sample.
- Preservatives and fixatives.
- Parameters to be analyzed and associated analytical method.
- Identification of couriers.
- Identification of laboratory.
- Data deliverable requirements and turn-around-time.

When completing COCs, field personnel must document pertinent project-specific field data (as required) and employ the applicable field documentation techniques described previously for field logbooks.

A Field Team member identified as the Sampler shall identify their affiliation, sign and date the COC when the samples are relinquished (see SOP016 - Sample Packing, Shipping and Labeling for more details on relinquishment).

### **3.4 Field Forms**

When conducting field activities, Field Team members may record field measurements, observations, and other relevant data on field forms (either paper or electronic field forms would be acceptable). This type of documentation is intended to complement the logbook records but shall not replace the use of a field logbook to record such information, with the following exception.

- In cases when the content of field form documentation is extensive and replication of the information in logbook records is impractical, the field form documents shall be maintained as the original records, as long as the following criteria are met:
  - The field form(s) contain a descriptive title, a specific reference to the subject of the activity (e.g., sampling location), the date and time of the activity, the name and location of the site, and the name of the Field Team member recording the information.

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- The field form(s) are specifically referenced in the field logbook along with notes pertaining to the respective activity; the reference shall include a brief description of the information that the field form(s) contain (e.g., groundwater geochemical parameter measurements).
- The field form records are retained (either in hardcopy, or preferably, in electronic format) in the respective project file or other document repository following the conclusion of the field activity.

Field form entries shall comply with the documentation procedures described below (note that some procedures may not apply to electronic forms).

- Each page of the field forms shall be consecutively numbered (if more than one page per sample location).
- Field form entries shall be made in indelible ink.
- Data shall be recorded directly and legibly on the field forms.
- Corrections on a field form shall be lined out (a single line strike-through), initialed and dated.
- Avoid leaving any blank line(s) between field form entries. Cross out any lines intentionally left blank with a single line strike-through, initial and date.
- Cross out any blank areas that exist with a single line strike-through, initial and date. (US EPA, 2014)
- Multiple blank lines may be crossed out using a single diagonal line, initial and date.

### **4.0 REFERENCES**

New Jersey Department of Environmental Protection. "Field Sampling Procedures Manual." August 2005. <http://www.state.nj.us/dep/srp/guidance/fspm>

Pennsylvania Department of Environmental Protection. "Groundwater Monitoring Guidance Manual." March 27, 2021.

<http://www.depgreenport.state.pa.us/elibrary/GetDocument?docId=1420614&DocName=08%20APPENDIX%20A:%20GROUNDWATER%20MONITORING%20GUIDANCE.PDF%20%20%3cspan%20style%3D%22color:blue%3b%22%3e%3c/3e>

US Environmental Protection Agency. "A Compendium of Superfund Field Operations Methods. Office of Solid Waste and Emergency Response." Directive 9355.0-14, 1987.

<http://www.hanford.gov/dqo/project/level5/Sfcompnd.pdf>

US Environmental Protection Agency. "Contract Laboratory Program Guidance for Field Samplers." Office of Superfund Remediation and Technology Innovation. OSWER 9240.0-44, EPA 540-R-17-06, July 2014.

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US Environmental Protection Agency. "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA." Office of Solid Waste and Emergency Response. Directive 9355.3-01, 1988. <http://www.epa.gov/superfund/policy/remedy/pdfs/540g-89004-s.pdf>

US Environmental Protection Agency. "Guidance for Performing Preliminary Assessments Under CERCLA." Office of Solid Waste and Emergency Response. Directive 9345.0-01A, 1993. <http://www.epa.gov/superfund/sites/npl/hrsres/#PA%20Guidance>

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**FIELD SCREENING INSTRUMENTATION and PROCEDURES  
(Standard Operating Procedure 002)**

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**TABLE**

Table 1: Field Screening Equipment & Material Checklist

**APPENDIX**

Appendix A: A Guideline for PID Instrument Response

# **FIELD SCREENING INSTRUMENTATION and PROCEDURES**

## **(Standard Operating Procedure 002)**

### **1.0 PURPOSE**

This standard operating procedure (SOP) provides the general technical requirements and operational guidelines for field screening air and soil during characterization activities. The requirements of this procedure are applicable to project activities that involve sampling and the generation of residual materials. The requirements and guidelines for storing, calibrating and operating the following types of monitoring instruments are included in this SOP:

- Photoionization detector (PID)
- Multi-gas detector (MGD)

### **2.0 GENERAL CONSIDERATIONS**

Thoroughly evaluate the potential hazards associated with the planned tasks prior to conducting field activities. Refer to the site-specific Health and Safety Plan (HASP) for a description of potential hazards and associated safety and control measures. PIDs are intrinsically safe and will not cause an explosion if exposed to an explosive atmosphere.

Air monitoring instruments are used to detect various volatile organic vapors and combustible gases and to identify oxygen rich or oxygen deficient atmospheres. The screening data acquired from the various air monitoring instruments will be used to determine the proper selection of personal protective equipment, engineering controls, and work practices; to designate “safe” zones; and to screen field samples. Field personnel who are responsible for operating the instruments are required to be familiar with the procedures detailed in this SOP and adequately trained in instrument operation procedures.

### **3.0 PROCEDURES**

This section documents general operating procedures and field screening methods associated with the following monitoring instruments:

- PID
- MGD

#### **3.1 Office Preparation**

Obtain the field instrument and ensure that it is functional prior to mobilization to the field. Also, ensure that instruction and maintenance manuals are stored with the instrument and are available for reference during use.

##### **3.1.1 Job Hazard Analysis**

Complete a job hazard analysis (JHA) as part of the HASP to select the appropriate monitoring equipment. The JHA will identify potential hazards inherent to specific tasks outlined in the scope-of-work. Upon completion of the JHA, project personnel will be able to more appropriately determine the potential risk associated with the task(s) and to select the appropriate instrumentation necessary to monitor potential hazards.

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### ***3.1.2 Instrument Maintenance, Storage, and Transport***

Ensure that the instrument is in good working order prior to mobilizing to the field. Transport and store instruments in a case suitable to protect them from damage.

### **3.2 Field Preparation**

Follow the start-up procedures, operational checks, and field calibration procedures provided in the instrument instruction manual in order to prepare the instrument for use. Field calibration is required to correct deviations from the initial calibration that may have been introduced during transport of the instrument or as a result of temperature variations. Evaluate the potential impact of weather on equipment operation and calibration and note evaluation results in the field logbook, if necessary. Document field preparation and calibration in the field logbook, consistent with Section 3.3.1.2 of this SOP.

### **3.3 Field Screening Instrument Operation**

#### ***3.3.1 PID Operation***

##### ***3.3.1.1 General Considerations***

This procedure provides the general technical requirements and operational guidelines for PID use. A PID is a real-time, direct-reading instrument designed to monitor volatile organic vapors in air, and may be used as a general air monitor/survey instrument. A PID displays concentrations (in units of parts per million [PPM]) of detected volatile organic compounds (VOCs; e.g., trichloroethene and benzene) that have an ionization energy (IE) that is less than the energy of the PID's ultraviolet lamp. Note that the following lamps are available for use in a PID (identified by their IE energy): 9.8 electron volts (eV), 10.6 eV, and 11.7 eV. Refer to Appendix A for a listing of VOCs and their respective IEs and lamp energy requirements.

Note that PID response may be affected by pressure, temperature, and matrix interferences. It is recommended that the PID be calibrated at the same pressure and temperature as the ambient conditions in the environment in which the instrument will be used for air monitoring. To the extent feasible, during use, keep the PID at the same or higher temperature than that of the monitoring environment to avoid condensation in the instrument. Matrix interferences such as methane and water vapor can reduce the PID response. Also, excessive humidity and condensation in the instrument can increase the PID response; these factors should be considered during PID use. If the environment or media to be monitored is expected to exhibit moderate or high humidity, equip the PID with a moisture filter during calibration and use. Refer to Appendix A for additional information regarding considerations for PID use.

The data generated by a PID are used to determine levels of personal protection, to designate "safe" zones, and to field-screen samples for the potential presence of VOCs. Table 1 provides a list of equipment associated with PID operation.

##### ***3.3.1.2 Calibration***

Prior to use each day, conduct a bump gas test in accordance with manufacturer-specific procedures. Perform a full calibration if the PID fails a bump gas test, when sensor maintenance or replacement is conducted, or at a minimum, once every 180 days. If the PID does not start up or will



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not calibrate properly or does not pass a gas bump check, send the instrument to an authorized repair facility for repairs. At a minimum, record the following information in the field logbook:

- Instrument manufacturer, model, and serial number
- Name of field team member performing calibration/bump gas check
- Date, time and location of calibration/bump gas check
- Type and lot number of the calibration gas
- PID response before and after calibration, if applicable

Perform and document bump gas checks throughout the day using the calibration gas to verify instrument response.

### **3.3.1.3 Operation**

Follow these procedures when using a PID in the field:

- Follow the manufacturer-specific start-up, calibration and operation procedures.
- Position the probe intake assembly as close as possible to the area/media to be screened to obtain a reliable reading. Do not lower the air intake into water because water may be pulled into the instrument by the air sampling pump, causing the PID's lamp to become clouded and the instrument to fail.
- False readings may occur when conditions such as high ambient relative humidity, temperature extremes, high winds, high electrical field interference (such as near overhead power lines) exist, or if the probe intake is too far from the media of interest. Alternative detection equipment may be necessary in these situations.
- A false reading will occur if a gas that has an IE greater than that of the lamp is present. Review Appendix A to determine if the IE of the chemicals anticipated to be present are within the range of detection of the lamp installed in the PID. Some compounds whose IE exceeds that of the 11.7 eV lamp are methane (IE = 12.98 eV), sulfur dioxide (IE = 12.30 eV), and hydrogen cyanide (IE = 13.60 eV). Lamps with a higher eV rating can detect more compounds than lamps with a lower rating. For example, propane (IE = 11.07 eV) can be detected by an 11.7 eV lamp but not by the other two available lamps (9.8 eV or 10.6 eV). Note that an 11.7 eV lamp has a short shelf life of a few weeks and should be ordered only when project condition require use of a 11.7 eV lamp.
- Monitor the work activity as specified in the site-specific HASP, JHA or other project control documents.
- At the end of the day or after field activities have been completed, carefully clean the outside of the PID with a damp, disposable towel to remove any visible dirt. Return the PID to a secure area for recharging.
- With the exception of the probe's intake and the PID's exhaust port, the PID can be wrapped in clear plastic to prevent contamination and water damage in the event of precipitation. Confirm that the PID is completely dry before wrapping it in plastic.

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### **3.3.2 MGD Operation**

#### **3.3.2.1 General Considerations**

This procedure provides the general technical requirements and operational guidelines for calibrating and using an MGD. An MGD is a real-time, direct-reading instrument that is designed to monitor the potential for combustion or explosion in atmospheres with unknown concentrations of explosive gases. An MGD measures both the oxygen levels and the levels of explosive gases present in an atmosphere. The data generated can be used to determine appropriate respiratory protection devices and “safe” zones. Table 1 provides a list of equipment associated with MGD operation.

An MGD measures explosive gases as a percentage of the lower explosive limit (LEL). The LEL is the lowest concentration of gas in air by volume that can be ignited and cause an explosion. MGD read-outs vary in units of percent LEL for combustible gases and in parts per million (ppm) for oxygen and toxics. Frequently, the types of combustible gases to be encountered are unknown. The operator needs to be familiar with the LEL concentrations for specific gases to effectively use instruments that provide data in ppm combustible gas (by volume) only.

The upper explosive limit (UEL) is the concentration of gas in the air above which there is insufficient oxygen available to support combustion; therefore, an explosion is unlikely. A flame, however, may burn at the gas/air interface. In addition, should additional air enter the mixture, an explosive atmosphere may develop.

MGD units have audible and visual alarms that can be adjusted to activate at specific thresholds. Several units incorporate oxygen analyzers that will set off an alarm if the oxygen level reaches an unacceptable level.

#### **3.3.2.2 Calibration**

Prior to use each day, calibrate or conduct a bump gas test of the instrument according to the manufacturer-specific procedures (refer to the instrument’s instruction manual for additional information). If the MGD does not start up or will not calibrate properly, do not use and send the instrument to an authorized facility for repair. At a minimum, record the following information in the field logbook.

- Instrument manufacturer, model, and serial number
- Name of individual performing calibration/bump gas check
- Date, time, and location of calibration/bump gas check
- Type and lot number of calibration gas
- MGD response before and after calibration, if applicable

Perform and document bump gas checks throughout the day using the calibration gas to verify instrument response.

Calibrate the MGD using a calibration gas such as 100 ppm isobutylene. It is important to choose the appropriate calibration gas to calibrate the parameters being measured in the field. MGDs can typically be calibrated using gases such as butane, pentane, and methane. Verify calibration of the instrument by exposing it to the calibration gas mixture, as if it were a sample, before placing the instrument into service each day. For those instruments with an internal or non-adjustable

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span, prepare a calibration curve using concentrations in the range expected to be encountered, in accordance with the instrument instruction manual.

The LEL of methane is 5% by volume in air; therefore, an air mixture containing 5% methane will be read as 100% LEL and will be explosive if a source of ignition is present. When combustible gases other than methane are sampled, the relative response of the detector to these other gases must be considered. Recalibration to other gases may be possible. Refer to the manufacturer's recommendations.

For concentrations between 0 and 100% of the LEL, the meter indicates percentage of the LEL. For example, if the meter indicates 0.5 LEL (50%), the instrument perceives that the equivalent of 50% of the concentration of combustible gas needed to reach a combustible situation is present. If the LEL of the gas is 5% in air and the instrument is calibrated to that gas, then the instrument indicates that a 2.5% mixture is present.

The relative sensitivity of the detector and the differences in LEL for different gases will produce varying meter responses. Correlation equations that convert the percent LEL (based on methane) read by the unit to a percent LEL for another combustible gas can usually be found in the MGD operating manual.

### **3.3.2.3 Operation**

Follow these procedures when using an MGD in the field.

- Follow the manufacturer-specific start-up, calibration and operation procedures outlined previously.
- Position the air intake close to the area to be screened to obtain a reliable reading. For readings taken down-hole during drilling, there will be a slight delay between positioning the intake tubing and the registering of accurate meter readings.
- Typical action limits for LEL of combustible gases in unknown atmospheres are as follows:
  - 0 - 10% of the LEL - Follow normal work practices.
  - 10% of the LEL – The alarm will sound on the instrument. Leave the area immediately.
- Typical action limits for oxygen readings in unknown atmospheres are as follows:
  - 19.5 - 21% - Normal; no special precautions provided that no toxics are present.
  - 19.5% - The alarm on the instrument will sound due to oxygen-deficient atmosphere.
  - < 19.5% - Must wear a positive-pressure (pressure demand) self-contained breathing apparatus (SCBA) or a combination airline/SCBA. Combustible gas meters may not function properly at this oxygen level.
  - 21 – 23.5% - Use extreme caution; an oxygen-rich atmosphere is present.
  - 23.5% - The alarm on the instrument will sound due to an oxygen-rich atmosphere. Leave the area immediately due to fire/explosion risk.

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- Refer to the site-specific HASP for action limits.
- Evacuate the area if any of the following occurs:
  - The MGD alarm sounds.
  - Readings reach the action levels designated in the site-specific HASP or JHA.
  - The MGD malfunctions.
- Important factors to keep in mind during MGD use include:
  - Slow sweeping motions with the MGD will help ensure that problem atmospheres are not missed. Cover an area from floor (ground) to ceiling, the breathing zone and areas where maximum concentrations may be expected (such as down hole during drilling).
  - Operation of the unit in temperatures outside of the recommended operating range may compromise the reliability of readings or damage the instrument. Check the operating manual for temperature limitations for a particular model.
  - Calibrate the MGD regularly and charge the battery fully after each field use. Refer to the operating manual for details.

### **3.4 Field Screening Procedures**

Visual assessment and field instrument readings will be used to screen soil, water, sediment and investigation-derived wastes (IDW) generated during field operations. Although incidental olfactory observations may be made and documented, these observations should not be made or relied upon as primary indications of the presence or absence of contamination or to determine sample collection locations. If the potential exists for the atmosphere to contain potentially harmful or unknown gasses, properly evaluate these locations. Residual materials that may require field screening include: excess sample material, drill cuttings, decontamination fluids, disposable sampling equipment, and personal protective equipment (PPE).

#### **3.4.1 Soil and Sediment Screening Procedures**

##### **3.4.1.1 Visual Assessment**

Prior to collecting a soil or sediment sample, visually observe the sampling area for signs of current or previous releases of hazardous materials or petroleum compounds. Potential indications of a release include:

- Areas of dead, distressed, or dying vegetation
- Seepage
- Oil slicks or discolorations on the ground or building surfaces
- Discernible chemical odors
- Recent soil disturbances such as grading or filling
- Evidence of waste disposal (e.g., waste piles, drums)

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Areas where potential releases can occur include:

- Solid or liquid waste disposal or storage areas
- Equipment containing oil or hazardous materials
- Wastewater or stormwater discharges and outfalls
- Underground storage tanks
- Pits and sumps (including current and historical use)

Record visual observations of the sampling area in the field logbook. Include a sketch and dimensions of areas where visual signs of releases are observed.

### **3.4.1.2 Instrument Readings**

Record PID or MGD instrument readings prior to sampling and continue to record readings either continuously or periodically, whichever is most appropriate, during sampling activities to monitor ambient air for health and safety purposes. Document instrument readings in the field logbook.

The following procedures apply when field-screening samples collected using direct-push equipment.

- Immediately following soil core retrieval from the sample location, remove the acetate liner containing the soil core from the direct-push sampler and place the acetate liner on a sheet of plastic.
- Carefully open the liner using a sharp cutter. Remove the liner and expose the soil core.
- Using gloved hands, make small breaks or holes in the soil core to expose a fresh face of soil at the desired screening interval (typically every 6 inches) and at locations that suggest a potential impact, if present, based on visual and olfactory assessments (i.e., areas containing stains or odors).
- At each break in the core, screen the soil by placing the tip of the monitoring instrument(s) into the break or hole. A gloved hand may be used to help trap vapors while screening. Do not place the intake of the instrument directly in (i.e., touching) the media, to avoid clogging the intake.
- Record the instrument readings and the location of the breaks in the field logbook. Typically, samples are collected from the area of the core that displays the highest screening reading (i.e., the area that is most potentially impacted). Consult the project control documents for specific instructions
- Dispose of the unused portion of the soil core and the acetate liner in accordance with the Management of Investigative-Derived Waste SOP (SOP 018).

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### **3.4.2 Water Screening Procedures**

#### **3.4.2.1 Visual Assessment**

Prior to collecting a water sample, visually observe the area surrounding the monitoring well or water body for signs of current or previous releases of hazardous materials or petroleum products (refer to Section 3.4.1.1) and document notable observations in the field logbook. For groundwater samples, observe the physical appearance of the water during purging and sample collection and document notable observations in the field logbook. Physical observations may include color, odor and presence of a discernible sheen or separate phase liquid.

#### **3.4.2.2 Instrument Readings**

Prior to groundwater sampling activities, measure monitoring well headspace and breathing zone with a calibrated PID or MGD and record the measurements in the field logbook. Use the breathing zone readings to evaluate proper levels of PPE and the well headspace readings to assess the relative VOC impact to groundwater and working conditions at each monitoring well.

### **3.4.3 Air Screening Procedures**

#### **3.4.3.1 Visual Assessment**

Prior to collecting an air sample, visually observe the sampling area for sources of air contamination (such as vents or exhaust pipes from buildings or machinery) and for signs of current or previous releases of hazardous materials or petroleum products (refer to Section 3.4.1.1). Document notable observations in the field logbook. Observations may include odor and presence of a discernible air contaminant (smoke or exhaust).

#### **3.4.3.2 Instrument Readings**

Monitor ambient air for health and safety purposes using a PID or MGD prior to and during sampling activities. Record the instrument readings in the field logbook.

Use the following procedure for field screening of air.

- Position the instrument such that the air intake is within the area to be screened and perform slow sweeping motions with the instrument to cover an area from floor (ground) to ceiling, the breathing zone, and other areas where maximum concentrations may be expected (such as at the top of the borehole during drilling).
- Record the instrument readings in the field logbook.

### **3.4.4 Investigation-Derived Waste**

IDW includes excess samples, cuttings, decontamination fluids, disposable sampling equipment and disposable PPE (e.g., Tyvek® suits, gloves, respirator cartridges, etc.). Containerize IDW in accordance with project requirements and project control documents. Containerized IDW can be field screened for VOCs to evaluate the relative level of impact. Use care when opening drums for field screening. Use appropriate engineering controls when screening and sampling drums that have the potential to contain pressurized liquid or other hazards. Refer to the site-specific HASP for additional information.

## **FIELD SCREENING INSTRUMENTATION and PROCEDURES (Standard Operating Procedure 002)**

### **3.5 Packing, Shipping, and Labeling Field-Screening Equipment**

Certain equipment items and supplies commonly used in the field (e.g., dangerous goods) require special shipping considerations.

Below is a general list of articles that, for shipping purposes, are considered “dangerous goods.” Each article is required to have the appropriate shipping label and shipping declaration form.

- MGD calibration gas
- PID calibration gas
- Lithium batteries
- pH solution(s)\*

\*Pertains to pH solutions with pH 2 or lower; typical calibration solutions of pH 4, 7, and 10 do not require hazardous shipping procedures.

When shipping dangerous goods, the shipper is responsible for completing the declaration form and proper labeling of the item to be shipped. The necessary provisions to enable a consignment of dangerous goods to be correctly prepared for ground and air transportation are based on US Code 49 CFR Parts 106-180 and International Air Transport Association (IATA) Dangerous Goods Regulations and are provided in the Sample Labeling, Packing and Shipping SOP (SOP 016).

### **3.6 Storage and Maintenance of Equipment**

Store calibration solutions, standards, and gases out of direct sunlight and in a dry location. Do not expose these materials to extreme temperatures or large temperature fluctuations. Follow the requirements of the product’s safety data sheet (SDS) and the manufacturer’s recommendations. Maintain an SDS for each calibration standard solution that is readily available and stored near the standard solutions. Do not use expired calibration solutions, standards and gases. Do not reuse calibration solutions and standards properly dispose of these materials in accordance with regulatory requirements. Return empty compressed gas cylinders to the supplier for proper disposal.

Return field screening instruments to the manufacturer for repairs or routine, scheduled maintenance at the frequency specified in the instrument’s instruction manual or as otherwise directed.

It is imperative that the field screening instruments are stored in an area where freezing will not occur. Turn the field screening instruments off and store them in a secure location when not in use. Consult the manufacturer’s instruction manual special considerations for the storage of probes or other sensitive components. For long-term storage, remove the batteries from the instruments.

### **3.7 Field Logbook Documentation**

Maintain field logbooks to record daily activities, including sample collection and tracking information. Enter information into the field logbook using waterproof ink.

In addition to the minimum requirements discussed in the Field Documentation Procedures SOP (SOP 001), document the following information in the field logbook:

- Field screening instrument calibration information consistent with Sections 3.3.1.2 and 3.3.2.2 of this SOP.

## **FIELD SCREENING INSTRUMENTATION and PROCEDURES (Standard Operating Procedure 002)**

- Number and type of samples collected for field screening
- Field screening results of each sample

### **3.8 Decontamination and Cleanup**

The field screening equipment should not require a significant amount of decontamination because the equipment should have minimal contact with the investigated media. Wipe the instrument clean using a damp towel and then dry after each use. Do not spray with or immerse the instruments in fluids. If further decontamination of field screening instrumentation is necessary, consult the instrument manual or manufacturer for further instructions.

### **4.0 REFERENCES**

- Montrose Environmental Solutions, Inc., Field Documentation Procedures SOP (SOP 001)
- Montrose Environmental Solutions, Inc., Sample Packing, Shipping, and Labeling SOP (SOP 016)
- Montrose Environmental Solutions, Inc., Management of Investigation-Derived Wastes SOP (SOP 018)



**FIELD SCREENING INSTRUMENTATION and PROCEDURES**  
**(Standard Operating Procedure 002)**

<b>TABLE 1: FIELD SCREENING EQUIPMENT &amp; MATERIAL CHECKLIST</b>	
<b>Item Description</b>	<b>CHECK    ✓</b>
<b>Health &amp; Safety</b>	
Nitrile gloves	
Hard hat	
Steel-toed boots	
Hearing protection	
Field first-aid kit	
Eyewash	
Safety glasses	
Disposable towels	
<b>PID Equipment</b>	
Photoionization detector	
Operation manual	
Battery charger	
Spare batteries	
Tool kit	
Calibration gas (typically, 100-ppm isobutylene)	
Additional items recommended by instrument manufacturer	

**FIELD SCREENING INSTRUMENTATION and PROCEDURES**  
**(Standard Operating Procedure 002)**

<b>TABLE 1: FIELD SCREENING EQUIPMENT &amp; MATERIAL CHECKLIST</b>	
<b>Item Description</b>	<b>CHECK    ✓</b>
<b>MGD Equipment</b>	
Multi-gas detector	
Operation manual	
Battery charger	
Spare batteries	
Additional items recommended by instrument manufacturer	

**FIELD SCREENING INSTRUMENTATION and PROCEDURES**  
**(Standard Operating Procedure 002)**

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Appendix A

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# A GUIDELINE FOR PID INSTRUMENT RESPONSE



## CORRECTION FACTORS AND IONIZATION ENERGIES\*

RAE Systems PIDs can be used for the detection of a wide variety of gases that exhibit different responses. In general, any compound with ionization energy (IE) lower than that of the lamp photons can be measured.\* The best way to calibrate a PID to different compounds is to use a standard of the gas of interest. However, correction factors have been determined that enable the user to quantify a large number of chemicals using only a single calibration gas, typically isobutylene. In our PIDs, correction factors can be used in one of three ways:

1. Calibrate the monitor with isobutylene in the usual fashion to read in isobutylene equivalents. Manually multiply the reading by the correction factor (CF) to obtain the concentration of the gas being measured.
2. Calibrate the unit with isobutylene in the usual fashion to read in isobutylene equivalents. Call up the correction factor from the instrument memory or download it from a personal computer and then call it up. The monitor will then read directly in units of the gas of interest.
3. Calibrate the unit with isobutylene, but input an equivalent, "corrected" span gas concentration when prompted for this value. The unit will then read directly in units of the gas of interest.

\* The term "ionization energy" is more scientifically correct and replaces the old term "ionization potential." High-boiling ("heavy") compounds may not vaporize enough to give a response even when their ionization energies are below the lamp photon energy. Some inorganic compounds like  $H_2O_2$  and  $NO_2$  give weak response even when their ionization energies are well below the lamp photon energy.

### Example 1:

With the unit calibrated to read isobutylene equivalents, the reading is 10 ppm with a 10.6 eV lamp. The gas being measured is butyl acetate, which has a correction factor of 2.6. Multiplying 10 by 2.6 gives an adjusted butyl acetate value of 26 ppm. Similarly, if the gas being measured were trichloroethylene (CF = 0.54), the adjusted value with a 10 ppm reading would be 5.4 ppm.

### Example 2:

With the unit calibrated to read isobutylene equivalents, the reading is 100 ppm with a 10.6 eV lamp. The gas measured is m-xylene (CF = 0.43). After downloading this factor, the unit should read about 43 ppm when exposed to the same gas, and thus read directly in m-xylene values.

### Example 3:

The desired gas to measure is ethylene dichloride (EDC). The CF is 0.6 with an 11.7 eV lamp. During calibration with 100 ppm isobutylene, insert 0.6 times 100, or 60 at the prompt for the calibration gas concentration. The unit then reads directly in EDC values.

### Conversion to $mg/m^3$

To convert from ppm to  $mg/m^3$ , use the following formula:

$$\text{Conc. (mg/m}^3\text{)} = \frac{[\text{Conc. (ppmv)} \times \text{mol. wt. (g/mole)}]}{\text{molar gas volume (L)}}$$

For air at 25°C (77°F), the molar gas volume is 24.4 L/mole and the formula reduces to:

$$\text{Conc. (mg/m}^3\text{)} = \text{Conc. (ppmv)} \times \text{mol. wt. (g/mole)} \times 0.041$$

For example, if the instrument is calibrated with a gas standard in ppmv, such as 100 ppm isobutylene, and the user wants the display to read in mg/m<sup>3</sup> of hexane, whose m.w. is 86 and CF is 4.3, the overall correction factor would be  $4.3 \times 86 \times 0.041$  equals 15.2.

### Correction Factors for Mixtures

The correction factor for a mixture is calculated from the sum of the mole fractions  $X_i$  of each component divided by their respective correction factors  $CF_i$ :

$$CF_{\text{mix}} = 1 / (X_1/CF_1 + X_2/CF_2 + X_3/CF_3 + \dots X_i/CF_i)$$

Thus, for example, a vapor phase mixture of 5% benzene and 95% n-hexane would have a  $CF_{\text{mix}}$  of  $CF_{\text{mix}} = 1 / (0.05/0.53 + 0.95/4.3) = 3.2$ . A reading of 100 would then correspond to 320 ppm of the total mixture, comprised of 16 ppm benzene and 304 ppm hexane.

For a spreadsheet to compute the correction factor and TLV of a mixture see the appendix at the end of the CF table.

### TLVs and Alarm Limits for Mixtures

The correction factor for mixtures can be used to set alarm limits for mixtures. To do this one first needs to calculate the exposure limit for the mixture. The Threshold Limit Value (TLV) often defines exposure limits. The TLV for the mixture is calculated in a manner similar to the CF calculation:

$$TLV_{\text{mix}} = 1 / (X_1/TLV_1 + X_2/TLV_2 + X_3/TLV_3 + \dots X_i/TLV_i)$$

In the above example, the 8-h TLV for benzene is 0.5 ppm and for n-hexane 50 ppm. Therefore the TLV of the mixture is  $TLV_{\text{mix}} = 1 / (0.05/0.5 + 0.95/50) = 8.4$  ppm, corresponding to 8.0 ppm hexane and 0.4 ppm benzene. For an instrument calibrated on isobutylene, the reading corresponding to the TLV is:

$$\text{Alarm Reading} = TLV_{\text{mix}} / CF_{\text{mix}} = 8.4 / 3.2 = 2.6 \text{ ppm}$$

A common practice is to set the lower alarm limit to half the TLV, and the higher limit to the TLV. Thus, one would set the alarms to 1.3 and 2.6 ppm, respectively.

## CALIBRATION CHARACTERISTICS

**A. Flow Configuration.** PID response is essentially independent of gas flow rate as long as it is sufficient to satisfy the pump demand. Four main flow configurations are used for calibrating a PID:

### 1. Pressurized gas cylinder (Fixed-flow regulator):

The flow rate of the regulator should match the flow demand of the instrument pump or be slightly higher.

### 2. Pressurized gas cylinder (Demand-flow regulator):

A demand-flow regulator better matches pump speed differences, but results in a slight vacuum during calibration and thus slightly high readings.

**3. Collapsible gas bag:** The instrument will draw the calibration gas from the bag at its normal flow rate, as long as the bag valve is large enough. The bag should be filled with enough gas to allow at least one minute of flow (~ 0.6 L for a MiniRAE, ~0.3 L for MultiRAE).

**4. T (or open tube) method:** The T method uses a T-junction with gas flow higher than the pump draw. The gas supply is connected to one end of the T, the instrument inlet is connected to a second end of the T, and excess gas flow escapes through the third, open end of the T. To prevent ambient air mixing, a long tube should be connected to the open end, or a high excess rate should be used. Alternatively, the instrument probe can be inserted into an open tube slightly wider than the probe. Excess gas flows out around the probe.

The first two cylinder methods are the most efficient in terms of gas usage, while the bag and T methods give slightly more accurate results because they match the pump flow better.

**B. Pressure.** Pressures deviating from atmospheric pressure affect the readings by altering gas concentration and pump characteristics. It is best to calibrate with the instrument and calibration gas at the same pressure as each other and the sample gas. (Note that the cylinder pressure is not relevant because the regulator reduces the pressure to ambient.) If the instrument is calibrated at atmospheric pressure in one of the flow configurations described above, then 1) pressures slightly above ambient are acceptable but high pressures can damage the pump and 2) samples under vacuum may give low readings if air leaks into the sample train.

**C. Temperature.** Because temperature affects gas density and concentration, the temperature of the calibration gas and instrument should be as close as possible to the ambient temperature where the unit will be used. We recommend that the temperature of the calibration gas be within the instrument's temperature specification (typically 14° to 113° F or -10° to 45° C). Also, during actual measurements, the instrument should be kept at the same or higher temperature than the sample temperature to avoid condensation in the unit.

**D. Matrix.** The matrix gas of the calibration compound and VOC sample is significant. Some common matrix components, such as methane and water vapor can affect the VOC signal.

PIDs are most commonly used for monitoring VOCs in air, in which case the preferred calibration gas matrix is air. For a MiniRAE, methane, methanol, and water vapor reduce the response by about 20% when their concentration is 15,000 ppm and by about 40% at 30,000 ppm. Despite earlier reports of oxygen effects, RAE PID responses with 10.6 eV lamps are independent of oxygen concentration, and calibration gases in a pure nitrogen matrix can be used. H<sub>2</sub> and CO<sub>2</sub> up to 5 volume % also have no effect.

**E. Concentration.** Although RAE Systems PIDs have electronically linearized output, it is best to calibrate in a concentration range close to the actual measurement range. For example, 100 ppm standard gas for anticipated vapors of 0 to 250 ppm, and 500 ppm standard for expected concentrations of 250 to 1000 ppm. The correction factors in this table were typically measured at 50 to 100 ppm and apply from the ppb range up to about 1000 ppm. Above 1000 ppm the CF may vary and it is best to calibrate with the gas of interest near the concentration of interest.

**F. Filters.** Filters affect flow and pressure conditions and therefore all filters to be used during sampling should also be in place during calibration. Using a water trap (hydrophobic filter) greatly reduces the chances of drawing water aerosols or dirt particles into the instrument. Regular filter replacements are recommended because dirty filters can adsorb VOCs and cause slower response time and shifts in calibration.

**G. Instrument Design.** High-boiling (“heavy”) or very reactive compounds can be lost by reaction or adsorption onto materials in the gas sample train, such as filters, pumps and other sensors. Multi-gas meters, including EntryRAE, MultiRAE and AreaRAE have the pump and other sensors upstream of the PID and are prone to these losses. Compounds possibly affected by such losses are shown in green in the table, and may give slow response, or in extreme cases, no response at all. In many cases the multi-gas meters can still give a rough indication of the relative concentration, without giving an accurate, quantitative reading. The ppbRAE and MiniRAE series instruments have inert sample trains and therefore do not exhibit significant loss; nevertheless, response may be slow for the very heavy compounds and additional sampling time up to a minute or more should be allowed to get a stable reading.

## TABLE ABBREVIATIONS

**CF** = Correction Factor (multiply by reading to get corrected value for the compound when calibrated to isobutylene)

**NR** = No Response

**IE** = Ionization Energy (values in parentheses are not well established)

**C** = Confirmed Value indicated by “+” in this column; all others are preliminary or estimated values and are subject to change

**ne** = Not Established ACGIH 8-hr. TWA

**C##** = Ceiling value, given where 8-hr.TWA is not available

## DISCLAIMER

TN-106 is a general guideline for Correction Factors (CF) for use with PID instruments manufactured by RAE Systems. The CF may vary depending on instrument and operation conditions. For the best accuracy, RAE Systems recommends calibrating the instrument to target gas. Actual readings may vary with age and cleanliness of lamp, relative humidity, and other factors as well. For accurate work, the instrument should be calibrated regularly under the operating conditions used. The factors in this table on the following pages were measured in dry air (40 to 50% RH) at room temperature, typically at 50 to 100 ppm. CF values may vary above about 1000 ppm.

## Updates

The values in this table on the following pages are subject to change as more or better data become available. Watch for updates of this table on the Internet at <http://www.raesystems.com>.

IE data are taken from the CRC Handbook of Chemistry and Physics, 73rd Edition, D.R. Lide (Ed.), CRC Press (1993) and NIST Standard Ref. Database 19A, NIST Positive Ion Energetics, Vers. 2.0, Lias, et.al., U.S. Dept. Commerce (1993). Exposure limits (8-h TWA and Ceiling Values) are from the 2005 ACGIH Guide to Occupational Exposure Values, ACGIH, Cincinnati, OH 2005. Equations for exposure limits for mixtures of chemicals were taken from the 1997 TLVs and BEIs handbook published by the ACGIH (1997).

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Acetaldehyde		75-07-0	C <sub>2</sub> H <sub>4</sub> O	NR	+	6	+	3.3	+	10.23	C25
Acetic acid	Ethanoic Acid	64-19-7	C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>	NR	+	22	+	2.6	+	10.66	10
Acetic anhydride	Ethanoic Acid Anhydride	108-24-7	C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>	NR	+	6.1	+	2.0	+	10.14	5
Acetone	2-Propanone	67-64-1	C <sub>3</sub> H <sub>6</sub> O	1.2	+	0.9	+	1.4	+	9.71	500
Acetone cyanohydrin	2-Hydroxyisobutyronitrile	75-86-5	C <sub>4</sub> H <sub>7</sub> NO					4	+	11.1	C5
Acetonitrile	Methyl cyanide, Cyanomethane	75-05-8	C <sub>2</sub> H <sub>3</sub> N					100		12.19	40
Acetylene	Ethyne	74-86-2	C <sub>2</sub> H <sub>2</sub>					2.1	+	11.40	ne
Acrolein	Propenal	107-02-8	C <sub>3</sub> H <sub>4</sub> O	42	+	3.9	+	1.4	+	10.10	0.1
Acrylic acid	Propenoic Acid	79-10-7	C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>			12	+	2.0	+	10.60	2
Acrylonitrile	Propenenitrile	107-13-1	C <sub>3</sub> H <sub>3</sub> N			NR	+	1.2	+	10.91	2
Allyl alcohol		107-18-6	C <sub>3</sub> H <sub>6</sub> O	4.5	+	2.4	+	1.6	+	9.67	2
Allyl chloride	3-Chloropropene	107-05-1	C <sub>3</sub> H <sub>5</sub> Cl			4.3		0.7		9.9	1
Ammonia		7664-41-7	NH <sub>3</sub>	NR	+	10.9	+	5.7	+	10.16	25
Amyl acetate	mix of n-Pentyl acetate & 2-Methylbutyl acetate	628-63-7	C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>	11	+	2.3	+	0.95	+	<9.9	100
Amyl alcohol	1-Pentanol	75-85-4	C <sub>5</sub> H <sub>12</sub> O			5				10.00	ne
Aniline	Aminobenzene	62-53-3	C <sub>6</sub> H <sub>7</sub> N	0.50	+	0.48	+	0.47	+	7.72	2
Anisole	Methoxybenzene	100-66-3	C <sub>7</sub> H <sub>8</sub> O	0.89	+	0.58	+	0.56	+	8.21	ne
Arsine	Arsenic trihydride	7784-42-1	AsH <sub>3</sub>			1.9	+			9.89	0.05
Benzaldehyde		100-52-7	C <sub>7</sub> H <sub>6</sub> O					1		9.49	ne
Benzene		71-43-2	C <sub>6</sub> H <sub>6</sub>	0.55	+	0.47	+	0.6	+	9.25	0.5
Benzonitrile	Cyanobenzene	100-47-0	C <sub>7</sub> H <sub>5</sub> N			1.6				9.62	ne
Benzyl alcohol	α-Hydroxytoluene, Hydroxymethylbenzene, Benzenemethanol	100-51-6	C <sub>7</sub> H <sub>8</sub> O	1.4	+	1.1	+	0.9	+	8.26	ne
Benzyl chloride	α-Chlorotoluene, Chloromethylbenzene	100-44-7	C <sub>7</sub> H <sub>7</sub> Cl	0.7	+	0.6	+	0.5	+	9.14	1
Benzyl formate	Formic acid benzyl ester	104-57-4	C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>	0.9	+	0.73	+	0.66	+		ne
Boron trifluoride		7637-07-2	BF <sub>3</sub>	NR		NR		NR		15.5	C1
Bromine		7726-95-6	Br <sub>2</sub>	NR	+	1.30	+	0.74	+	10.51	0.1
Bromobenzene		108-86-1	C <sub>6</sub> H <sub>5</sub> Br			0.6		0.5		8.98	ne
2-Bromoethyl methyl ether		6482-24-2	C <sub>3</sub> H <sub>7</sub> OBr			0.84	+			~10	ne
Bromoform	Tribromomethane	75-25-2	CHBr <sub>3</sub>	NR	+	2.7	+	0.5	+	10.48	0.5
Bromopropane, 1-	n-Propyl bromide	106-94-5	C <sub>3</sub> H <sub>7</sub> Br	150	+	1.5	+	0.6	+	10.18	ne
Butadiene	1,3-Butadiene, Vinyl ethylene	106-99-0	C <sub>4</sub> H <sub>6</sub>	0.8		0.6	+	1.1		9.07	2
Butadiene diepoxide, 1,3-	1,2,3,4-Diepoxybutane	298-18-0	C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>	25	+	3.5	+	1.2		~10	ne
Butane		106-97-8	C <sub>4</sub> H <sub>10</sub>			67	+	1.2		10.53	800
Butanol, 1-	Butyl alcohol, n-Butanol	71-36-3	C <sub>4</sub> H <sub>10</sub> O	70	+	4.7	+	1.4	+	9.99	20
Butanol, t-	tert-Butanol, t-Butyl alcohol	75-65-0	C <sub>4</sub> H <sub>10</sub> O	6.9	+	2.9	+			9.90	100
Butene, 1-	1-Butylene	106-98-9	C <sub>4</sub> H <sub>8</sub>			0.9				9.58	ne
Butoxyethanol, 2-	Butyl Cellosolve, Ethylene glycol monobutyl ether	111-76-2	C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>	1.8	+	1.2	+	0.6	+	<10	25
Butoxyethyl Acetate, 2-	2-Butoxyethyl acetate; 2-Butoxy-ethanol acetate; Butyl Cellosolve acetate; Butyl glycol acetate; EGBEA; Ektasolve EB acetate	112-07-2	C <sub>8</sub> H <sub>16</sub> O <sub>3</sub>			1.27	+				20
Butyl acetate, n-		123-86-4	C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>			2.6	+			10	150
Butyl acrylate, n-	Butyl 2-propenoate, Acrylic acid butyl ester	141-32-2	C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>			1.6	+	0.6	+		10
Butylamine, n-		109-73-9	C <sub>4</sub> H <sub>11</sub> N	1.1	+	1.1	+	0.7	+	8.71	C5
Butyl cellosolve	see 2-Butoxyethanol	111-76-2									
Butyl hydroperoxide, t-		75-91-2	C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>	2.0	+	1.6	+			<10	1



Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Butyl mercaptan	1-Butanethiol	109-79-5	C <sub>4</sub> H <sub>10</sub> S	0.55	+	0.52	+			9.14	0.5
Butyraldehyde	Butanal	123-72-8	C <sub>4</sub> H <sub>8</sub> O			1.87	+			9.82	20
Camelinal HRJ						1.1	+	0.32	+		
Camelinal HRJ/JP-8 50/50						0.89	+	0.41	+		
CamelinalHRJ						1.15	+				
CamelinalHRJ/JP-8						1.07	+				
Carbon disulfide		75-15-0	CS <sub>2</sub>	4	+	1.2	+	0.44		10.07	10
Carbon tetrachloride	Tetrachloromethane	56-23-5	CCl <sub>4</sub>	NR	+	NR	+	1.7	+	11.47	5
Carbonyl sulfide	Carbon oxysulfide	463-58-1	COS							11.18	
Cellosolve	see 2-Ethoxyethanol										
CFC-14	see Tetrafluoromethane										
CFC-113	see 1,1,2-Trichloro-1,2,2-trifluoroethane										
Chlorine		7782-50-5	Cl <sub>2</sub>					1.0	+	11.48	0.5
Chlorine dioxide		10049-04-4	ClO <sub>2</sub>	NR	+	NR	+	NR	+	10.57	0.1
Chlorobenzene	Monochlorobenzene	108-90-7	C <sub>6</sub> H <sub>5</sub> Cl	0.44	+	0.55	+	0.39	+	9.06	10
Chlorobenzotrifluoride, 4-	PCBTf, OXSOL 100 p-Chlorobenzotrifluoride	98-56-6	C <sub>7</sub> H <sub>4</sub> ClF <sub>3</sub>	0.74	+	0.63	+	0.55	+	<9.6	
Chloro-1,3-butadiene, 2-	Chloroprene	126-99-8	C <sub>4</sub> H <sub>5</sub> Cl			3					10
Chloro-1,1-difluoroethane, 1-	HCFC-142B, R-142B	75-68-3	C <sub>2</sub> H <sub>3</sub> ClF <sub>2</sub>	NR		NR		NR		12.0	ne
Chlorodifluoromethane	HCFC-22, R-22	75-45-6	CHClF <sub>2</sub>	NR		NR		NR		12.2	1000
Chloroethane	Ethyl chloride	75-00-3	C <sub>2</sub> H <sub>5</sub> Cl	NR	+	NR	+	1.1	+	10.97	100
Chloroethanol	Ethylene chlorhydrin	107-07-3	C <sub>2</sub> H <sub>5</sub> ClO							10.52	C1
Chloroethanol, 2-	2-Chloroethanol; 2-Chloroethyl alcohol; Ethylene chlorhydrin	107-07-3	C <sub>2</sub> H <sub>5</sub> ClO			2.88	+			10.5	5
Chloroethyl ether, 2-	bis (2-chloroethyl) ether	111-44-4	C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub> O	8.6	+	3.0	+				5
Chloroethyl methyl ether, 2-	Methyl 2-chloroethyl ether	627-42-9	C <sub>3</sub> H <sub>7</sub> ClO			3					ne
Chloroform	Trichloromethane	67-66-3	CHCl <sub>3</sub>	NR	+	NR	+	3.5	+	11.37	10
Chloro-2-methylpropene, 3-	Methallyl chloride, Isobutenyl chloride	563-47-3	C <sub>4</sub> H <sub>7</sub> Cl	1.4	+	1.2	+	0.63	+	9.76	ne
Chloropicrin		76-06-2	CCl <sub>3</sub> NO <sub>2</sub>	NR	+	~400	+	7	+		0.1
Chlorotoluene, o-	o-Chloromethylbenzene	95-49-8	C <sub>7</sub> H <sub>7</sub> Cl			0.5		0.6		8.83	50
Chlorotoluene, p-	p-Chloromethylbenzene	106-43-4	C <sub>7</sub> H <sub>7</sub> Cl					0.6		8.69	ne
Chlorotrifluoroethene	CTFE, Chlorotrifluoroethylene Genetron 1113	79-38-9	C <sub>2</sub> ClF <sub>3</sub>	6.7	+	3.9	+	1.2	+	9.76	5
Chlorotrimethylsilane		75-77-4	C <sub>3</sub> H <sub>9</sub> ClSi	NR		NR		0.82	+	10.83	ne
Cresol, m-	m-Hydroxytoluene, 3-Methylphenol	108-39-4	C <sub>7</sub> H <sub>8</sub> O	0.57	+	0.50	+	0.57	+	8.29	5
Cresol, o-	ortho-Cresol; 2-Cresol; o-Cresylic acid; 1-Hydroxy-2-methylbenzene; 2-Hydroxytoluene; 2-Methyl phenol	95-48-7	C <sub>7</sub> H <sub>8</sub> O			1	+			8.14	5
Cresol, p-	para-Cresol; 4-Cresol; p-Cresylic acid; 1-Hydroxy-4-methylbenzene; 4-Hydroxytoluene; 4-Methyl phenol	106-44-5	C <sub>7</sub> H <sub>8</sub> O			1.4	+			8.34	5
Crotonaldehyde	trans-2-Butenal	123-73-9 4170-30-3	C <sub>4</sub> H <sub>6</sub> O	1.5	+	1.1	+	1.0	+	9.73	2
Cumene	Isopropylbenzene	98-82-8	C <sub>9</sub> H <sub>12</sub>	0.58	+	0.54	+	0.4	+	8.73	50
Cyanogen bromide		506-68-3	CNBr	NR		NR		NR		11.84	ne
Cyanogen chloride		506-77-4	CNCl	NR		NR		NR		12.34	C0.3
Cyclohexane		110-82-7	C <sub>6</sub> H <sub>12</sub>	3.3	+	1.4	+	0.64	+	9.86	300
Cyclohexanol	Cyclohexyl alcohol	108-93-0	C <sub>6</sub> H <sub>12</sub> O	1.5	+	0.9	+	1.1	+	9.75	50
Cyclohexanone		108-94-1	C <sub>6</sub> H <sub>10</sub> O	1.0	+	0.9	+	0.7	+	9.14	25



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Cyclohexene		110-83-8	C <sub>6</sub> H <sub>10</sub>			0.8	+			8.95	300
Cyclohexylamine		108-91-8	C <sub>6</sub> H <sub>13</sub> N			1.2				8.62	10
Cyclopentane 85% 2,2-dimethylbutane 15%		287-92-3	C <sub>5</sub> H <sub>10</sub>	NR	+	15	+	1.1		10.33	600
Cyclopropylamine	Aminocyclopropane	765-30-0	C <sub>3</sub> H <sub>7</sub> N	1.1	+	0.9	+	0.9	+		ne
Decamethylcyclopentasiloxane		541-02-6	C <sub>10</sub> H <sub>30</sub> O <sub>5</sub> Si <sub>5</sub>	0.16	+	0.13	+	0.12	+		ne
Decamethyltetrasiloxane		141-62-8	C <sub>10</sub> H <sub>30</sub> O <sub>3</sub> Si <sub>4</sub>	0.17	+	0.13	+	0.12	+	<10.2	ne
Decane		124-18-5	C <sub>10</sub> H <sub>22</sub>	4.0	+	1.4	+	0.35	+	9.65	ne
Diacetone alcohol	4-Methyl-4-hydroxy-2-pentanone	123-42-2	C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>			0.7					50
Dibromochloromethane	Chlorodibromomethane	124-48-1	CHBr <sub>2</sub> Cl	NR	+	5.2	+	0.7	+	10.59	ne
Dibromo-3-chloropropane, 1,2-	DBCP	96-12-8	C <sub>3</sub> H <sub>5</sub> Br <sub>2</sub> Cl	NR	+	1.7	+	0.43	+		0.001
Dibromoethane, 1,2-	EDB, Ethylene dibromide, Ethylene bromide	106-93-4	C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>	NR	+	1.7	+	0.6	+	10.37	ne
Dichlorobenzene, o-	1,2-Dichlorobenzene	95-50-1	C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>	0.54	+	0.64	+	0.38	+	9.08	25
Dichlorodifluoromethane	CFC-12	75-71-8	CCl <sub>2</sub> F <sub>2</sub>			NR	+	NR	+	11.75	1000
Dichlorodimethylsilane		75-78-5	C <sub>2</sub> H <sub>6</sub> Cl <sub>2</sub> Si	NR		NR		1.1	+	>10.7	ne
Dichloroethane, 1,2-	EDC, 1,2-DCA, Ethylene dichloride	107-06-2	C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>			NR	+	0.6	+	11.04	10
Dichloroethene, 1,1-	1,1-DCE, Vinylidene chloride	75-35-4	C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>			0.82	+	0.8	+	9.79	5
Dichloroethene, c-1,2-	c-1,2-DCE, <i>cis</i> -Dichloroethylene	156-59-2	C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>			0.8				9.66	200
Dichloroethene, t-1,2-	t-1,2-DCE, <i>trans</i> -Dichloroethylene	156-60-5	C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>			0.45	+	0.34	+	9.65	200
Dichloro-1-fluoroethane, 1,1-	R-141B	1717-00-6	C <sub>2</sub> H <sub>3</sub> Cl <sub>2</sub> F	NR	+	NR	+	2.0	+		ne
Dichloromethane	see Methylene chloride										
Dichloropentafluoropropane	AK-225, mix of ~45% 3,3-dichloro-1,1,1,2,2-pentafluoropropane (HCFC-225ca) & ~55% 1,3-Dichloro-1,1,2,2,3-pentafluoropropane (HCFC-225cb)	442-56-0 507-55-1	C <sub>3</sub> HCl <sub>2</sub> F <sub>5</sub>	NR	+	NR	+	25	+		ne
Dichloropropane, 1,2-		78-87-5	C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>					0.7		10.87	75
Dichloro-1-propene, 1,3-		542-75-6	C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>	1.3	+	0.96	+			<10	1
Dichloro-1-propene, 2,3-		78-88-6	C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>	1.9	+	1.3	+	0.7	+	<10	ne
Dichloro-1,1,1-trifluoroethane, 2,2-	R-123	306-83-2	C <sub>2</sub> HCl <sub>2</sub> F <sub>3</sub>	NR	+	NR	+	10.1	+	11.5	ne
Dichloro-2,4,6-trifluoropyridine, 3,5-	DCTFP	1737-93-5	C <sub>5</sub> Cl <sub>2</sub> F <sub>3</sub> N	1.1	+	0.9	+	0.8	+		ne
Dichlorvos**	Vapona; O,O-dimethyl O-dichlorovinyl phosphate	62-73-7	C <sub>4</sub> H <sub>7</sub> Cl <sub>2</sub> O <sub>4</sub> P			0.9	+			<9.4	0.1
Dicyclopentadiene	DCPD, Cyclopentadiene dimer	77-73-6	C <sub>10</sub> H <sub>12</sub>	0.57	+	0.48	+	0.43	+	8.8	5
Diesel Fuel**		68334-30-5	m.w. 226			0.9	+				11
Diesel Fuel #2 (Automotive)**		68334-30-5	m.w. 216	1.3		0.7	+	0.4	+		11
Diethylamine		109-89-7	C <sub>4</sub> H <sub>11</sub> N			1	+			8.01	5
Diethylaminopropylamine, 3-		104-78-9	C <sub>7</sub> H <sub>18</sub> N <sub>2</sub>			1.3					ne
Diethylbenzene	see Dowtherm J										
Diethyl ether	Diethyl ether; Diethyl oxide; Ethyl oxide; Ether; Solvent ether	60-29-7	C <sub>4</sub> H <sub>10</sub> O			1.74	+			9.51	400
Diethylene glycol butyl ether	2-(2-Butoxyethoxy)ethanol, BDG, Butyldiglycol, DB Solvent	112-34-5	C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>			4.6	+				5
Diethylene glycol monobutyl ether acetate	Butyldiglycol acetate, DB Acetate, Diethylene glycol monobutyl ether acetate	124-17-4	C <sub>10</sub> H <sub>20</sub> O <sub>4</sub>			5.62	+				ne
Diethylmaleate		141-05-9	C <sub>8</sub> H <sub>12</sub> O <sub>4</sub>			4					ne
Diethyl sulfide	see Ethyl sulfide										
Diglyme	see Methoxyethyl ether	111-96-6	C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>								

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Diisobutyl ketone	DIBK, 2,2-dimethyl-4-heptanone	108-83-8	C <sub>9</sub> H <sub>18</sub> O	0.71	+	0.61	+	0.35	+	9.04	25
Diisopropylamine		108-18-9	C <sub>6</sub> H <sub>15</sub> N	0.84	+	0.74	+	0.5	+	7.73	5
Diisopropylcarbodiimide, N,N'-	DIPC	693-13-0	C <sub>7</sub> H <sub>14</sub> N <sub>2</sub>			0.42	+				ne
Diisopropylethylamine	'Hünig's base', N-Ethyl-diisopropylamine, DIPEA, Ethyl-diisopropylamine	7087-68-5	C <sub>8</sub> H <sub>19</sub> N			0.7	+				ne
Diketene	Ketene dimer	674-82-8	C <sub>4</sub> H <sub>4</sub> O <sub>2</sub>	2.6	+	2.0	+	1.4	+	9.6	0.5
Dimethylacetamide, N,N-	DMA	127-19-5	C <sub>4</sub> H <sub>9</sub> NO	0.87	+	0.8	+	0.8	+	8.81	10
Dimethylamine		124-40-3	C <sub>2</sub> H <sub>7</sub> N			1.5				8.23	5
Dimethyl carbonate	Carbonic acid dimethyl ester	616-38-6	C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>	NR	+	~70	+	1.7	+	~10.5	ne
Dimethyl disulfide	DMDS	624-92-0	C <sub>2</sub> H <sub>6</sub> S <sub>2</sub>	0.2	+	0.20	+	0.21	+	7.4	ne
Dimethyl ether	see Methyl ether										
Dimethylethylamine	DMEA	598-56-1	C <sub>4</sub> H <sub>11</sub> N	1.1	+	1.0	+	0.9	+	7.74	~3
Dimethylformamide, N,N-	DMF	68-12-2	C <sub>3</sub> H <sub>7</sub> NO	0.7	+	0.7	+	0.8	+	9.13	10
Dimethylhydrazine, 1,1-	UDMH	57-14-7	C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>			0.8	+	0.8	+	7.28	0.01
Dimethyl methylphosphonate	DMMP, methyl phosphonic acid dimethyl ester	756-79-6	C <sub>3</sub> H <sub>9</sub> O <sub>3</sub> P	NR	+	4.3	+	0.74	+	10.0	ne
Dimethyl sulfate		77-78-1	C <sub>2</sub> H <sub>6</sub> O <sub>4</sub> S	~23		~20	+	2.3	+		0.1
Dimethyl sulfide	see Methyl sulfide										
Dimethyl sulfoxide	DMSO, Methyl sulfoxide	67-68-5	C <sub>2</sub> H <sub>6</sub> OS			1.4	+			9.10	ne
Dioxane, 1,4-		123-91-1	C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>			1.3				9.19	25
Dioxolane, 1,3-	Ethylene glycol formal	646-06-0	C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>	4.0	+	2.3	+	1.6	+	9.9	20
Dowtherm A	see Therminol®**										
Dowtherm J (97% Diethylbenzene)**		25340-17-4	C <sub>10</sub> H <sub>14</sub>			0.5					
DS-108F Wipe Solvent	Ethyl lactate/Isopar H/ Propoxypropanol ~7:2:1	97-64-3 64742-48-9 1569-01-3	m.w. 118	3.3	+	1.6	+	0.7	+		ne
Epichlorohydrin	ECH Chloromethyloxirane, 1-chloro-2,3-epoxypropane	106-89-8	C <sub>2</sub> H <sub>5</sub> ClO	~200	+	8.5	+	1.4	+	10.2	0.5
Ethane		74-84-0	C <sub>2</sub> H <sub>6</sub>			NR	+	15	+	11.52	ne
Ethanol	Ethyl alcohol	64-17-5	C <sub>2</sub> H <sub>6</sub> O			9.6	+	3.1	+	10.47	1000
Ethanolamine**	MEA, Monoethanolamine	141-43-5	C <sub>2</sub> H <sub>7</sub> NO	5.6	+	1.6	+			8.96	3
Ethene	Ethylene	74-85-1	C <sub>2</sub> H <sub>4</sub>			9	+	4.5	+	10.51	ne
Ethoxyethanol, 2-	Ethyl cellosolve, Ethylene glycol monoethyl ether	110-80-5	C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>			1.3				9.6	5
Ethyl acetate	Acetic ester; Acetic ether; Ethyl ester of acetic acid; Ethyl ethanoate	141-78-6	C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>			3.8	+			10.01	400
Ethyl acetoacetate		141-97-9	C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>	1.4	+	1.2	+	1.0	+	<10	ne
Ethyl acrylate		140-88-5	C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>			2.4	+	1.0	+	<10.3	5
Ethyl lactate	Acetic ester; Acetic ether; Ethyl ester of acetic acid; Ethyl ethanoate	141-78-6	C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>					2.18	+	10.01	400
Ethylamine		75-04-7	C <sub>2</sub> H <sub>7</sub> N			0.8				8.86	5
Ethylbenzene		100-41-4	C <sub>8</sub> H <sub>10</sub>	0.52	+	0.65	+	0.51	+	8.77	100
Ethyl caprylate	Ethyl octanoate	106-32-1	C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>		+	0.52	+	0.51	+		
Ethylenediamine	1,2-Ethanediamine; 1,2-Diaminoethane	107-15-3	C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>	0.9	+	0.8	+	1.0	+	8.6	10
(Ethylenedioxy)diethanethiol, 2,2'-	1,2-Bis(2-mercaptoethoxy)ethane, 3,6-Dioxo-1,8-octane-dithiol	14970-87-7	C <sub>6</sub> H <sub>14</sub> O <sub>2</sub> S <sub>2</sub>			1.3	+				ne
Ethylene glycol**	1,2-Ethandiol	107-21-1	C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>			16	+	6	+	10.16	C100
Ethylene glycol, Acrylate**	2-hydroxyethyl Acrylate	818-61-1	C <sub>5</sub> H <sub>8</sub> O <sub>3</sub>			8.2				≤10.6	
Ethylene glycol dimethyl ether	1,2-Dimethoxyethane, Monoglyme	110-71-4	C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>	1.1		1.1		0.7		9.2	ne

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Ethylene glycol monobutyl ether acetate	1,2-Dimethoxyethane, Monoglyme	110-71-4	C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>	1.1		1.1		0.7		9.2	ne
Ethylene glycol, monothio		60-24-2	C <sub>2</sub> H <sub>6</sub> OS			1.5				9.65	
Ethylene oxide	Oxirane, Epoxyethane	75-21-8	C <sub>2</sub> H <sub>4</sub> O			13	+	3.5	+	10.57	1
Ethyl ether	Diethyl ether	60-29-7	C <sub>4</sub> H <sub>10</sub> O			1.1	+			9.51	400
Ethyl 3-ethoxypropionate	EEP	763-69-9	C <sub>7</sub> H <sub>14</sub> O <sub>3</sub>	1.2	+	0.75	+				ne
Ethyl formate		109-94-4	C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>					1.9		10.61	100
Ethyl-1-hexanol, 2-	Isooctyl alcohol	104-76-7	C <sub>8</sub> H <sub>18</sub> O			1.9	+				ne
Ethyl hexyl acrylate, 2-	Acrylic acid 2-ethylhexyl ester	103-11-7	C <sub>11</sub> H <sub>20</sub> O <sub>2</sub>			1.1	+	0.5	+		ne
Ethylidenenorbornene	5-Ethylidene bicyclo(2,2,1) hept-2-ene	16219-75-3	C <sub>9</sub> H <sub>12</sub>	0.4	+	0.39	+	0.34	+	≤8.8	ne
Ethyl (S)-(-)-lactate see also DS-108F	Ethyl lactate, Ethyl (S)-(-)-hydroxypropionate	687-47-8 97-64-3	C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>	13	+	3.2	+	1.6	+	~10	ne
Ethyl mercaptan	Ethanethiol	75-08-1	C <sub>2</sub> H <sub>6</sub> S	0.60	+	0.56	+			9.29	0.5
Ethyl sulfide	Diethyl sulfide	352-93-2	C <sub>4</sub> H <sub>10</sub> S			0.5	+			8.43	ne
Formaldehyde	Formalin	50-00-0	CH <sub>2</sub> O	NR	+	NR	+	1.6	+	10.87	C0.3
Formamide		75-12-7	CH <sub>3</sub> NO			6.9	+	4		10.16	10
Formic acid		64-18-6	CH <sub>2</sub> O <sub>2</sub>	NR	+	NR	+	9	+	11.33	5
Furfural	2-Furaldehyde	98-01-1	C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>			0.92	+	0.8	+	9.21	2
Furfuryl alcohol		98-00-0	C <sub>5</sub> H <sub>6</sub> O <sub>2</sub>			0.80	+			<9.5	10
Gasoline #1		8006-61-9	m.w. 72			0.9	+				300
Gasoline #2, 92 octane		8006-61-9	m.w. 93	1.3	+	1.0	+	0.5	+		300
Glutaraldehyde	1,5-Pentanedial, Glutaric dialdehyde	111-30-8	C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>	1.1	+	0.8	+	0.6	+		C0.05
Glycidyl methacrylate	2,3-Epoxypropyl methacrylate	106-91-2	C <sub>7</sub> H <sub>10</sub> O <sub>3</sub>	2.6	+	1.2	+	0.9	+		0.5
Halothane	2-Bromo-2-chloro-1,1,1-trifluoroethane	151-67-7	C <sub>2</sub> HBrClF <sub>3</sub>					0.6		11.0	50
HCFC-22	see Chlorodifluoromethane										
HCFC-123	see 2,2-Dichloro-1,1,1-trifluoroethane										
HCFC-141B	see 1,1-Dichloro-1-fluoroethane										
HCFC-142B	see 1-Chloro-1,1-difluoroethane										
HCFC-134A	see 1,1,1,2-Tetrafluoroethane										
HCFC-225	see Dichloropentafluoropropane										
Heptane, n-		142-82-5	C <sub>7</sub> H <sub>16</sub>	45	+	2.8	+	0.60	+	9.92	400
Heptanol, 4-	Dipropylcarbinol	589-55-9	C <sub>7</sub> H <sub>16</sub> O	1.8	+	1.3	+	0.5	+	9.61	ne
Hexamethyldisilazane, 1,1,1,3,3,3-**	HMDS	999-97-3	C <sub>6</sub> H <sub>19</sub> NSi <sub>2</sub>			0.2	+	0.2	+	~8.6	ne
Hexamethyldisiloxane	HMDSx	107-46-0	C <sub>6</sub> H <sub>18</sub> OSi <sub>2</sub>	0.33	+	0.27	+	0.25	+	9.64	ne
Hexane, n-		110-54-3	C <sub>6</sub> H <sub>14</sub>	350	+	4.3	+	0.54	+	10.13	50
Hexanol, 1-	Hexyl alcohol	111-27-3	C <sub>6</sub> H <sub>14</sub> O	9	+	2.5	+	0.55	+	9.89	ne
Hexene, 1-		592-41-6	C <sub>6</sub> H <sub>12</sub>			0.8				9.44	30
HFE-7100	see Methyl nonafluorobutyl ether										
Histoclear (Histo-Clear)	Limonene/corn oil reagent		m.w. ~136	0.5	+	0.4	+	0.3	+		ne
Hydrazine**		302-01-2	H <sub>4</sub> N <sub>2</sub>	>8	+	2.6	+	2.1	+	8.1	0.01
Hydrazoic acid	Hydrogen azide		HN <sub>3</sub>							10.7	
Hydrogen	Synthesis gas	1333-74-0	H <sub>2</sub>	NR	+	NR	+	NR	+	15.43	ne
Hydrogen cyanide	Hydrocyanic acid	74-90-8	HCN	NR	+	NR	+	NR	+	13.6	C4.7
Hydrogen iodide**	Hydriodic acid	10034-85-2	HI			~0.6				10.39	
Hydrogen peroxide		7722-84-1	H <sub>2</sub> O <sub>2</sub>	NR	+	NR	+	NR	+	10.54	1
Hydrogen sulfide		7783-06-4	H <sub>2</sub> S	NR	+	3.3	+	1.5	+	10.45	10
Hydroxyethyl acrylate, 2-	Ethylene glycol monoacrylate	818-61-1	C <sub>5</sub> H <sub>8</sub> O <sub>3</sub>			8.2	+				ne

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Hydroxypropyl methacrylate		27813-02-1 923-26-2	C <sub>7</sub> H <sub>12</sub> O <sub>3</sub>	9.9	+	2.3	+	1.1	+		ne
Iodine**		7553-56-2	I <sub>2</sub>	0.1	+	0.1	+	0.1	+	9.40	C0.1
Iodomethane	Methyl iodide	74-88-4	CH <sub>3</sub> I	0.21	+	0.22	+	0.26	+	9.54	2
Isoamyl acetate	Isopentyl acetate	123-92-2	C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>	10.1		2.1		1.0		<10	100
Isobutane	2-Methylpropane	75-28-5	C <sub>4</sub> H <sub>10</sub>			100	+	1.2	+	10.57	ne
Isobutanol	2-Methyl-1-propanol	78-83-1	C <sub>4</sub> H <sub>10</sub> O	19	+	3.8	+	1.5		10.02	50
Isobutene	Isobutylene, Methyl butene	115-11-7	C <sub>4</sub> H <sub>8</sub>	1.00	+	1.00	+	1.00	+	9.24	ne
Isobutyl acetate	2-methylpropyl ethanoate, β-methylpropyl acetate	110-19-0	C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>			2.1	+			9.97	150
Isobutyl acrylate	Isobutyl 2-propenoate, Acrylic acid Isobutyl ester	106-63-8	C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>			1.5	+	0.60	+		ne
Isoflurane	1-Chloro-2,2,2-trifluoroethyl difluoromethyl ether, forane	26675-46-7	C <sub>3</sub> H <sub>2</sub> ClF <sub>5</sub> O	NR	+	NR	+	48	+	~11.7	ne
Isooctane	2,2,4-Trimethylpentane	540-84-1	C <sub>8</sub> H <sub>18</sub>			1.2				9.86	ne
Isopar E Solvent	Isoparaffinic hydrocarbons	64741-66-8	m.w. 121	1.7	+	0.8	+				ne
Isopar G Solvent	Photocopier diluent	64742-48-9	m.w. 148			0.8	+				ne
Isopar K Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 156	0.9	+	0.5	+	0.27	+		ne
Isopar L Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 163	0.9	+	0.5	+	0.28	+		ne
Isopar M Solvent	Isoparaffinic hydrocarbons	64742-47-8	m.w. 191			0.7	+	0.4	+		ne
Isopentane	2-Methylbutane	78-78-4	C <sub>5</sub> H <sub>12</sub>			8.2					ne
Isophorone		78-59-1	C <sub>9</sub> H <sub>14</sub> O					3		9.07	C5
Isoprene	2-Methyl-1,3-butadiene	78-79-5	C <sub>5</sub> H <sub>8</sub>	0.69	+	0.63	+	0.60	+	8.85	ne
Isopropanol	Isopropyl alcohol, 2-propanol, IPA	67-63-0	C <sub>3</sub> H <sub>8</sub> O	500	+	4.6	+	2.7		10.12	200
Isopropyl acetate		108-21-4	C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>			2.6				9.99	100
Isopropyl ether	Diisopropyl ether	108-20-3	C <sub>6</sub> H <sub>14</sub> O			0.8				9.20	250
Jet fuel JP-4	Jet B, Turbo B, F-40 Wide cut type aviation fuel	8008-20-6 + 64741-42-0	m.w. 115			1.0	+	0.4	+		ne
Jet fuel JP-5	Jet 5, F-44, Kerosene type aviation fuel	8008-20-6 + 64747-77-1	m.w. 167			0.6	+	0.5	+		29
Jet fuel JP-8	F-34, Kerosene type aviation fuel	8008-20-6 + 64741-77-1	m.w. 165			0.94	+	0.3	+		30
Jet fuel A-1	F-34, Kerosene type aviation fuel	8008-20-6 + 64741-77-1	m.w. 145			0.67					34
Jet Fuel TS	Thermally Stable Jet Fuel, Hydrotreated kerosene fuel	8008-20-6 + 64742-47-8	m.w. 165	0.9	+	0.6	+	0.3	+		30
JP-10						0.7	+	0.5	+		
JP5, Petroleum/camelinal						1.05	+				
JP5/Petroleum						0.98	+				
Limonene, D-	(R)-(+)-Limonene	5989-27-5	C <sub>10</sub> H <sub>16</sub>			0.33	+			~8.2	ne
Kerosene C10-C16 petro.distillate	see Jet Fuels	8008-20-6									
MDI	see 4,4'-Methylenebis (phenylisocyanate)										
Maleic anhydride	2,5-Furandione	108-31-6	C <sub>4</sub> H <sub>2</sub> O <sub>3</sub>							~10.8	0.1
Mercapto-2-ethanol	β-Mercaptoethanol, 2-Hydroxyethylmercaptan, BME, Thioethylene glycol	60-24-2	C <sub>2</sub> H <sub>6</sub> OS			1.5	+			9.65	0.2
Mesitylene	1,3,5-Trimethylbenzene	108-67-8	C <sub>9</sub> H <sub>12</sub>	0.36	+	0.35	+	0.3	+	8.41	25
Methallyl chloride	see 3-Chloro-2-methylpropene										
Methane	Natural gas	74-82-8	CH <sub>4</sub>	NR	+	NR	+	NR	+	12.61	ne
Methanol	Methyl alcohol, carbinol	67-56-1	CH <sub>4</sub> O	NR	+	NR	+	2.5	+	10.85	200
Methoxyethanol, 2-	Methyl cellosolve, Ethylene glycol monomethyl ether	109-86-4	C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>	4.8	+	2.4	+	1.4	+	10.1	5

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
<b>Methoxyethoxyethanol, 2-</b>	2-(2-Methoxyethoxy)ethanol Diethylene glycol monomethyl ether	111-77-3	C <sub>7</sub> H <sub>16</sub> O	2.3	+	1.2	+	0.9	+	<10	ne
<b>Methoxyethyl ether, 2-</b>	bis(2-Methoxyethyl) ether, Diethylene glycol dimethyl ether, Diglyme	111-96-6	C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>	0.64	+	0.54	+	0.44	+	<9.8	ne
<b>Methyl acetate</b>		79-20-9	C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>	NR	+	6.6	+	1.4	+	10.27	200
<b>Methyl acrylate</b>	Methyl 2-propenoate, Acrylic acid methyl ester	96-33-3	C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>			3.7	+	1.2	+	(9.9)	2
<b>Methylamine</b>	Aminomethane	74-89-5	CH <sub>5</sub> N			1.2				8.97	5
<b>Methyl amyl ketone</b>	MAK, 2-Heptanone, Methyl pentyl ketone	110-43-0	C <sub>7</sub> H <sub>14</sub> O	0.9	+	0.85	+	0.5	+	9.30	50
<b>Methylaniline, N-</b>	MA; (Methylamino) benzene; N-Methyl aniline; Methylphenylamine; N-Phenylmethylamin	100-61-8	C <sub>7</sub> H <sub>9</sub> N			0.68	+			7.32	2
<b>Methyl bromide</b>	Bromomethane	74-83-9	CH <sub>3</sub> Br	110	+	1.7	+	1.3	+	10.54	1
<b>Methyl-2-butanol, 2-</b>	<i>tert</i> -Amyl alcohol, <i>tert</i> -Pentyl alcohol	75-85-4	C <sub>5</sub> H <sub>12</sub> O			1.62	+			10.16	100
<b>Methyl t-butyl ether</b>	MTBE, <i>tert</i> -Butyl methyl ether	1634-04-4	C <sub>5</sub> H <sub>12</sub> O			0.9	+			9.24	40
<b>Methyl cellosolve</b>	see 2-Methoxyethanol										
<b>Methyl chloride</b>	Chloromethane	74-87-3	CH <sub>3</sub> Cl	NR	+	NR	+	0.74	+	11.22	50
<b>Methylcyclohexane</b>		107-87-2	C <sub>7</sub> H <sub>14</sub>	1.6	+	0.97	+	0.53	+	9.64	400
<b>Methylene bis (phenyl-isocyanate), 4,4'-**</b>	MDI, Mondur M		C <sub>15</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>	Very slow ppb level response							0.005
<b>Methylene chloride</b>	Dichloromethane	75-09-2	CH <sub>2</sub> Cl <sub>2</sub>	NR	+	NR	+	0.89	+	11.32	25
<b>Methyl ether</b>	Dimethyl ether	115-10-6	C <sub>2</sub> H <sub>6</sub> O	4.8	+	3.1	+	2.5	+	10.03	ne
<b>Methyl ethyl ketone</b>	MEK, 2-Butanone	78-93-3	C <sub>4</sub> H <sub>8</sub> O	0.86	+	1.0	+	1.1	+	9.51	200
<b>Methylhydrazine</b>	Monomethylhydrazine, Hydrazomethane	60-34-4	C <sub>2</sub> H <sub>6</sub> N <sub>2</sub>	1.4	+	1.2	+	1.3	+	7.7	0.01
<b>Methyl isoamyl ketone</b>	MIAK, 5-Methyl-2-hexanone	110-12-3	C <sub>7</sub> H <sub>14</sub> O	0.8	+	0.76	+	0.5	+	9.28	50
<b>Methyl isobutyl ketone</b>	MIBK, 4-Methyl-2-pentanone	108-10-1	C <sub>6</sub> H <sub>12</sub> O	0.9	+	0.8	+	0.6	+	9.30	50
<b>Methyl isocyanate</b>		624-83-9	C <sub>2</sub> H <sub>3</sub> NO	NR	+	4.6	+	1.5		10.67	0.02
<b>Methyl isothiocyanate</b>		551-61-6	C <sub>2</sub> H <sub>3</sub> NS	0.5	+	0.45	+	0.4	+	9.25	ne
<b>Methyl mercaptan</b>	Methanethiol	74-93-1	CH <sub>4</sub> S	0.65		0.54		0.66		9.44	0.5
<b>Methyl methacrylate</b>		80-62-6	C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>	2.7	+	1.5	+	1.2	+	9.7	100
<b>Methyl nonafluorobutyl ether</b>	HFE-7100DL	163702-08-7, 163702-07-6	C <sub>5</sub> H <sub>3</sub> F <sub>9</sub> O			NR	+	~35	+		ne
<b>Methyl-1,5-pentanediamine, 2- (coats lamp)**</b>	Dytek-A amine, 2-Methyl pentamethylenediamine	15520-10-2	C <sub>6</sub> H <sub>16</sub> N <sub>2</sub>			~0.6	+			<9.0	ne
<b>Methyl propyl ketone</b>	MPK, 2-Pentanone	107-87-9	C <sub>5</sub> H <sub>12</sub> O			0.93	+	0.79	+	9.38	200
<b>Methyl-2-pyrrolidinone, N-</b>	NMP, N-Methylpyrrolidone, 1-Methyl-2-pyrrolidinone, 1-Methyl-2-pyrrolidone	872-50-4	C <sub>5</sub> H <sub>9</sub> NO	1.0	+	0.8	+	0.9	+	9.17	ne
<b>Methyl salicylate**</b>	Methyl 2-hydroxybenzoate	119-36-8	C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>	1.3	+	0.9	+	0.9	+	~9	ne
<b>Methylstyrene, α-</b>	2-Propenylbenzene	98-83-9	C <sub>9</sub> H <sub>10</sub>			0.5				8.18	50
<b>Methyl sulfide</b>	DMS, Dimethyl sulfide	75-18-3	C <sub>2</sub> H <sub>6</sub> S	0.49	+	0.44	+	0.46	+	8.69	ne
<b>Methyl vinyl ketone</b>	MVK, 3-Buten-2-one	78-94-4	C <sub>4</sub> H <sub>6</sub> O			0.93	+			9.65	ne
<b>Methyltetrahydrofuran</b>	2-MeTHF, Tetrahydro-2- methylfuran, Tetrahydrosilvan	96-47-9	C <sub>5</sub> H <sub>10</sub> O			2.44	+			9.22	ne
<b>Mineral spirits</b>	Stoddard Solvent, Varsol 1, White Spirits	8020-83-5 8052-41-3 68551-17-7	m.w. 144	1.0		0.69	+	0.38	+		100
<b>Mineral Spirits</b>	Viscor 120B Calibration Fluid, b.p. 156-207°C	8052-41-3	m.w. 142	1.0	+	0.7	+	0.3	+		100

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
<b>Monoethanolamine</b> see Ethanolamine											
<b>Mustard</b>	HD, Bis (2-chloroethyl) sulfide	505-60-2 39472-40-7 68157-62-0	C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub> S			0.6					0.0005
<b>Naphtha</b> see VM & P Naphtha											
<b>Naphthalene</b>	Mothballs	91-20-3	C <sub>10</sub> H <sub>8</sub>	0.45	+	0.42	+	0.40	+	8.13	10
<b>Nickel carbonyl (in CO)</b>	Nickel tetracarbonyl	13463-39-3	C <sub>4</sub> NiO <sub>4</sub>			0.18				<8.8	0.001
<b>Nicotine</b>	3-(1-Methyl-2-pyrrolidyl)pyridine	54-11-5	C <sub>10</sub> H <sub>14</sub> N <sub>2</sub>			1.98	+				ne
<b>Nitric oxide</b>		10102-43-9	NO	~6		5.2	+	2.8	+	9.26	25
<b>Nitrobenzene</b>		98-95-3	C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>	2.6	+	1.9	+	1.6	+	9.81	1
<b>Nitroethane</b>		79-24-3	C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>					3		10.88	100
<b>Nitrogen dioxide</b>		10102-44-0	NO <sub>2</sub>	23	+	16	+	6	+	9.75	3
<b>Nitrogen trifluoride</b>		7783-54-2	NF <sub>3</sub>	NR		NR		NR		13.0	10
<b>Nitromethane</b>		75-52-5	CH <sub>3</sub> NO <sub>2</sub>					4		11.02	20
<b>Nitropropane, 2-</b>		79-46-9	C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>					2.6		10.71	10
<b>Nonane</b>		111-84-2	C <sub>9</sub> H <sub>20</sub>			1.4				9.72	200
<b>Norpar 12</b>	n-Paraffins, mostly C <sub>10</sub> -C <sub>13</sub>	64771-72-8	m.w. 161	3.2	+	1.1	+	0.28	+		ne
<b>Norpar 13</b>	n-Paraffins, mostly C <sub>13</sub> -C <sub>14</sub>	64771-72-8	m.w. 189	2.7	+	1.0	+	0.3	+		ne
<b>Octamethylcyclotetrasiloxane</b>		556-67-2	C <sub>8</sub> H <sub>24</sub> O <sub>4</sub> Si <sub>4</sub>	0.21	+	0.17	+	0.14	+		ne
<b>Octamethyltrisiloxane</b>		107-51-7	C <sub>8</sub> H <sub>24</sub> O <sub>2</sub> Si <sub>3</sub>	0.23	+	0.18	+	0.17	+	<10.0	ne
<b>Octane, n-</b>		111-65-9	C <sub>8</sub> H <sub>18</sub>	13	+	1.8	+			9.82	300
<b>Octene, 1-</b>		111-66-0	C <sub>8</sub> H <sub>16</sub>	0.9	+	0.75	+	0.4	+	9.43	75
<b>Pentachloropropane</b>	1,1,1,3,3-pentachloropropane	23153-23-3	C <sub>3</sub> H <sub>3</sub> Cl <sub>5</sub>					1.25	+		0.1
<b>Pentane</b>		109-66-0	C <sub>5</sub> H <sub>12</sub>	80	+	8.4	+	0.7	+	10.35	600
<b>Peracetic acid**</b>	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	C <sub>2</sub> H <sub>4</sub> O <sub>3</sub>	NR	+	NR	+	2.3	+		ne
<b>Peracetic/Acetic acid mix**</b>	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	C <sub>2</sub> H <sub>4</sub> O <sub>3</sub>			50	+	2.5	+		ne
<b>Perchloroethene</b>	PCE, Perchloroethylene, Tetrachloroethylene	127-18-4	C <sub>2</sub> Cl <sub>4</sub>	0.69	+	0.57	+	0.31	+	9.32	25
<b>Propylene glycol methyl ether, 1-Methoxy-2-propanol</b>	PGME	107-98-2	C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>	2.4	+	1.5	+	1.1	+		100
<b>Propylene glycol methyl ether acetate, 1-Methoxy-2-acetoxypropane, 1-Methoxy-2-propanol acetate</b>	PGMEA	108-65-6	C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>	1.65	+	1.0	+	0.8	+		ne
<b>Phenol</b>	Hydroxybenzene	108-95-2	C <sub>6</sub> H <sub>6</sub> O	1.0	+	1.0	+	0.9	+	8.51	5
<b>Phosgene</b>	Dichlorocarbonyl	75-44-5	CCl <sub>2</sub> O	NR	+	NR	+	8.5	+	11.2	0.1
<b>Phosgene in Nitrogen</b>	Dichlorocarbonyl	75-44-5	CCl <sub>2</sub> O	NR	+	NR	+	6.8	+	11.2	0.1
<b>Phosphine (coats lamp)</b>		7803-51-2	PH <sub>3</sub>	28		3.9	+	1.1	+	9.87	0.3
<b>Photocopier Toner</b>	Isoparaffin mix					0.5	+	0.3	+		ne
<b>Picoline, 3-</b>	3-Methylpyridine	108-99-6	C <sub>6</sub> H <sub>7</sub> N			0.9				9.04	ne
<b>Pinene, α-</b>		2437-95-8	C <sub>10</sub> H <sub>16</sub>			0.31	+	0.47		8.07	ne
<b>Pinene, β-</b>		18172-67-3	C <sub>10</sub> H <sub>16</sub>	0.38	+	0.37	+	0.37	+	~8	100
<b>Piperylene, isomer mix</b>	1,3-Pentadiene	504-60-9	C <sub>5</sub> H <sub>8</sub>	0.76	+	0.69	+	0.64	+	8.6	100
<b>Propane</b>		74-98-6	C <sub>3</sub> H <sub>8</sub>			NR	+	1.8	+	10.95	2500
<b>Propanol, n-</b>	Propyl alcohol	71-23-8	C <sub>3</sub> H <sub>8</sub> O			5.5		1.7		10.22	200
<b>Propene</b>	Propylene	115-07-1	C <sub>3</sub> H <sub>6</sub>	1.5	+	1.4	+	1.6	+	9.73	ne
<b>Propionaldehyde</b>	Propanal	123-38-6	C <sub>3</sub> H <sub>6</sub> O			1.9				9.95	ne
<b>Propyl acetate, n-</b>		109-60-4	C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>			3.5				10.04	200
<b>Propyl acetate</b>	Propylacetate; n-Propyl ester of acetic acid	109-60-4	C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>			2.27	+			10.04	200



Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Propylamine, n-	1-Propylamine, 1-Aminopropane	107-10-8	C <sub>3</sub> H <sub>9</sub> N	1.1	+	1.1	+	0.9	+	8.78	ne
Propylene carbonate**		108-32-7	C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>			62	+	1	+	10.5	ne
Propylene glycol	1,2-Propanediol	57-55-6	C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>	18		4.2	+	1.6	+	<10.2	ne
Propylene glycol propyl ether	1-Propoxy-2-propanol	1569-01-3	C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>	1.3	+	1.0	+	1.6	+		ne
Propylene oxide	Methyloxirane	75-56-9 16088-62-3 15448-47-2	C <sub>3</sub> H <sub>6</sub> O	~240		6.6	+	2.9	+	10.22	20
Propyleneimine	2-Methylaziridine	75-55-8	C <sub>3</sub> H <sub>7</sub> N	1.5	+	1.3	+	1.0	+	9.0	2
Propyl mercaptan, 2-	2-Propanethiol, Isopropyl mercaptan	75-33-2	C <sub>3</sub> H <sub>8</sub> S	0.64	+	0.66	+			9.15	ne
Pyridine		110-86-1	C <sub>5</sub> H <sub>5</sub> N	0.78	+	0.7	+	0.7	+	9.25	5
Pyrrolidine (coats lamp)	Azacyclohexane	123-75-1	C <sub>4</sub> H <sub>9</sub> N	2.1	+	1.3	+	1.6	+	~8.0	ne
RR7300 (PGME/PGMEA)	70:30 PGME:PGMEA (1-Methoxy-2-propanol: 1-Methoxy-2-acetoxyp propane)	107-98-2	C <sub>4</sub> H <sub>10</sub> O <sub>2</sub> / C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>			1.4	+	1.0	+		ne
Sarin	GB, Isopropyl methylphosphonofluoridate	107-44-8 50642-23-4	C <sub>4</sub> H <sub>10</sub> FO <sub>2</sub> P			~3					
Shell SPK						1.26	+				
Shell SPK						1.29	+	0.4	+		
Shell SPK 50/50						1.02	+	0.41	+		
Shell SPK/JP-8						1.11	+				
Stoddard Solvent see Mineral Spirits		8020-83-5									
Styrene		100-42-5	C <sub>8</sub> H <sub>8</sub>	0.45	+	0.43	+	0.4	+	8.43	20
Sulfur dioxide		7446-09-5	SO <sub>2</sub>	NR		NR	+	NR	+	12.32	2
Sulfur hexafluoride		2551-62-4	SF <sub>6</sub>	NR		NR		NR		15.3	1000
Sulfuryl fluoride	Vikane	2699-79-8	SO <sub>2</sub> F <sub>2</sub>	NR		NR		NR		13.0	5
Tabun**	Ethyl N, N-dimethylphosphoramidocyanidate	77-81-6	C <sub>5</sub> H <sub>11</sub> N <sub>2</sub> O <sub>2</sub> P			0.8					15ppt
Tallow HRJ						1.09	+				
Tallow HRJ						0.95	+	0.36	+		
Tallow HRJ/JP-8						1.14	+				
Tallow HRJ/JP-8 50/50						0.9	+	0.39	+		
Tetrachloroethane, 1,1,1,2-		630-20-6	C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>					1.3		~11.1	ne
Tetrachloroethane, 1,1,2,2-		79-34-5	C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>	NR	+	NR	+	0.60	+	~11.1	1
Tetrachlorosilane		10023-04-7	SiCl <sub>4</sub>	NR		NR		15	+	11.79	ne
Tetraethyllead	TEL	78-00-2	C <sub>8</sub> H <sub>20</sub> Pb	0.4		0.3		0.2		~11.1	0.008
Tetraethyl orthosilicate	Ethyl silicate, TEOS	78-10-4	C <sub>8</sub> H <sub>20</sub> O <sub>4</sub> Si			0.7	+	0.2	+	~9.8	10
Tetrafluoroethane, 1,1,1,2-	HFC-134A	811-97-2	C <sub>2</sub> H <sub>2</sub> F <sub>4</sub>			NR		NR			ne
Tetrafluoroethene	TFE, Tetrafluoroethylene, Perfluoroethylene	116-14-3	C <sub>2</sub> F <sub>4</sub>			~15				10.12	ne
Tetrafluoromethane	CFC-14, Carbon tetrafluoride	75-73-0	CF <sub>4</sub>			NR	+	NR	+	>15.3	ne
Tetrahydrofuran	THF	109-99-9	C <sub>4</sub> H <sub>8</sub> O	1.9	+	1.7	+	1.0	+	9.41	200
Tetramethyl orthosilicate	Methyl silicate, TMOS	681-84-5	C <sub>4</sub> H <sub>12</sub> O <sub>4</sub> Si	10	+	1.9	+			~10	1
Therminol® D-12**	Hydrotreated heavy naphtha	64742-48-9	m.w. 160	0.8	+	0.51	+	0.33	+		ne
Therminol® VP-1**	Dowtherm A, 3:1 Diphenyl oxide: Biphenyl	101-84-8 92-52-4	C <sub>12</sub> H <sub>10</sub> O C <sub>12</sub> H <sub>10</sub>			0.4	+				1
Toluene	Methylbenzene	108-88-3	C <sub>7</sub> H <sub>8</sub>	0.54	+	0.45	+	0.51	+	8.82	50
Tolylene-2,4-diisocyanate	TDI, 4-Methyl-1,3-phenylene-2,4-diisocyanate	584-84-9	C <sub>9</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>	1.4	+	1.4	+	2.0	+		0.002
Trichlorobenzene, 1,2,4-	1,2,4-TCB	120-82-1	C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub>	0.7	+	0.9	+			9.04	C5
Trichloroethane, 1,1,1-	1,1,1-TCA, Methyl chloroform	71-55-6	C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>			NR	+	1	+	11	350

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Trichloroethane, 1,1,2-	1,1,2-TCA	79-00-5	C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>	NR	+	NR	+	0.9	+	11.0	10
Trichloroethene	TCE, Trichloroethylene	79-01-6	C <sub>2</sub> HCl <sub>3</sub>	0.62	+	0.54	+	0.43	+	9.47	50
Trichloromethylsilane	Methyltrichlorosilane	75-79-6	CH <sub>3</sub> Cl <sub>3</sub> Si	NR		NR		1.8	+	11.36	ne
Trichlorotrifluoroethane, 1,1,2-	CFC-113	76-13-1	C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>			NR		NR		11.99	1000
Triethylamine	TEA	121-44-8	C <sub>6</sub> H <sub>15</sub> N	0.95	+	0.9	+	0.65	+	7.3	1
Triethyl borate	TEB; Boric acid triethyl ester, Boron ethoxide	150-46-9	C <sub>6</sub> H <sub>15</sub> O <sub>3</sub> B			2.2	+	1.1	+	~10	ne
Triethyl phosphate	Ethyl phosphate	78-40-0	C <sub>6</sub> H <sub>15</sub> O <sub>4</sub> P	~50	+	3.1	+	0.60	+	9.79	ne
Trifluoroethane, 1,1,2-		430-66-0	C <sub>2</sub> H <sub>3</sub> F <sub>3</sub>					34		12.9	ne
Trimethylamine		75-50-3	C <sub>3</sub> H <sub>9</sub> N			0.9				7.82	5
Trimethylbenzene, 1,3,5- see Mesitylene		108-67-8									25
Trimethyl borate	TMB; Boric acid trimethyl ester, Boron methoxide	121-43-7	C <sub>3</sub> H <sub>9</sub> O <sub>3</sub> B			5.1	+	1.2	+	10.1	ne
Trimethyl phosphate	Methyl phosphate	512-56-1	C <sub>3</sub> H <sub>9</sub> O <sub>4</sub> P			8.0	+	1.3	+	9.99	ne
Trimethyl phosphite	Methyl phosphite	121-45-9	C <sub>3</sub> H <sub>9</sub> O <sub>3</sub> P			1.1	+		+	8.5	2
Turpentine	Pinenes (85%) + other diisoprenes	8006-64-2	C <sub>10</sub> H <sub>16</sub>	0.37	+	0.4	+	0.29	+	~8	20
Undecane		1120-21-4	C <sub>11</sub> H <sub>24</sub>			2				9.56	ne
Varsol see Mineral Spirits											
Vinyl acetate		108-05-4	C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>	1.5	+	1.2	+	1.0	+	9.19	10
Vinyl bromide	Bromoethylene	593-60-2	C <sub>2</sub> H <sub>3</sub> Br			0.4				9.80	5
Vinyl chloride	Chloroethylene, VCM	75-01-4	C <sub>2</sub> H <sub>3</sub> Cl			2.0	+	0.6	+	9.99	5
Vinyl-1-cyclohexene, 4-	Butadiene dimer, 4-Ethenylcyclohexene	100-40-3	C <sub>8</sub> H <sub>12</sub>	0.6	+	0.56	+			9.83	0.1
Vinylidene chloride see 1,1-Dichloroethene											
Vinyl-2-pyrrolidinone, 1-	NVP, N-vinylpyrrolidone, 1-ethenyl-2-pyrrolidinone	88-12-0	C <sub>6</sub> H <sub>9</sub> NO	1.0	+	0.8	+	0.9	+		ne
Viscor 120B see Mineral Spirits—Viscor 120B Calibration Fluid											
V. M. & P. Naphtha	Ligroin; Solvent naphtha; Varnish maker's & painter's naphtha	64742-89-8	m.w. 111 (C <sub>8</sub> -C <sub>9</sub> )	1.7	+	0.97	+				300
Xylene, m-	1,3-Dimethylbenzene	108-38-3	C <sub>8</sub> H <sub>10</sub>	0.50	+	0.44	+	0.40	+	8.56	100
Xylene, o-	1,2-Dimethylbenzene	95-47-6	C <sub>8</sub> H <sub>10</sub>	0.56	+	0.45	+	0.43		8.56	100
Xylene, p-	1,4-Dimethylbenzene	106-42-3	C <sub>8</sub> H <sub>10</sub>	0.48	+	0.39	+	0.38	+	8.44	100

\* The term "ionization energy" is more scientifically correct and replaces the old term "ionization potential." High-boiling ("heavy") compounds may not vaporize enough to give a response even when their ionization energies are below the lamp photon energy. Some inorganic compounds like H<sub>2</sub>O<sub>2</sub> and NO<sub>2</sub> give weak response even when their ionization energies are well below the lamp photon energy.

\*\* Compounds indicated in green can be detected using a MiniRAE 3000, UltraRAE 3000 or ppbRAE 3000 with slow response, but may be lost by adsorption on a MultiRAE, EntryRAE and AreaRAE. Response on multi-gas meters can give an indication of relative concentrations, but may not be quantitative and for some chemicals no response is observed.

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**UTILITY CLEARANCE**  
**(Standard Operating Procedure 003)**

**Revision No: 2**

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SOP Approval: Stephen D. Brower Date: 4/29/2021  
Stephen D. Brower, Principal Geoscientist

SOP Approval: Daniel P. Claycomb Date: 4/29/2021  
Daniel P. Claycomb, Principal Geoscientist

**UTILITY CLEARANCE  
(Standard Operating Procedure 003)**

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**TABLE**

Table 1      Utility Clearance Equipment & Material Checklist

# **UTILITY CLEARANCE (Standard Operating Procedure 003)**

## **1.0 PURPOSE**

This standard operating procedure (SOP) provides the general technical requirements and operational guidelines for conducting and successfully completing a utility clearance prior to intrusive activities. The requirements of this procedure are applicable to project activities that involve advancement of soil borings, drilling, excavation and trenching, or other intrusive activities. The following utility clearance activities are addressed in this SOP:

- Visual Inspection of Overhead Utilities
- Using the 811 System
- Using Local One Call System
- Using Independent Line Locating Services

Field personnel conducting intrusive activities are required to be familiar with the procedures provided in this SOP as well as standard industry practices.

## **2.0 GENERAL CONSIDERATIONS**

Potential hazards associated with the planned intrusive tasks should be thoroughly evaluated prior to conducting field activities. Refer to the site-specific Health and Safety Plan (HASP) for a description of potential hazards and associated safety and control measures.

At least three days prior to intrusive subsurface activities, the appropriate utility notifications (*i.e.*, National 811 One Call [811]) must be completed. If the intrusive work is delayed more than ten business days from the original start date, 811 must be notified again. Verify, to the extent practicable, that utility companies have responded to the One Call request and have marked their respective utilities. If there is uncertainty associated with potentially unmarked utilities, the Field Team Leader should suspend work until the issue has been resolved.

## **3.0 PROCEDURES**

This section documents general operating procedures and methods associated with successfully completing a thorough utility clearance.

### **3.1 Overhead Utility Lines**

Before the commencement of site activities, complete a visual assessment to identify overhead utilities at the subject property. Minimum isolation distances of 20 feet (10 feet if you know the line is less than 50,000 volts) from overhead utilities that could potentially be contacted by lifts, articulating masts, or drilling rails are required.

When working adjacent to high-voltage overhead electrical transmission lines, contact the utility company directly for additional guidance and approvals.

#### **3.1.1 Clearance of Overhead Utility Lines**

- Locate the proposed activity location and look above the location. If overhead utility lines are present within a 20-foot radius of the raised mast, lifts, or elevated workstations (*e.g.*, cherry picker), relocation is required. The radius is 10 feet if you know the line is less than 50,000 volts. If it is necessary to relocate a sampling point, document the reason for

## **UTILITY CLEARANCE (Standard Operating Procedure 003)**

relocation and information regarding the new location in the field logbook. Refer to Section 3.3 of this SOP for additional information regarding Field Logbooks and proper documentation procedures.

- If relocating the work area is not possible, the lines can be covered with protective sheaths or deactivated. The appropriate utility company must be contacted to complete these tasks.

### **3.2 Utility Clearance for Underground Utilities**

Either the national call-before-you-dig phone number (811) or the local One Call Center (OCC) must be contacted prior to the commencement of intrusive activities. Additionally, an independent line locating service may be used for more complex properties and to successfully locate underground utilities on private property.

#### ***3.2.1 Using 811 System for Underground Utility Line Clearance***

- Mark the boundaries of the areas where intrusive activities are proposed with white spray paint. These areas include excavation boundaries or boring/monitoring well locations. It is the responsibility of the person making the call under the law to provide exact and specific work site information to the call center.
- Dial 811. A phone call to 811 initiates the process whereby underground utilities lines at the site will be marked by the appropriate utility companies. When 811 is called from anywhere in the continental United States, the call is routed to the local OCC.

#### ***3.2.2 Using the Local OCC for Underground Utility Line Clearance***

- Call the local OCC by dialing direct.
- Local OCC operators will request the following information:
  - Property location (state/county/city/town/township/ward)
  - Property address
  - Latitude/longitude
  - Nearest roadway intersection to the site
  - Type of work to be performed
  - Dimensions of the excavation area
  - Site contact person and phone number (mobile and office)
  - Planned excavation date(s)
- The local OCC operator will provide a serial number associated with the notification.
- For routine notifications, the OCC automated response system will notify the requestor of the status of the affected utilities at the end of the second business day. The notification will specify if contacted utilities are not affected, cleared, or conflicted. Additional notices will be provided regarding changes in status.
- Affected utility companies will send a professional locator to the subject property to mark the lines within 3 business days.

## UTILITY CLEARANCE (Standard Operating Procedure 003)

- Wait for the site to be marked before conducting intrusive activities.
- The type of underground utility at a site can be identified by the color of paint used to mark its location. Utilities are marked using the following color codes:

Red	-	Electric
Yellow	-	Gas – Oil
Orange	-	Communications/CATV
Blue	-	Potable Water
Green	-	Sewer
White	-	Proposed Excavation
Pink	-	Temporary Survey Markings
Purple	-	Reclaimed Water

- Respect all markings. Do not disregard markings because you do not believe there are utilities in the area. Positively identify utility presence or non-presence before commencing intrusive activities.
- Once the underground utilities have been located and marked with the appropriate color paint, the approximate location of the line(s) is known; this is not an exact location. Establish an isolation zone of 5 feet on both sides of the estimated (marked) utility location. Do not conduct intrusive activities within this isolation zone.
- If intrusive activities must be completed within the isolation zone (within 5 feet of the underground utility), the exact line location must be determined by hand digging methods prior to mechanized excavation. Consider special safety precautions to address the hazards associated with each utility. For example, non-conductive (fiberglass) digging tools when electrical lines are in conflict or non-aggressive digging techniques such as air knife or soft dig that use forced air to expose but not damage gas and oil/water/communication lines.
- If the original utility markings are destroyed or removed prior to intrusive activities, contact the OCC to mark the utilities again.
- The local OCC does not mark underground utilities on private lots and utility mark-outs will typically terminate at the curb or roadway boundary. Consider a private utility locating service when the project area is located at an interior portion of the property and utilities are not adequately marked.
- Inspect site buildings or paved areas for indications of underground utilities. For example, exterior sewer line vents are often found proximal to site lavatory facilities and can be lined up with green curb markings; electrical and communication line conduits commonly surface adjacent to building foundations proximal to interior electrical breaker boxes or communication centers. Also, underground storage tank (UST) fill/vent pipes are installed vertically from USTs proximal to the building boiler or heating units that they support. If there is uncertainty regarding the location of site utilities, consult Section 3.2.3 of this SOP for additional guidance.

## **UTILITY CLEARANCE (Standard Operating Procedure 003)**

### ***3.2.3 Using an Independent Line Locating Services for Underground Utility Clearance***

Contract an independent Line Locating Service (LLS) on larger properties or when the utility clearance procedures in Section 3.2.1 and 3.2.2 do not adequately establish/delineate the presence or absence of underground utilities (e.g., private utilities).

When underground utilities are identified along a property boundary and it is reasonable to assume and/or the identification of signature components supports the inference that subsurface lines traverse the subject property, an LLS must be contracted to provide accurate underground utility locations.

#### ***3.2.3.1 Contracting Line Locating Services***

- Contract an LLS provider based on the following information:

Serial or Confirmation Number assigned by the OCC.

Site address including:

Property location (state/city/town and township)

Property Address

Nearest intersection

- Outline expected excavation/drilling locations with white spray paint.

#### ***3.2.3.2 Background/Historical Information Compilation***

- Contact the property owner and request copies of site “as built” drawings or figures. These figures will indicate the locations of underground utilities installed at the site including electrical, potable water, sanitary sewer, and communication.
- Interview key site personnel (owner, supervisor, maintenance personnel) regarding the location of underground utilities.
- Inspect site buildings/paved areas proximal to site structures for indications of underground utilities.
- Review and finalize with the LLS provider the specific subsurface sensing techniques and instrumentation that will be utilized to locate site utilities. Make sure that the proposed sensing instrumentation can detect the suspected underground utilities. More than one instrument may be required to locate shallow and deep utilities.

#### ***3.2.3.3 On-Site Activities***

- Direct the LLS provider to the proposed excavation/drilling location.
- Provide the LLS provider with the information obtained from the Background/Historical Information Compilation described in Section 3.2.3.2 of this SOP.
- Coordinate a meeting of key site personnel and the LLS provider to transfer information regarding the location of known underground utilities.

## **UTILITY CLEARANCE (Standard Operating Procedure 003)**

- Review the property boundary with the LLS provider and outline the OCC markings. The type of underground utility located at the site can be identified by the color paint used to mark its location.
- If the utility identifications are not consistent between the LLS provider and the OCC, contact the OCC immediately. Have the Confirmation/Serial Number readily available so the OCC can easily identify the project and contact the appropriate utility locator.
- Request an additional site visit by the utility locator(s) in the event of problematic utility locations (conflict). Do not conduct intrusive activities at the property until utilities have been located and conflicts have been resolved.

### **3.3 Field Logbook Documentation**

Field logbooks will be maintained by the field team to record daily activities. The minimum requirements for field logbook documentation are discussed in the Field Documentation Procedures SOP (SOP 001).

The Field Team Leader will review the field logbook entries for completeness and accuracy. The Field Team Leader is responsible for completion of the required data collection forms.

### **4.0 REFERENCES**

- 811 National Call Before You Dig Number - <https://call811.com/>
- Montrose Environmental Solutions, Inc. Field Documentation Procedures SOP (SOP 001).
- “Conditions for Working in the Vicinity of Electrical Transmission Lines of PECO Energy Company and its Subsidiaries,” S-7070, Revised 6/95.

**UTILITY CLEARANCE  
(Standard Operating Procedure 003)**

<b>TABLE 1: UTILITY CLEARANCE EQUIPMENT &amp; MATERIAL CHECKLIST</b>	
<b>Item Description</b>	<b>CHECK</b> ✓
<b>Health &amp; Safety</b>	
Nitrile gloves	
Hard hat	
Steel-toed boots	
Hearing protection	
Field first-aid kit	
Eyewash	
Safety glasses	
Respirator and cartridges (if necessary)	
Saranex/Tyvek suits and booties (if necessary)	
<b>Utility Clearance Equipment</b>	
Field logbook	
Pin flags and white marking paint	
Permanent marker	
Tape measure and other measuring equipment as needed	
Digital camera	
Site utility “as-built” maps, drawings, or figures	





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**SURFICIAL AND SUBSURFACE SOIL SAMPLING  
(Standard Operating Procedure 004)**

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Stephen D. Brower, Principal Geoscientist

SOP Approval: Daniel P. Claycomb Date: 04/28/2023  
Daniel P. Claycomb, Principal Geoscientist

**SURFICIAL AND SUBSURFACE SOIL SAMPLING**  
**(Standard Operating Procedure 004)**

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**TABLE**

Table 1          Soil Sampling Equipment & Material Checklist

**ATTACHMENT**

Attachment 1    USCS Field Sheet

# **SURFICIAL AND SUBSURFACE SOIL SAMPLING**

## **(Standard Operating Procedure 004)**

### **1.0 PURPOSE**

This standard operating procedure (SOP) provides the general technical requirements and operational guidelines for collecting surficial and subsurface soil samples for chemical analysis using the following methods:

- Manual collection methods (e.g., hand auger systems, step samplers, manual probe, sampling trowels, sampling spatulas, core samplers)
- Mechanical collection methods (e.g., direct-push equipment, conventional drilling equipment)

Field personnel conducting soil sampling activities are required to be familiar with the procedures provided in this SOP as well as standard industry practices.

### **2.0 GENERAL CONSIDERATIONS**

Thoroughly evaluate potential hazards associated with the planned tasks prior to conducting field activities. Refer to the site-specific Health and Safety Plan (HASP) for a description of potential hazards and associated safety and control measures.

Prior to intrusive subsurface activities, the appropriate utility notifications (e.g., National 811 One Call) must be made and the dates of intrusive activities must be completed within the lawful dates provided by the One Call Center. Verify, to the extent practicable, that utility owners have responded to the One Call request and have marked their respective utility. If there is uncertainty associated with potentially unmarked utilities, suspend field work until the issues can be resolved. Refer to the Utility Clearance SOP (SOP 003) for additional information.

Decontaminate field sampling equipment in accordance with the Decontamination of Equipment SOP (SOP 017) prior to use. Although sampling should typically be conducted in the order from least-impacted to most-impacted, field logistics may necessitate a different order for sample collection. When sampling does not proceed in a least-impacted to most-impacted order, extra precautions must be taken to ensure that equipment is properly decontaminated to help prevent cross-contamination.

### **3.0 PROCEDURES**

This section documents general operating procedures and methods associated with surficial and subsurface soil sampling activities. Surficial and subsurface soil sampling may be conducted using one of two general methods: manual or mechanical. These methods are described in further detail in the following sections.

#### **3.1 Manual Soil Sampling Methods**

Manual soil sampling methods involve the use of hand equipment such as hand augers, step samplers, probes, trowels, spatulas, and core samplers. Manual soil sampling procedures are discussed below.

- Prior to sampling, remove vegetation, rocks, leaves, debris, or other obstructions within the sampling location that interfere with soil sample collection using a disposable plastic sampling scoop (or similar device). If it is necessary to relocate a sampling point, document the reason for the relocation and describe the new sample location in the field logbook.

## SURFICIAL AND SUBSURFACE SOIL SAMPLING (Standard Operating Procedure 004)

- Use a fresh disposable or decontaminated manual collection device to collect the soil sample from the sample location and depth interval based on either pre-determined sample intervals or field observations/screening as prescribed in the project control documents.
- If the constituents of concern being investigated include volatile organic compounds (VOCs), then soil samples shall be screened for the presence of volatile organic vapors using a properly calibrated photoionization detector (PID). Soil samples shall be scanned with a PID immediately following collection, and the resulting readings shall be documented in the field logbook or on project-specific soil boring logs. Refer to the Air Monitoring - Field Screening Instrumentation and Procedures SOP (SOP 002) for additional information regarding the use and calibration of a PID.
- Soil samples shall be examined and logged for soil classification, color, and moisture according to ASTM D2488-17e1 Standard Practice for Description and Identification of Soils (Visual-Manual Procedures). This practice describes a procedure for identifying soils, at the option of the user, based on the classification system described in ASTM D2487-17 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System [USCS]).
- Soil samples shall be examined for evidence of impacts such as odors, staining, or other field observations. Such potential impacts/observations shall be documented along with other pertinent observations in the field logbook or on project-specific soil boring logs. See the attached USCS Field Sheet (Attachment 1) for a description of the USCS.
- Soil samples shall only be collected or handled while wearing clean nitrile gloves. Nitrile gloves shall be donned before collection of the first sample and changed between samples, sampling locations, and prior to handling samples for packing and shipping purposes.

### **3.1.1** *Collection of Samples for VOC analysis*

- Soil samples for VOC analysis shall be collected and placed in sample containers immediately (within minutes) following removal from the ground to reduce loss of VOCs to volatilization and biodegradation.
- Soil samples for VOC analysis will typically be collected using a Terra Core® sampling kit (or equivalent) or an EnCore® sampler.

#### *Terra Core Sampling Kit*

- The Terra Core sampling kit will typically include: one disposable T-Handle for sampling; three pre-preserved 40-ml volatile vials (one containing methanol and two containing reagent water); and one 2-ounce sample jar (for moisture content analysis).

**Note:** Samples that are not methanol-preserved must be received and either frozen or analyzed by the laboratory within 48 hours of sample collection. Consequently, if shipping via an overnight courier the samples must be shipped to the laboratory on the same day that the samples are collected so that sample extraction can be performed at the laboratory within 48 hours from the time of collection.

## **SURFICIAL AND SUBSURFACE SOIL SAMPLING**

### **(Standard Operating Procedure 004)**

As an exception to the above, two sodium bisulfate-preserved vials may be used in place of reagent water when the contaminant of concern is a petroleum hydrocarbon and the samples are not anticipated to contain calcium carbonate. The presence of calcium carbonate may cause the sample aliquot to effervesce in the vial and result in the loss of VOCs and possibly breakage. In addition, reactive compounds such as 2-chloroethylvinyl ether readily break down under acidic conditions. If sodium bisulfate is used as a preservative, the holding time from sample collection to analysis is 14-days.

- Inspect the T-handle sampler to ensure it is in the “rest” or “sample load” position: the top of the plunger rod flush is with the T-handle so that a plug of soil can fill the cavity at the bottom of the T-handle.
- Using the T-handle, push the sampler into soil until the coring cavity is completely full. The T-handle sampler is designed to collect approximately 5-grams of soil. Remove sampler from soil.
- Wipe excess soil from exterior of the coring body using a clean paper towel.
- Insert the plug end of the T-handle into a preserved vial and expel the contents into the vial by rotating the T-handle 90-degrees and pushing down. Cap and seal the vial.
- Repeat the process for each vial. Collect the three soil plugs as close together as possible.
- Fill the 2-ounce sample jar last. Using a disposable plastic sampling scoop, completely fill the jar with soil, and then immediately seal the container. The soil in this container is used to determine moisture content.
- Properly label sample containers according to Section 3.4. Do not place labels directly on the vials as they are pre-weighed by the laboratory. If the vials do not already have labels when received by the laboratory, place the vials in a re-sealable plastic bag and label the bag.
- Following collection, place samples upright in a cooler containing wet ice.
- Samples containing gravel/rocks or very wet/loose soil may be difficult to collect using a Terra Core sampler. If several attempts to collect a soil plug with a Terra Core sampler are unsuccessful (e.g., because the sample contains gravel or rocks that are wet/loose), contact the Project Manager to assess sample collection options.

#### *En Core Sampler:*

- The En Core sampler is made of an inert, composite polymer and is available in 5-gram and 25-gram sizes. Three En Core samplers are typically used for each soil sample location. An En Core stainless steel T-Handle is required when using the En Core sampler.
- While holding the En Core sampler’s coring body, push the plunger rod down until the small O-ring rests against the tabs to ensure that the plunger moves freely.
- Depress the locking lever on the En Core T-handle, aligning the two slots on the coring body with the two locking pins in the T-handle. Twist the coring body clockwise to lock the pins into the slots. Check to ensure that the sampler is in place. The sampler is now ready for use.

## SURFICIAL AND SUBSURFACE SOIL SAMPLING (Standard Operating Procedure 004)

- Turn the T-Handle with the “T” pointed up and the coring body pointed down; this action positions the plunger bottom flush with the bottom of the coring body. Using the T-handle, push the sampler into soil until the coring body is completely full. When full, the small O-ring will be centered in the T-handle viewing hole. Remove the sampler from the soil. Wipe excess soil from the coring body exterior with a clean paper towel.
- Cap the coring body while still on the T-handle. Push and twist the cap over the bottom until the grooves on the locking arms seat over the ridge on the coring body.
  - **Note: The cap must be seated on both sides to seal the sampler.**
- Repeat the process until the required number of En Core samplers have been filled with soil samples (typically three). Collect the three soil plugs as close together as possible.
- Following collection, place the En Core samplers into their respective resealable bags and properly label according to Section 3.4.
- Fill a 2-ounce sample jar last. Using a disposable plastic sampling scoop, completely fill the jar with soil, and then immediately seal the container. The soil in this container is used to determine moisture content.
- The sampled material contained in an En Core Sampler can only be stored in the device for a maximum of 48 hours; consequently, if shipping via an overnight courier the samples must be shipped to the laboratory on the same day that the samples are collected so that sample extraction can be performed at the laboratory within 48 hours from the time of collection.
- Samples containing gravel/rocks or very wet/loose soils may be difficult to collect using an En Core Sampler. If several attempts to collect a soil plug with an En Core Sampler are unsuccessful (e.g., because the sample contains gravel or rocks that are wet/loose), contact the Project Manager to assess sample collection options.

**Note:** If possible, it is preferable to collect the VOC sample from undisturbed soil (at the top of the sample interval) because the use of a manual collection device breaks up the soil structure and can result in the loss of VOCs.

### 3.1.2 Collection of Samples for Non-VOC Analysis

- Soil samples for analysis of non-VOC constituents, such as semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), metals, or cyanide, must be homogenized to create a representative sample, prior to transferring the soil into sample jars.
- When sample quantity is limited, prioritize the analytical parameters in consultation with the Project Manager.
- Homogenization can take place either *in-situ* (in the case of shallow soil samples) or in a decontaminated stainless-steel or glass mixing bowl/tray.
  - **Note:** Avoid the use of stainless-steel equipment or disposable aluminum pans for samples that will be analyzed for metals.

## **SURFICIAL AND SUBSURFACE SOIL SAMPLING**

### **(Standard Operating Procedure 004)**

- The goal of homogenization is to achieve a consistent physical appearance and texture and to evenly distribute the geochemical characteristics of the soil over the entire sample to eliminate or minimize analytical bias.
- Prior to homogenization, remove twigs, roots, leaves, rocks, and miscellaneous debris from the sample using a decontaminated stainless-steel spoon/scoop/spatula or a clean disposable plastic sampling scoop.
- Thoroughly homogenize the sample until a consistent physical appearance has been obtained. Care should be taken to minimize contact of the sample media with nitrile gloves.
- Following homogenization, transfer appropriate volumes of soil into certified-clean, laboratory-supplied bottleware using either a decontaminated stainless-steel or glass spoon/scoop/spatula or a clean disposable plastic sampling scoop.
- Following collection, properly label the sample containers according to Section 3.4.
- Immediately place sample containers upright in a cooler containing wet ice (samples for metals analysis do not need to be temperature preserved, except for mercury and hexavalent chromium, which do need to be temperature preserved).

### **3.2 Mechanical Soil Sampling Methods**

Mechanical soil sampling methods involve the use of direct-push or conventional drilling equipment to collect soil cores. Mechanical soil sampling methods are discussed in the following sections.

#### **3.2.1 Direct-Push Technology Systems**

Direct-push technology (DPT) systems are hydraulically-powered machines that use static and dynamic percussion forces to advance small-diameter sampling tools and retrieve soil samples. The Macro Core Sampler (or its equivalent for other name brand systems) will typically be utilized for Geoprobe® systems to collect soil samples.

Utilize the following procedures to collect soil samples using DPT systems.

- Decontaminate reusable down-hole equipment prior to use.
- Prior to sampling, remove vegetation, rocks, leaves, debris, or other obstructions within the sampling location that may interfere with soil boring advancement. If it is necessary to relocate a sampling point, document the reason for relocation and information regarding the new location in the field logbook.
- Thread the decontaminated DPT sampler onto the leading end of a probe rod and begin advancing the probe rod to the desired sampling depth. Do not apply petroleum-based lubricants to the probe rod threads. Depending on the drilling company and the make and model of the DPT rig, the sampler will typically be either 3, 4, or 5 feet in length.
- Upon reaching the desired depth, retrieve the DPT sampler by retracting the probe rods.

## **SURFICIAL AND SUBSURFACE SOIL SAMPLING (Standard Operating Procedure 004)**

- Directly following DPT sampler retrieval, remove the acetate liner containing the soil core from the DPT sample barrel and place the liner on a clean working surface (e.g., plastic sheeting, plastic table, etc.). Keep track of the top and bottom of the soil core.
- Using a liner cutter, make two longitudinal cuts down the entire length of the liner. Remove the cut piece of liner to expose the soil core for examination.
- If the chemicals being investigated include VOCs, screen the soil core with a calibrated PID for the potential presence of volatile organic vapors. While wearing clean nitrile gloves, separate the two edges of the liner and immediately scan the soil core sample with the PID. Document PID readings in the field logbook or on project-specific soil boring logs. Refer to SOP 002 for additional information regarding the use and calibration of a PID.
- Collect soil samples for VOC analysis, if required, from the undisturbed soil core according to the procedures presented in Section 3.1.1 of this SOP.
- Examine and log the characteristics of the soil core according to the USCS. Also document pertinent observations in the field logbook or on project-specific soil boring logs. See the attached USCS Field Sheet (Attachment 1) for a description of the USCS.
- For each soil core that is recovered, record the following information in the field logbook or field form:
  - Soil characteristics according to the USCS
  - Relative degree of soil moisture (e.g., dry, moist, saturated)
  - PID readings
  - Presence of staining or odors
  - Amount of soil sample recovered, in inches, for each interval that the DPT sampler is driven (e.g., 36/48 inches)
  - If refusal is encountered, note the depth of refusal
  - The interval in which a sample was collected for laboratory analysis
- Collect soil samples for non-VOC analysis if required, according to the procedures presented in Section 3.1.2 of this SOP. Document sample collection depths in the field logbook or on the soil boring log.
- Decontaminate and re-attach the DPT sampler to the probe rods and advance the sampler to the next sample collection depth with a new acetate sample liner installed. Retrieve the DPT sampler and repeat the soil screening, classification, and sampling process for each soil core that is removed.
- Keep track of the rod measurements and number of rods added as the DPT sampler is advanced such that an accurate sampling depth can be recorded. Also, note in the field logbook the difficulty/ease with which the sampler is advanced, as well as other important subsurface probing/sampling characteristics. Continue this process until the final sampling depth interval is reached or until the DPT sampler can no longer be advanced (i.e., refusal is reached).
- Dispose of the unused portion of the soil core and the DPT liner in accordance with the Management of Investigation-Derived Waste SOP (SOP 018) or site-specific requirements.



## **SURFICIAL AND SUBSURFACE SOIL SAMPLING (Standard Operating Procedure 004)**

- Abandon boreholes in accordance with Section 3.2.3 and/or state regulations.

### **3.2.2 Conventional Drilling Systems**

The following section describes the procedures for collecting soil samples using conventional drilling systems (such as hollow stem auger drilling methods) to ensure that acceptable, consistent, subsurface samples are collected for chemical analysis and physical characterization.

- The drilling rig and associated equipment and materials must arrive on site in a clean condition and shall be free of oil, grease, and debris. The Field Team Leader will inspect the rig for any significant fluid leaks. If leaks are present, the equipment must be repaired before any drilling activities begin.
- Set up a decontamination area for the drill rig and associated equipment and materials such that liquids/solids generated during decontamination processes will be collected for proper disposal. To the extent practicable, perform decontamination away from and downgradient of marked boring locations and existing monitoring wells.
- Decontaminate reusable down-hole equipment prior to use and between samples/borings.
- Prior to sampling, remove vegetation, rocks, leaves, debris, or other obstructions at the sampling location that interfere with drilling. If it is necessary to relocate a sampling point, document the reason for relocation and describe new location information in the field logbook.
- Soil samples may be collected with a split-barrel sampler (split spoon), typically at 1.5- or 2-foot intervals, to evaluate and characterize subsurface conditions.
- To collect intact subsurface soil samples, the auger will be advanced to the top of the targeted sample interval. The split-barrel sampler will then be driven, in 6-inch increments, the length of the split barrel sampler using a drop hammer. Record the blow counts (hammer drops) for each 6-inch interval of advancement.
- After the split-barrel sampler is driven the desired interval, it will be withdrawn from the boring.
- If the chemicals being investigated include VOCs, then soil samples shall be screened for the potential presence of volatile organic vapors using a properly calibrated PID. Immediately following retrieval, open the split-barrel sampler and screen the soil sample with a PID.
- Document PID readings in the field logbook or on project-specific soil boring logs. Refer to SOP 002 for additional information regarding the use and calibration of a PID.
- Avoid collecting soil samples from the top 3-inches of the sampler as this material is often slough from a previous interval or material that was pushed up into the auger.
- Collect soil samples for VOC analysis directly from the undisturbed soil core according to the procedures presented in Section 3.1.1 of this SOP.
- Collect soil samples for non-VOC analysis according to the procedures presented in Section 3.1.2 of this SOP.

## **SURFICIAL AND SUBSURFACE SOIL SAMPLING**

### **(Standard Operating Procedure 004)**

- For each interval that is sampled, record the following information:
  - Soil characteristics according to the USCS
  - Relative degree of soil moisture or whether the soil is saturated (e.g., dry, moist, saturated)
  - PID readings
  - Presence of staining or odors
  - Amount of soil sample recovered, in inches, for each interval that the split-barrel sample is driven (e.g., 20/24 inches)
  - Blow counts for each 6-inch interval the split-barrel sampler is driven for the entire desired interval (e.g., 8-12-12-20). If the split-barrel sampler cannot be driven the entire 6-inch distance due to an obstruction or very dense material, record the maximum number of blow count and the distance the split-barrel sampler traveled and the 6-inch interval where this occurred (e.g., 25-30-35-50/3). Typically, attempts at driving the split-barrel sampler are discontinued if it fails to advance 6-inches after 50 blows of the drop hammer.
  - The interval in which a sample was collected for laboratory analysis
- Decontaminate and re-attach the split-barrel sampler to the drilling rods, advanced down the borehole to the top of the next sampling interval, and repeat the process. Keep track of the rod measurements and number of rods added as the sampler is advanced so that an accurate sampling depth can be recorded. Continue this process to the desired termination depth or refusal.
- Dispose of the unused portion of the soil core sample in accordance with SOP 018.
- Abandon boreholes in accordance with Section 3.2.3.

### **3.2.3 Borehole Abandonment**

For borings with no observed impacts, backfilling the borings with non-impacted, native soil material, sand, or topsoil is acceptable. Soil from borings with observed impacts should be properly containerized and characterized for disposal, and the boring should be backfilled with bentonite chips or pellets (or as state regulations require). If groundwater is encountered in the borehole, consider tremie grouting to abandon the borehole.

If bentonite chips or pellets are used, pour slowly into the borehole to avoid “bridging.” Place bentonite from the bottom of the boring to a depth of approximately 2 feet below the ground surface. The bentonite should be placed in approximately 2-foot “lifts” followed by the addition of potable water after each lift to ensure that the bentonite is adequately hydrated. Place native soil material (non-impacted) on top of the bentonite to the ground surface.

Deep borings (i.e., deeper than 25 feet) or where the water table is encountered may require tremie grouting with either a bentonite slurry or a cement/bentonite grout. Bentonite slurries shall consist of potable water and bentonite containing approximately 20% solids. Consult with the Project Manager and review project control documents to determine if tremie grouting is necessary.

If the surface around the boring is paved or covered with concrete, repair the surface using asphalt cold patch or concrete, unless site requirements dictate otherwise.

## **3.3 Investigation-Derived Waste**

## **SURFICIAL AND SUBSURFACE SOIL SAMPLING (Standard Operating Procedure 004)**

Investigation-derived waste (IDW) includes excess soil samples, cuttings, decontamination fluids, disposable sampling equipment, and used, disposable personal protective equipment. Manage IDW according to SOP 018.

### **3.4 Sample Handling, Packing, and Shipping**

Samples will be marked, labeled, packaged, and shipped in accordance with the Sample Labeling, Packing, and Shipping SOP (SOP 016). Do not affix labels to pre-weighed sample containers such as VOC vials included with Terra Core kits.

### **3.5 Field Quality Control Samples**

Field quality control (QC) samples may include trip blanks, equipment rinsate blanks, field duplicate samples, field blanks and matrix spike and matrix spike duplicate samples. Refer to the Field Quality Control Sampling Procedures SOP (SOP 015) for a description of common field QC samples and the associated collection methods.

### **3.6 Field Logbook Documentation**

Field logbooks will be maintained by the field team to record daily activities. The minimum requirements for field logbook documentation are presented in the Field Documentation Procedures SOP (SOP 001).

### **3.7 Decontamination and Cleanup**

Sampling equipment decontamination will be performed in a manner consistent with SOP 017 and SOP 018.

## **4.0 REFERENCES**

- ASTM International (ASTM). Standard Practice for Description and Identification of Soils (Visual-Manual Procedures) – D2488-17e1, 2017.
- ASTM International (ASTM). Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations - D6282-M14, 2014.
- ASTM International (ASTM). Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils - D1586 – 11
- Montrose Environmental Solutions, Inc. Field Documentation Procedures SOP (SOP 001)
- Montrose Environmental Solutions, Inc. Field Screening Instrumentation and Procedures SOP (SOP 002)
- Montrose Environmental Solutions, Inc. Utility Clearance SOP (SOP 003)
- Montrose Environmental Solutions, Inc. Field Quality Control Sampling Procedures SOP (SOP 015)
- Montrose Environmental Solutions, Inc. Sample Labeling, Packing, and Shipping SOP (SOP 016)
- Montrose Environmental Solutions, Inc. Decontamination of Equipment SOP (SOP 017)
- Montrose Environmental Solutions, Inc. Management of Investigation-Derived Waste (SOP 018)
- New Jersey Department of Environmental Protection. Field Sampling Procedures Manual. August 2005.

**SURFICIAL AND SUBSURFACE SOIL SAMPLING  
(Standard Operating Procedure 004)**

- US EPA, SW-846 Method 5035A, Closed-System Purge-and-Trap Extraction for Volatile Organics in Soil and Waste Samples, Revision 1 July 2002.
- US EPA, Test Methods for Evaluating Solid Waste Physical/Chemical Analysis (SW-846), July 2014.

**SURFICIAL AND SUBSURFACE SOIL SAMPLING**  
(Standard Operating Procedure 004)

<b>TABLE 1: SOIL SAMPLING EQUIPMENT &amp; MATERIAL CHECKLIST</b>	
<b>Item Description</b>	<b>CHECK</b> ✓
<b>Health &amp; Safety</b>	
Nitrile gloves	
Hard hat	
Steel-toed boots	
Hearing protection	
Field first-aid kit	
Eyewash	
Safety glasses	
Respirator and cartridges (if necessary)	
Saranex/Tyvek suits and booties (if necessary)	
<b>Soil Sampling Equipment</b>	
Photoionization detector	
Portable table	
Plastic sheeting	
Knife/DPT liner opening tool	
Tape measure	
Digital camera	
Hand auger/Step sampler system	
Stainless steel scoops or trowels	
Stainless/Glass steel mixing bowl/disposable aluminum pans	

**SURFICIAL AND SUBSURFACE SOIL SAMPLING**  
**(Standard Operating Procedure 004)**

<b>TABLE 1: SOIL SAMPLING EQUIPMENT &amp; MATERIAL CHECKLIST (cont.)</b>	
<b>Item Description</b>	
Pre-cleaned disposable plastic sampling scoops	
Laboratory-supplied bottleware	
Chain-of-custody forms and custody seals	
Wire tags	
Packaging tape	
Field logbook	
Pin flags and marking paint	
Indelible Ink Pen	
<b>Decontamination and Waste Management Equipment</b>	
US DOT-approved 55-gallon drums or other appropriate containers	
Drum wrench	
Duct tape	
Rinse bottle	
Potable water	
Non-phosphate detergent	
Decontamination fluids (deionized water, nitric acid, isopropyl alcohol, methanol) as appropriate	
Buckets or tubs	
Brushes	
Trash bags	
Paper towels	

# SURFICIAL AND SUBSURFACE SOIL SAMPLING (Standard Operating Procedure 004)

## Attachment 1 - USCS Field Sheet

SOIL CLASSIFICATION				SLOPE DESCRIPTION																																																																	
Major Division	Group Symbol	Typical Descriptions		%	Simple	Complex	Ratio	Degrees																																																													
Coarse-grained soils (>50% retained on #200 sieve)	Gravels (<50% pass on #4 sieve)	Clean gravel	GW	well graded gravels, gravel-sand mix	0-2	Nearly level	Nearly level	0-50:1	0-1																																																												
		Gravel w/fines	GP	poorly-graded gravels, gravel-sand mix	2-5	Gently sloping	Undulating	50:1-20:1	1-3																																																												
			GM	silty gravels, gravel-sand-silt mix	5-10	Moderately sloping	Gently rolling	20:1-10:1	3-6																																																												
			GC	clayey gravels, gravel-sand-clay mix	10-15	Strongly sloping	Rolling	10:1-6.5:1	6-9																																																												
		Sands (>50% pass on #4 sieve)	Clean sand	SW	well graded sands, gravelly sands	15-30	Moderately steep	Hilly	6.5:1-3:1	9-18																																																											
	Sand w/fines		SP	poorly-graded sands, gravelly sands	30-50	Steep	Steep	3:1-2:1	18-27																																																												
			SM	silty sands, sand-silt mix	50-75	Very steep	Very steep	2:1-1.3:1	27-38																																																												
			SC	clayey sands, sand-clay mix	>75	Extremely steep	Extremely steep	>1.3:1	>38																																																												
					<b>SOIL CLASSIFICATION FORMAT</b> Unified symbol; principal constituent; modifier for principal constituent(s) (i.e. grain size or plasticity); minor constituent(s); modifier for minor constituents(s); consistency/density/rock hardness; moisture content; color; additional descriptions																																																																
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**SEDIMENT SAMPLING**  
**(Standard Operating Procedure 007)**

**Revision No: 2**

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SOP Approval: Stephen D. Brower Date: 6/16/2021  
Stephen D. Brower, Principal Geoscientist

SOP Approval: Daniel P. Claycomb Date: 6/16/2021  
Daniel P. Claycomb, Principal Geoscientist



**SEDIMENT SAMPLING**  
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**ATTACHMENT**

Attachment 1   USCS Field Sheet

## **SEDIMENT SAMPLING** **(Standard Operating Procedure 007)**

### **1.0 PURPOSE**

This standard operating procedure (SOP) provides the general technical requirements and operational guidelines for collecting sediment samples that are representative of the environment that the samples are intended to characterize.

The requirements of this SOP are applicable to sediment sampling in marine environments, streams, rivers, lakes, ponds, and drainage ditches.

### **2.0 GENERAL CONSIDERATIONS**

Thoroughly evaluate potential hazards associated with the planned tasks prior to conducting field activities. Refer to the site-specific Health and Safety Plan (HASP) for a description of potential hazards and associated safety and control measures.

Prior to intrusive subsurface activities, the appropriate utility notifications (*i.e.*, National 811 One Call) must be made and the dates of intrusive activities must be within the lawful dates provided by the One Call Center. Verify, to the extent practicable, that utility owners have responded to the One Call request and have marked their respective utility. Suspend work if there is uncertainty associated with potentially unmarked utilities until the issues are resolved. Refer to the Utility Clearance SOP (SOP 003) for additional information.

Decontaminate reusable field sampling equipment in accordance with the Decontamination of Equipment SOP (SOP 017) prior to use and between sampling locations. Although sampling should typically be conducted in a relative least-impacted to most-impacted order (*i.e.*, clean to dirty), field logistics may necessitate other sample collection orders. When sampling does not proceed in a least-impacted to most-impacted fashion, take extra precautions to ensure that appropriate levels of decontamination are achieved.

Review project control documents for project-specific sampling requirements including sample collection locations.

Obtain the equipment necessary to conduct the sediment sampling program (see Table 1).

### **3.0 PROCEDURES**

Selection of sampling equipment and the sediment sample collection method will depend on the depth and velocity of the water and the sediment characteristics (*e.g.*, soft, hard, or rocky). Care must be taken when designing the sampling approach and selecting equipment to ensure that representative samples are collected.

In flowing water bodies, the preferred sampling location is downstream from a point where the water is well mixed both laterally and vertically. Sites immediately below riffle areas are excellent points to obtain sediment samples that are representative of the entire flow.

When possible, sampling is to proceed from downstream to upstream locations so that disturbance of sediments related to sampling does not affect the sample quality of subsequent locations.

The preferable sampling location of non-flowing water bodies, such as ponds and lakes, is the center of the water body. Additionally, take into consideration the water body shape, inflow pattern,

## **SEDIMENT SAMPLING**

### **(Standard Operating Procedure 007)**

bathymetry, and water circulation when selecting sampling sites in non-flowing water bodies. Only collect and handle sediment samples with clean, gloved (nitrile) hands. Change nitrile gloves between sampling locations and prior to handling samples for packing and shipping purposes.

### **3.1 On-Shore Method (Shallow Water)**

When liquid flow and water depth are minimal (*i.e.*, less than approximately four inches) and sediment is easy to reach, a trowel or scoop may be used to collect sediment samples. This situation is applicable to shallow rivers/streams, drainage ditches, or shallow portions of ponds/lakes. In general, when water is flowing or is greater than four inches in depth, a core sampler or clamshell device is best suited to collect the sediment sample in order to minimize loss of sediment as it is retrieved and moves through the water column. Complete the following steps when using the On-shore Method:

- Locate sediment sampling locations based upon the project control documents and mark the sediment sampling locations with pin flags or survey stakes (if possible).
- Use a hand-held Global Positioning System (GPS) unit to obtain sample location coordinates. Document sediment sampling locations in the field logbook. It is also recommended that a photograph be taken of the sampling location.
- Collect sediments at the appropriate depth interval(s) as specified in the project control documents, using a properly decontaminated stainless steel trowel, scoop, or similar device and a stainless steel or tempered glass container.

**Note:** To the extent practicable, stainless-steel equipment should be avoided when collecting samples that will be submitted for metals analysis.

- If necessary, subdivide the sample into the appropriate depth intervals.
- Classify and log the sediment sample according to the Unified Soil Classification System (USCS) along with other pertinent observations in the field logbook or on a project-specific soil boring log. See the attached USCS Field Sheet for details on USCS.

#### **3.1.1 Collection of Sediment Samples for VOC Analysis**

- Sediment samples that will be submitted for VOC analysis must be collected and placed in sample containers immediately (within minutes) following retrieval to reduce the loss of VOCs to volatilization and biodegradation. Refer to the Surficial and Subsurface Soil Sampling SOP (SOP 004) for additional VOC sample collection guidance.
- Sediment samples for VOC analysis will typically be collected using a Terra Core® sampling kit (or equivalent) or an EnCore® sampler.

##### *Terra Core Sampling Kit*

- The Terra Core sampling kit will typically include: one disposable T-Handle for sampling; three pre-preserved 40-ml volatile vials (one containing methanol and two containing reagent water); and one 2-ounce sample jar (for moisture content analysis).

## **SEDIMENT SAMPLING**

### **(Standard Operating Procedure 007)**

**Note:** Samples that are not methanol-preserved must be received and either frozen or analyzed by the laboratory within 48 hours of sample collection. Consequently, if shipping via an overnight courier the samples must be shipped to the laboratory on the same day that the samples are collected so that sample extraction can be performed at the laboratory within 48 hours from the time of collection.

As an exception to the above, two sodium bisulfate-preserved vials may be used in place of reagent water when the contaminant of concern is a petroleum hydrocarbon and the samples are not anticipated to contain calcium carbonate. The presence of calcium carbonate may cause the sample aliquot to effervesce in the vial and result in the loss of VOCs and possibly breakage. In addition, reactive compounds such as 2-chloroethylvinyl ether readily break down under acidic conditions. If Sodium bisulfate is used as a preservative, the holding time from sample collection to analysis is 14-days.

- Inspect the T-handle sampler to ensure it is in the “rest” or “sample load” position: the top of the plunger rod flush is with the T-handle so that a plug of soil can fill the cavity at the bottom of the T-handle.
- Using the T-handle, push the sampler into soil until the coring cavity is completely full. The T-handle sampler is designed to collect approximately 5-grams of sediment. Remove sampler from the sediment.
- Wipe excess sediment from exterior of the coring body using a clean paper towel.
- Insert the plug end of the T-handle into a preserved vial and expel the contents into the vial by rotating the T-handle 90-degrees and pushing down. Cap and seal the vial.
- Repeat the process for each vial. Collect the three sediment plugs as close together as possible.
- Fill the 2-ounce sample jar last. Using a disposable plastic sampling scoop, completely fill the jar with sediment, and then immediately seal the container. The sediment in this container is used to determine moisture content.
- Properly label sample containers according to Section 3.5. Do not place labels directly on the vials as they are pre-weighed by the laboratory. If the vials do not already have labels when received by the laboratory, place the vials in a re-sealable plastic bag and label the bag.
- Place samples upright in a cooler containing wet ice.

Samples containing gravel/rocks or very wet/loose sediment may be difficult to collect using a Terra Core sampler. If several attempts to collect a sediment plug with a Terra Core sampler are unsuccessful (e.g., because the sample contains gravel or rocks that are wet/loose), fill a 4-oz wide-mouth jar with undisturbed sediment as full as practical using a disposable plastic sampling scoop (or similar device) to minimize headspace.

#### *En Core Sampler:*

- The En Core sampler is made of an inert, composite polymer and is available in 5-gram and 25-gram sizes. Three En Core samplers are typically used for each sediment sample

## SEDIMENT SAMPLING (Standard Operating Procedure 007)

location. An En Core stainless steel T-Handle is also required when using the En Core sampler.

- While holding the En Core sampler coring body, push the plunger rod down until the small O-ring rests against the tabs to ensure that the plunger moves freely.
- Depress the locking lever on the En Core T-handle, aligning the two slots on the coring body with the two locking pins in the T-handle. Twist the coring body clockwise to lock the pins into the slots. Check to ensure that the sampler is in place. The sampler is now ready for use.
- Turn the T-Handle with the “T” pointed up and the coring body pointed down; this action positions the plunger bottom flush with the bottom of the coring body. Using the T-handle, push the sampler into the sediment until the coring body is completely full. When full, the small O-ring will be centered in the T-handle viewing hole. Remove the sampler from the sediment. Wipe excess sediment from the coring body exterior with a clean paper towel.
- Cap the coring body while still on the T-handle. Push and twist the cap over the bottom until the grooves on the locking arms seat over the ridge on the coring body. The **cap must be seated on both sides to seal the sampler.**
- Repeat the process until the required number of En Core samplers have been filled with sediment samples (typically three). Collect the three sediment plugs as close together as possible.
- Following collection, place the En Core samplers into their respective resealable bags and label the bags according to Section 3.5.
- The sampled material contained in an En Core Sampler can only be stored in the device for a maximum of 48 hours; consequently, if shipping via an overnight courier the samples must be shipped to the laboratory on the same day that the samples are collected so that sample extraction can be performed at the laboratory within 48 hours from the time of collection.
- Samples containing gravel/rocks or very wet/loose sediment may be difficult to collect using an En Core Sampler. If several attempts to collect a soil plug with an En Core Sampler are unsuccessful (e.g., because the sample contains gravel or rocks that are wet/loose), fill a 4-oz wide-mouth jar with undisturbed sediment as full as practical using a disposable plastic sampling scoop (or similar device) to minimize headspace.

**Note:** If possible, it is preferable to collect the VOC sample from undisturbed sediment (at the top of the sample interval) because the use of a manual collection device breaks up the sediment structure and can result in the loss of VOCs.

### **3.1.2 Collection of Sediment Samples for Non-VOC Analysis**

- Sediment samples submitted for analysis of non-VOC constituents, such as semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), metals, or cyanide, must be homogenized, provided sample volume allows, to create a representative sample. Refer to the Surficial and Subsurface Soil Sampling SOP (SOP 004) for additional non-VOC sample collection guidance.

## **SEDIMENT SAMPLING**

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- When sample quantity is limited, prioritize the analytical parameters in consultation with the Project Manager.
- Homogenization shall take place in a decontaminated stainless steel or glass mixing bowl/tray.

**Note:** Do not use stainless steel equipment for samples that will be analyzed for metals.

- The goal of homogenization is to achieve a consistent physical appearance over the entire sediment sample.

**Note:** Prior to homogenization, remove twigs, roots, leaves, rocks, and miscellaneous debris from the sample using a decontaminated stainless steel spoon/scoop/spatula or a clean plastic sampling scoop.

- Conduct homogenization by mixing the sample and then quartering the sample. Once quartered, mix each quarter individually and then roll the quarters to the center and mix the entire sample again. Repeat this process at least twice. Care should be taken to minimize contact of disposable gloves worn during sampling with sediment.
- Once a consistent physical appearance has been obtained, transfer appropriate volumes of sediment into certified-clean, laboratory-supplied, and preserved (if necessary) bottlenecks with either a decontaminated stainless steel or glass spoon/scoop/spatula or a clean plastic sampling scoop.
- Following collection, seal and properly label the sample containers according to Section 3.5.
- Immediately place sample containers upright in a cooler containing wet ice.

### **3.2 Off-Shore Method (Deep Water)**

It will be necessary, in some cases, to use a boat or barge to collect sediment samples. Generally, water that is deeper than the knees is considered unsafe to enter without a watercraft. In some cases the water may be too deep to use a scoop or trowel, but not deep enough for a boat or barge. In these instances, samples may be collected by a person standing in the water, provided it is deemed safe to do so. Select sampling devices used to collect sediment samples in deep water by considering the depth and flow of the water and the sediment bed characteristics. Usually, manual equipment (scoops and trowels) are not suitable for off-shore sampling; rather dredges, benthic samplers, or core samplers are more appropriate.

Sediment samples collected in deep water will normally be collected using either a spring-loaded sediment dredge (*i.e.*, Ponar grab sampler), benthic grab sampler, core sampler, or other similar equipment.

- Locate sediment sampling locations in accordance with the project control documents. Use a hand-held GPS unit to measure location coordinates and document coordinates in the field logbook. It is also recommended that a photograph be taken of the sediment sample location.
- Use a properly decontaminated sampler to collect a sediment sample.

## **SEDIMENT SAMPLING**

### **(Standard Operating Procedure 007)**

- When using a spring-loaded sediment dredge or a benthic grab sampler, lower the sampler into place in an open position. Once the device is lowered to the sediment-water interface, the weight of the sampler contacting the sediment will automatically trigger the trap to close.
- If necessary, subdivide the sample into the appropriate depth intervals.
- Classify and log the sediment sample according to the USCS along with pertinent observations in the field logbook or on project-specific sediment sampling logs.

#### **3.2.1 Collection of Sediment Samples for VOC Analysis**

- Perform the procedures presented in Section 3.1.1 of this SOP.

#### **3.2.2 Collection of Sediment Samples for Non-VOC Analysis**

- Perform the procedures presented in Section 3.2.1 of this SOP.

### **3.3 Sample Handling, Packing, and Shipping**

Samples will be marked, labeled, packaged, and shipped in accordance with the Sample Labeling, Packing, and Shipping SOP (SOP 016). Do not affix labels to pre-weighed sample containers such as VOC vials included with Terra Core kits.

### **3.4 Field Quality Control Samples**

Field QC samples may include trip blanks, equipment rinsate blanks, field duplicate samples, matrix spike, and matrix spike duplicate samples. Refer to the Field Quality Control Sampling Procedures SOP (SOP 015) for a description of common field QC samples and the associated collection method.

### **3.5 Field Logbook Documentation**

Field logbooks will be maintained by the Field Team Leader (or designee) to record daily activities. The minimum requirements for field logbook documentation are presented in the Field Documentation Procedures SOP (SOP 001).

### **3.6 Decontamination and Cleanup**

Sampling equipment decontamination will be performed in a manner consistent with SOP 017 and SOP 018.

### **3.7 Investigation-Derived Waste**

Investigation-derived waste (IDW) includes excess sediment samples, decontamination fluids, disposable sampling equipment, and disposable personal protective equipment (PPE). Manage IDW according to SOP 018.

## **SEDIMENT SAMPLING**

### **(Standard Operating Procedure 007)**

#### **4.0 REFERENCES**

- ASTM International (ASTM). Standard Practice for Description and Identification of Soils (Visual-Manual Procedures) – D2488-17e1, 2017.
- Montrose Environmental Solutions, Inc., Field Documentation Procedures SOP (SOP 001)
- Montrose Environmental Solutions, Inc., Field Screening Instrumentation and Procedures SOP (SOP 002).
- Montrose Environmental Solutions, Inc., Surficial and Subsurface Soil Sampling SOP (SOP 004).
- Montrose Environmental Solutions, Inc., Field Quality Control Sampling Procedures SOP (SOP 015).
- Montrose Environmental Solutions, Inc., Sample Labeling, Packing, and Shipping SOP (SOP 016).
- Montrose Environmental Solutions, Inc., Decontamination of Equipment SOP (SOP 017).
- Montrose Environmental Solutions, Inc., Management of Investigation-Derived Waste SOP (SOP 018).
- US EPA, SW-846 Method 5035A, Closed-System Purge-and-Trap Extraction for Volatile Organics in Soil and Waste Samples, Revision 1 July 2002.
- US EPA, Test Methods for Evaluating Solid Waste Physical/Chemical Analysis (SW-846).



**SEDIMENT SAMPLING**  
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<b>TABLE 1: SEDIMENT SAMPLING EQUIPMENT &amp; MATERIAL CHECKLIST</b>	
<b>Item Description</b>	<b>CHECK ✓</b>
<b>Health &amp; Safety</b>	
Nitrile gloves	
Hard hat	
Steel-toed boots	
Hearing protection	
First-aid kit	
Eyewash	
Safety glasses	
Respirator and cartridges (if necessary)	
Saranex/Tyvek suits and booties (if necessary)	
<b>Sediment Sampling Equipment</b>	
Photoionization detector	
Portable table	
Plastic sheeting	
Knife/DPT liner opening tool	
Tape measure	
Hand-held GPS unit	
Digital camera	
Sediment dredge sampler, benthic grab sampler, or similar sampling devices	
Stainless steel or glass scoops or trowels	
Stainless steel or glass mixing bowl	

**SEDIMENT SAMPLING**  
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<b>TABLE 1: SEDIMENT SAMPLING EQUIPMENT &amp; MATERIAL CHECKLIST (cont.)</b>	
<b>Item Description</b>	
Environmental sampling scoops	
Terra Core or En Core Samplers (if VOC sample collection is required)	
Laboratory-provided bottleware	
Disposable plastic sampling scoops	
Laboratory-supplied bottleware	
Sample cooler with wet-ice (and bags for ice)	
Chain-of-custody forms and custody seals	
Packing tape	
Field logbook	
Pin flags and marking paint	
Permanent marker and indelible ink pen	
<b>Decontamination and Waste Management Equipment</b>	
US DOT-approved 55-gallon drums or other appropriate containers	
Drum wrench	
Duct tape	
Rinse bottle	
Potable water	
Non-phosphate detergent	
Decontamination fluids (deionized water, nitric acid, isopropyl alcohol, methanol)	
Buckets or tubs	
Brushes	
Trash bags	
Paper towels	

# SEDIMENT SAMPLING (Standard Operating Procedure 007)

## Attachment 1 - USCS Field Sheet


SOIL CLASSIFICATION				SLOPE DESCRIPTION					
Major Division	Group Symbol	Typical Descriptions		%	Simple	Complex	Ratio	Degrees	
Coarse-grained soils (>50% retained on #200 sieve)	Gravels (<50% pass on #4 sieve)	Clean gravel	GW	well graded gravels, gravel-sand mix	0-2	Nearly level	Nearly level	0-50:1	0-1
		Gravel with fines	GP	poorly-graded gravels, gravel-sand mix	2-5	Gently sloping	Undulating	50:1-20:1	1-3
			GM	silty gravels, gravel-sand-silt mix	5-10	Moderately sloping	Gently rolling	20:1-10:1	3-6
		GC	clayey gravels, gravel-sand-clay mix	10-15	Strongly sloping	Rolling	10:1-6.5:1	6-9	
	Sands (<50% pass on #4 sieve)	Clean sand	SW	well graded sands, gravelly sands	15-30	Moderately steep	Hilly	6.5:1-3:1	9-18
		Sand with fines	SP	poorly-graded sands, gravelly sands	30-50	Steep	Steep	3:1-2:1	18-27
			SM	silty sands, sand-silt mix	50-75	Very steep	Very steep	2:1-1.3:1	27-38
		SC	clayey sands, sand-clay mix	>75	Extremely steep	Extremely steep	>1.3:1	>38	
		<b>SOIL CLASSIFICATION FORMAT</b>							
		<b>ADDITIONAL SOIL DESCRIPTIONS</b>							
<b>USCS ADDITIONAL SYMBOLS</b>									
Fine-grained soils (>50% passing on #200 sieve)	Silt and Clays (LL < 50)	ML	inorganic silts and v. fine sands, rock flour, silty or clayey sands, or clayey silts with slight PI	clay & silt	- #200		<b>STRIKE &amp; DIP</b> STRIKE - line made by intersection of bedding with horizontal DIP - Angle of bedding plane made from horizontal		
		CL	inorganic clays of low to med. PI, gravelly clays, sandy clays, silty clays, lean clays	sand	#200 to #4				
		OL	organic silts and organic silty clays with low PI	gravel	#4 to 3"				
		OH	fat clays	cobbles	3" to 12"				
	Silt and Clays (LL > 50)	MH	inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	boulders	12" +	<b>USCS ADDITIONAL SYMBOLS</b> Gravels with 5% to 12% fines require dual symbols: GW-GM well graded gravel with silt GW-GC well graded gravel with clay GP-GM poorly graded gravel with silt GP-GC poorly graded gravel with clay Sands with 5% to 12% fines require dual symbols: SW-SM well graded sand with silt SW-SC well graded sand with clay SP-SM poorly graded sand with silt SP-SC poorly graded sand with clay			
		CH	inorganic clays with high PI, fat clays						
		OH	organic silts and organic silty clays with low PI						
		Pt	Peat and other very organic soil						
	Highly organic soils								
<b>SOIL MOISTURE</b>				<b>PERCENTAGE DESCRIPTION</b>					
dry				Qualifier					
slightly moist				No qualifier					
moist				'slightly'					
very moist				... 'y'					
wet				'very'					
<b>HAND-SPECIMEN</b>				<b>BLOW COUNT</b>					
Clay Only		Cohesive Soil		Cohesionless Soil		Bedrock			
		Consistency	Blows/ft	Density	Blows/ft	Hardness	Blows/ft		
Squeezes between fingers closing hand		very soft	0 - 2	very loose	< 4	weathered	< 20		
Easily molded by fingers		soft	2 - 4	loose	4 - 10	firm	20 - 30		
Molded by strong finger pressure		medium stiff	4 - 8	medium dense	10 - 30	med. hard	30 - 50		
Dented by strong finger pressure		stiff	8 - 15	dense	30 - 50	hard	50 - 80		
Dented slightly by finger pressure		very stiff	15 - 30	very dense	50 +	very hard	80 +		
Dented slightly by pencil point		hard	30 +						

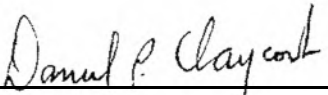
**SURFACE WATER SAMPLING**  
**(Standard Operating Procedure 008)**

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Stephen D. Brower, Principal Geoscientist

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**SURFACE WATER SAMPLING**  
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**TABLE**

Table 1: Surface Water Sampling Equipment & Materials Checklist

# **SURFACE WATER SAMPLING**

## **(Standard Operating Procedure 008)**

### **1.0 PURPOSE**

This standard operating procedure (SOP) provides the general technical requirements and operational guidelines for the collection of surface water samples for laboratory analysis.

This procedure is applicable to surface water sampling of streams, lakes, ponds, and shallow water features such as drainage ditches.

### **2.0 GENERAL CONSIDERATIONS**

Thoroughly evaluate potential hazards associated with the planned tasks prior to conducting field activities. Refer to the site-specific Health and Safety Plan (HASP) for a description of potential hazards and associated safety and control measures.

Sampling personnel who must enter the water shall remain downstream of the sampling location, if possible. Wear the appropriate level of PPE (refer to site-specific HASP) at all times when entering the water. In general, use the US Geological Survey (USGS) rule of thumb that prohibits wading if the product of depth (in feet) and velocity (in feet/second) exceeds eight anywhere in the river cross-section (USGS, variously dated). If flow data are unavailable, personnel will not enter beyond knee height. Make every attempt to utilize a sampling device that eliminates the need for personnel to enter the water body. For sample locations that are a considerable distance from the shoreline, a boat, barge, dock, or bridge should be employed for sampling (when possible). Water safety hazards and associated precautions must be thoroughly considered and understood prior to conducting sampling activities in the vicinity of surface water.

Surface water samples will be collected at locations that are most likely to be impacted based on factors such as source, drainage patterns, and environmental features of concern or as specified in project control documents. Collect surface water samples prior to the collection of sediment, benthic, or biological samples to avoid contamination of the samples by agitation of the bottom sediments. Consideration should be given to using a container large enough to collect samples for both field and laboratory analysis.

Decontaminate reusable field sampling equipment in accordance with the Decontamination of Equipment SOP (SOP 017) prior to use. Although sampling is ideally conducted in a relative least-impacted to most-impacted order, field conditions may necessitate other sample collection orders. When sampling does not proceed in a least-impacted to most-impacted fashion, take extra precautions to ensure that appropriate levels of decontamination are achieved.

Surface waters generally fall into two broad categories - flowing surface waters and still or stagnant waters. Surface water samples will generally be listed as grab or composite samples. Specific considerations associated with sampling each type of surface water encountered are discussed in the following sections.

The following devices are generally used to collect surface water samples:

- Laboratory-provided sample bottle
- Kemmerer depth sampler
- Water bottle sampler
- ISCO composite sampler

## **SURFACE WATER SAMPLING (Standard Operating Procedure 008)**

### **3.0 PROCEDURES**

Wear clean nitrile gloves when collecting and handling surface water samples. Change nitrile gloves between sampling locations and prior to handling samples for packing and shipping purposes.

#### **3.1 Sampling Flowing Surface Waters (Rivers, Streams, or Drainage Ditches)**

- Project control documents may necessitate a specific sampling location; in general, however, the preferable sampling location of flowing water bodies is where the water is well mixed laterally and vertically. These locations are characterized by fast moving or turbulent waters. Sites immediately below riffle areas are generally representative of the entire flow.
- In the case of calmer waters, the preferred sampling location is the thalweg (area of highest flow rate).
- Begin by selecting the farthest downstream sampling location. If possible, collect downstream samples first, followed by upstream samples. This order minimizes the disturbance of bottom sediments and the likelihood to impact downstream sample locations.

##### **3.1.1 *Grab (or Discrete) Sample Collection***

- When the collection of a discrete sample at a specific depth is required, use of a Kemmerer sampler (or similar device) is preferred. A Kemmerer sampler is comprised of an open tube that is allowed to float between its top and bottom caps. At a desired sample depth, a weighted messenger is sent down the associated towline compressing the top cap into the tube and into the bottom cap, thereby closing the sample tube on both ends.
- Lower the Kemmerer sampler to the appropriate depth.
- Once at the desired depth, use the weighted messenger or trigger to close the sampling device.
- A grab sample may also be collected by lowering the capped sample container to the desired depth, removing the cap and allowing the sample container to fill, replacing the cap, and then removing the container from the water. This method is only applicable to sample containers that are not pre-preserved.
- For sample bottles containing preservatives, first fill a separate, certified-clean, unpreserved bottle (*i.e.* transfer container) and then transfer the water from the transfer container into the preserved bottle. See section 3.1.1.1 of this SOP for additional information on collecting samples for volatile organic compound (VOC) analysis.
- A surface grab sample may be collected when a surface sheen/film is observed, when low water conditions exist, when a sample from the upper surface of the water body is required, or when the current velocity is such that sample collection cannot be accomplished at the desired depth.
- When a surface film is visible or suspected, the surface of the water will be sampled by gently lowering the sample bottle into the water with the mouth of the bottle tilted upstream, taking reasonable measures to avoid suspended/floating debris.

## **SURFACE WATER SAMPLING**

### **(Standard Operating Procedure 008)**

- If a surface film is not present, gently submerge the sample bottle into the current just beneath the surface so that the open end of the bottle is tilted downstream to minimize the potential entrainment of floating debris into the sample.
- Immediately cap/seal each sample and place the sample into a cooler containing bagged wet ice to maintain sample temperature preservation requirements in accordance with the procedures outlined in the Sample Labeling, Packing, and Shipping SOP (SOP 016).
- Note the sample identification and sample collection time in field logbook and on the Chain-of-Custody record.
- Once sampling is completed, decontaminate reusable sampling items in accordance with the procedures outlined in the Decontamination of Equipment SOP (SOP 017) prior to collection of the next sample.

#### **3.1.1.1 Collection of Samples for VOC analysis**

- For VOC analysis, gently fill 40-mL glass vials supplied by the analytical laboratory using the unpreserved transfer bottle until there is a reverse or convex meniscus at the top of the vial. The sample should be collected with as little agitation or disturbance as possible.
- After the cap is securely tightened, ensure there are no bubbles (headspace) in the vial by inverting the vial and tapping it several times on the palm of one hand.
- If the sample is being field-preserved and a "pea-sized" or larger bubble (*i.e.*, bubbles exceeding 1/4 inch or 6 mm in diameter) is present, discard the sample, refill the vial and add the appropriate preservative. If the vial is pre-preserved, discard the vial and recollect the sample using a new, preserved vial.

**Note:** If effervescence due to the presence of carbonaceous material is anticipated or identified, samples for VOC analysis shall be collected in unpreserved vials and submitted to the laboratory as soon as possible. Notify the laboratory that the VOC samples are unpreserved. Unpreserved aqueous VOC samples have a holding time from sample collection to analysis of 7-days.

#### **3.1.2 Composite (or Time-Weighted) Sample Collection**

- When the collection of a sample will be used to characterize general water-quality over a period of time, an automatic ISCO sampler (or similar device) can be used (See SOP 005, Water Sample Collection Procedures using a Composite Sampler).
- Determination of total sample time, total sample volume, and time between aliquot collection (sub-samples) should be considered when programming automatic ISCO samplers to obtain a representative time-weighted sample.
- Once all sample aliquots have been collected, combine the water from the individual sub-sample containers into a clean composite container. Thoroughly homogenize the sample.



## **SURFACE WATER SAMPLING**

### **(Standard Operating Procedure 008)**

- Transfer water from the composite sample container into the laboratory sample container. Shake the composite container after bottleware for each parameter is filled so that the sample remains homogenized.
- Grab samples may also be composited with samples taken at varying locations.
- This method is not appropriate for VOC analysis. VOC samples must be collected as grab samples, either before, during, or after the composite sampling event.

### **3.2 Sampling Still or Stagnant Waters (e.g., ponds, lakes, puddles)**

- Project control documents may necessitate a specific sampling location; in general, however, when sampling still or stagnant waters, it is important to collect a “vertical” sample of the water because still waters have a greater tendency to stratify than rivers or streams. Collect a sample near the bottom of the body of water (without disturbing the sediment).
- If the water body is large enough so that the sample location cannot be reached from the shore, a boat or other type of watercraft should be used (when possible) to reach the sampling area. Gentle rowing in a small boat will cause less sediment disturbance than wading through the surface water feature.

#### **3.2.1 *Grab (or Discrete) Sample Collection***

- Grab samples can be collected using a Kemmerer sampler (or similar device) or clean sample bottle. Refer to Section 3.1.1 of this SOP for details on the use of the selected sample device.

#### **3.2.2 *Composite (or Time-Weighted) Sample Collection***

- Procedures for collecting samples from still/stagnant waters are similar to the procedures for samples collected from flowing surface waters. Composite sample collection methods are described in Section 3.1.2 of this SOP, and in Montrose Environmental Solutions, Inc. Water Sample Collection Procedures using a Composite Sampler SOP (SOP 005).

### **3.3 Sample Handling, Packing, and Shipping**

Samples will be marked, labeled, packaged, and shipped in accordance with the Sample Labeling, Packing, and Shipping SOP (SOP 016).

### **3.4 Field Quality Control Samples**

Field QC samples may include trip blanks, equipment rinsate blanks, field duplicate samples, matrix spike and matrix spike duplicate samples. Refer to the Field Quality Control Sampling Procedures SOP (SOP 015) for a description of common field QC samples and associated collection methods.

### **3.5 Field Logbook Documentation**

Field logbooks will be maintained by the Field Team Leader (or designee) to record daily activities. The minimum requirements for field logbook documentation are presented in the Field Documentation Procedures SOP (SOP 001).

## **SURFACE WATER SAMPLING (Standard Operating Procedure 008)**

In addition to the minimum requirements discussed in the Field Documentation Procedures SOP (SOP 001), record the following information when surface water sampling:

- Sample identification code and/or number.
- Water depth and location of sample (e.g., surface, mid-depth).
- Water characteristics (e.g., turbidity, color, temperature, flow rate).
- Description and sketch of sample locations and the water body.
- Start time, stop time, total volume, and number of aliquots, if a composite sample was collected.
- Changes to the sampling locations and reasons.
- Description of photographs taken.

### **3.6 Decontamination and Cleanup**

Sampling equipment decontamination will be performed in a manner consistent with SOP 017.

### **3.7 Investigation-Derived Waste**

Investigation-derived waste (IDW) includes excess samples, decontamination fluids, disposable sampling equipment, and disposable personal protective equipment (PPE). Manage IDW according to SOP 018.

## **4.0 REFERENCES**

- Montrose Environmental Solutions, Inc. Field Documentation Procedures SOP (SOP 001).
- Montrose Environmental Solutions, Inc. Water Sample Collection Procedures using a Composite Sampler (SOP 005).
- Montrose Environmental Solutions, Inc. Field Quality Control Sampling Procedures SOP (SOP 015).
- Montrose Environmental Solutions, Inc. Sample Labeling, Packing, and Shipping SOP (SOP 016).
- Montrose Environmental Solutions, Inc. Decontamination of Equipment SOP (SOP 017).
- Montrose Environmental Solutions, Inc., Management of Investigation-Derived Waste SOP (SOP 018).
- US Geological Survey, variously dated\*, National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Chaps. A1-A9.
- US EPA, SW-846 Method 5035A, Closed-System Purge-and-Trap Extraction for Volatile Organics in Soil and Waste Samples, Revision 1 July 2002.
- US EPA, Test Methods for Evaluating Solid Waste Physical/Chemical Analysis (SW-846).

\*Citation information is for the online manual and its individually updated chapters. All versions that were published previously in a printed format have been superseded by the online manual <http://pubs.water.usgs.gov/twri9A>

**SURFACE WATER SAMPLING**  
(Standard Operating Procedure 008)

<b>TABLE 1: SURFACE WATER SAMPLING EQUIPMENT &amp; MATERIALS CHECKLIST</b>	
<b>Item Description</b>	<b>CHECK</b> ✓
<b>Health &amp; Safety</b>	
Nitrile gloves	
Hard hat	
Steel-toed boots	
Hearing protection	
Field first-aid kit	
Eyewash	
Safety glasses	
Barricades, cones, flashing lights, signs (if sampling from a bridge)	
US Coast Guard-approved personal flotation device (PFD)	
Sufficient length of rescue line	
Waders	
Health and Safety Plan	
<b>Surface Water Sampling Equipment</b>	
Sampling plan/scope-of-work/project guidance documents	
Location map, field data from previous sampling events	
Portable table	
Tape measure	
Hand-held GPS unit	
Digital camera	
Laboratory-supplied bottleware (including sample transfer bottle) and cooler	

**SURFACE WATER SAMPLING**  
**(Standard Operating Procedure 008)**

<b>TABLE 1: SURFACE WATER SAMPLING EQUIPMENT &amp; MATERIALS CHECKLIST (cont.)</b>	
<b>Item Description</b>	<b>CHECK</b> ✓
Chain-of-Custody forms and custody seals	
Field logbook	
Permanent marker and indelible ink pen	
Packing tape	
Kemmerer Depth Sampler	
ISCO Manual or Composite Sampler	
<b>Decontamination and Waste Management Equipment</b>	
US DOT-approved 55-gallon drums or other appropriate containers	
Drum wrench	
Duct tape	
Plastic sheeting	
Rinse bottle	
Non-phosphate detergent	
Potable water	
Decontamination fluids (deionized water, nitric acid, isopropyl alcohol, methanol)	
Buckets or tubs	
Brushes	
Trash bags	
Paper towels	



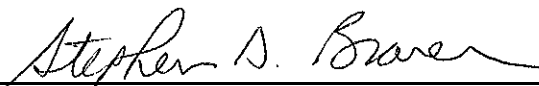
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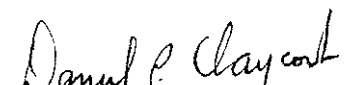
**LOW-FLOW (Reduced Drawdown) GROUNDWATER SAMPLING  
(Standard Operating Procedure 013)**

**Revision No: 2**

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Original Date: November 12, 2008

SOP Approval:  Date: 4/30/2021  
Stephen D. Brower, Principal Geoscientist

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Daniel P. Claycomb, Principal Geoscientist

**LOW-FLOW (Reduced Drawdown) GROUNDWATER SAMPLING  
(Standard Operating Procedure 013)**

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**TABLE**

Table 1	Low-Flow (Reduced Drawdown) Groundwater Sampling Equipment & Material Checklist
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**ATTACHMENT**

Attachment A Low-Flow Indicator Parameter Stabilization Form

# **LOW-FLOW (Reduced Drawdown) GROUNDWATER SAMPLING (Standard Operating Procedure 013)**

## **1.0 PURPOSE**

This standard operating procedure (SOP) provides the general technical requirements and operational guidelines for the collection of groundwater samples from monitoring wells using low-flow purging and sampling techniques.

## **2.0 GENERAL CONSIDERATIONS**

Thoroughly evaluate potential hazards associated with the planned tasks prior to conducting field activities. Refer to the site-specific Health and Safety Plan (HASP) for a description of potential hazards and associated safety and control measures.

Decontaminate reusable field sampling equipment in accordance with the Decontamination of Equipment SOP (SOP 017) prior to use. Although sampling is ideally conducted in a relative least-impacted to most-impacted order, field conditions may necessitate other sample collection orders. When sampling does not proceed in a least-impacted to most-impacted fashion, take extra precautions to ensure that appropriate levels of decontamination are achieved.

Review the following information prior to the start of sampling activities and make the information available for reference in the field as necessary. This information is useful when determining the sampling order, pump intake depths, and purge and recharge rates and can also facilitate troubleshooting.

- A list specifying the monitoring wells to be sampled.
- Monitoring well location information.
- A list of the analytical requirements for each sampling location.
- Boring logs and well construction details.
- Survey data that identify the documented point of reference (V-notch or other mark on well casing).
- Prior depth-to-water (DTW) and depth-to-bottom (DTB) measurements.
- Previous pump placement depths for each monitoring well.
- Previous pump settings and pumping and drawdown rates.
- Previous analytical results for each monitoring well, if known.

The equipment required to properly conduct low-flow purging and sampling is listed on Table 1.

## **3.0 PROCEDURES**

### **3.1 Water-Level Measurements**

Prior to pump placement, measure the initial DTW level. For monitoring wells screened across the water table, this measurement will be used to determine the appropriate depth to set the pump intake (typically, mid-point of the saturated screen length). The following procedure will be used to measure DTW levels.

- Inspect the well head area for evidence of damage or disturbance. Record notable observations in the field logbook.
- Open the protective outer cover of the monitoring well. Remove any debris that has accumulated around the riser near the well plug. If present, remove water above the top of the riser and well plug. Do not remove the well plug until the water above the well plug has

## **LOW-FLOW (Reduced Drawdown) GROUNDWATER SAMPLING (Standard Operating Procedure 013)**

been removed.

- For wells where volatile organic vapors may be present, or if specified in the project control documents, monitor the headspace in the well with a photoionization detector (PID) immediately after opening the well plug. Record the PID readings in the field logbook.
- After opening the well, allow the groundwater level to equilibrate a minimum of five minutes prior to measuring DTW.
- Using an electronic water-level indicator accurate to 0.01 foot, measure the distance between the established point of reference (usually a V-notch or indelible mark on the well riser) and the surface of the standing water present within the well. Repeat this measurement until two successive readings agree to within 0.01 foot. Record this measurement in the field logbook.
- If the monitoring well has the potential to contain non-aqueous phase liquids (NAPLs), gauge the well for these materials using an optical interface probe. If NAPL is present, consult the Project Manager for direction regarding sample collection. In general, groundwater samples should not be collected for laboratory analysis from monitoring wells containing NAPL.
- Decontaminate the water-level indicator (and interface probe if applicable) and return it to its clean protective case. When collecting water-level measurements from multiple wells, proceed in a relative least-impacted to most-impacted order and properly decontaminate the water-level indicator (and interface probe, if applicable) between wells to avoid cross-contamination.

### **3.2 Well Purging**

Wells must be purged prior to sampling to ensure that representative groundwater is obtained from the water-bearing unit. If the well has been previously sampled in accordance with this SOP, use existing information regarding pump intake depths and the pumping rates from previous sampling events to guide the current sampling event.

Published US EPA guidance states that “Suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds”; accordingly, peristaltic pumps (suction) are not recommended for use in low-flow purging and sampling (US EPA, 1996). Adjustable-rate bladder and electric submersible pumps are preferred for use during low-flow purging and sampling activities. Note that a ball valve (or similar valve constructed of polyethylene or brass) may need to be installed to reduce the flow rate to the required level.



## LOW-FLOW (Reduced Drawdown) GROUNDWATER SAMPLING (Standard Operating Procedure 013)

The low-flow purging and sampling technique is described below.

- Using the specific details of well construction and the current DTW measurement, determine the pump set depth (typically the mid-point of the saturated well screen or other target sample collection depth adjacent to specific high-yield zones).
- Measure the length of string needed to situate the pump intake at the desired depth. Be sure to account for the distance from where the string is attached to the pump to the pump intake location.
- Attach tubing and string to the pump and very slowly lower the pump until the desired pump intake depth is reached. Record the distance from the established point of reference to the pump intake in the field logbook.

**Note:** Slowly lowering the pump through the water column will reduce the amount of sediment released from the well pack thereby reducing the purge time required to meet the stability criterion for turbidity.

- After allowing at least five minutes for the water level to equilibrate, slowly lower the electronic water-level meter probe into the well until the probe contacts the groundwater surface. Record the DTW in the field logbook.
- If the well has been previously sampled using low-flow purging and sampling methods, begin purging at a rate known to induce minimal drawdown. Frequently monitor the drawdown in the well. If results from previous sampling event are not known, begin purging the well at the minimum pumping rate (0.1 liter per minute (LPM); US EPA, July 1996). Slowly increase the pumping rate to a level that does not cause the well to drawdown more than 0.3 foot, if possible. Never increase the pumping rate to a level in excess of 0.5 LPM. Record the stabilized flow rate, drawdown, and purge time in the field logbook or on field data sheets.

For wells screened below the static water level, if the drawdown does not stabilize at a pumping rate of 0.1 LPM, pumping may continue until the drawdown reaches a depth of two feet above the top of the well screen. If this occurs, pumping may be stopped, and a groundwater sample may be collected once the well has recovered sufficiently to collect the appropriate volume. Document the details of purging, including the purge start time, rate, and drawdown in the field logbook.

For wells screened across the static water level, if the drawdown does not stabilize at 0.1 LPM, pumping may continue; however, in general, the water level shall not be drawn down more than 25% of the distance between the static water level and pump intake depth (ASTM, 2002). If the recharge rate of the well is lower than the minimum pumping rate, then samples may be collected at this point even though groundwater quality indicator parameters have not stabilized (US EPA, July 1996). Sampling can commence as soon as the water level has recovered sufficiently to collect the required sample volumes. Do not remove or otherwise disturb the pump during this recovery period to minimize the turbidity of the water samples. Fully document the pump settings, pumping rate, drawdown, and groundwater quality indicator parameter readings in the field logbook.

**Note:** *For wells that have very slow recharge rates or that draw down excessively at the minimum pumping rate (0.1 L/min), the procedures described previously may not apply. For these “special*

## **LOW-FLOW (Reduced Drawdown) GROUNDWATER SAMPLING (Standard Operating Procedure 013)**

*case” wells, the Field Team Leader shall seek guidance from the Project Manager about the appropriate purging and sampling methodologies to be employed (e.g., volume-averaged purging and sampling).*

- Once an acceptable purge rate has been established and maintained, begin monitoring designated groundwater quality indicator parameters. Base the frequency of the measurements on the time required to completely evacuate one volume of the multi-parameter water-quality instrument's flow-through cell to ensure that independent measurements are made. For example, a 500-mL cell in a system pumped at a rate of 100 mL/minute will be evacuated in 5 minutes; accordingly, measurements should be made and recorded in the field logbook or on the Low-Flow Indicator Parameter Stabilization Form (Attachment A) at least 5 minutes apart.
- Groundwater quality indicator parameters are pH, oxidation-reduction potential (ORP or Eh), dissolved oxygen (DO), specific conductance, and turbidity.
- Stabilization has been reached when three consecutive readings, taken at 3-minute to 5-minute intervals, meet the following criteria (US EPA July 1996):

Parameter	Stabilization Criteria
pH	± 0.1 standard unit
Specific Conductance	± 3%
ORP/Eh	± 10 millivolts
DO	± 10% for values greater than 0.5 milligrams per liter (mg/L); Three readings less than 0.5 mg/L shall be considered stable.
Turbidity*	± 10% for values greater than 5 Nephelometric Turbidity Units (NTUs); Three readings less than 5 NTU is considered stable.

While every effort shall be taken to ensure that each groundwater quality indicator parameter stabilizes, some indicator parameters are more critical with respect to certain contaminant types. It is important to identify which indicator parameters are most important to the project prior to commencement of field activities so that unnecessarily protracted purge times can be avoided (e.g., the critical indicator parameter associated with sampling for volatile organic compounds (VOCs) is DO, and the critical indicator parameter associated with metals is turbidity).

\* In some instances, turbidity levels may be difficult to stabilize due to natural aquifer conditions or how the pump is deployed within the well. If turbidity readings do not stabilize, the decision to begin sampling will be based upon stabilization of more critical (e.g., dissolved oxygen for VOC analysis) indicator parameters without attainment of the targeted turbidity.

If after one hour of purging, critical groundwater quality indicator field parameters have not stabilized, consult the Project Manager for direction. Per US EPA guidance (US EPA 2017), if after two hours of purging, indicator field parameters have not stabilized, one of three optional

## **LOW-FLOW (Reduced Drawdown) GROUNDWATER SAMPLING (Standard Operating Procedure 013)**

courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization), c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may reflect a sampling bias and therefore, the data may not meet the data quality objectives of the sampling event). Fully document all efforts used to stabilize the parameters (e.g., modified pumping rates).

There are a variety of water-quality meters available that measure the groundwater quality indicator parameters identified above. It is preferred, but not required, to utilize a water-quality meter capable of measuring each of the water-quality parameters referenced previously (except for turbidity) in a single flow-through cell. If daily on-site calibration is recommended by the instrument manufacturer, follow the calibration procedures specified in the owner's manual. Document calibration procedures, including the calibration solutions used, expiration date(s), lot numbers, and calibration results in the project field logbook. Do not use expired calibration standards. Refer to the Field Screening Instrumentation and Procedures SOP (SOP 002) for additional information.

### **3.3 Sampling**

The following procedure applies to the collection of groundwater samples.

- Record the final pump settings immediately prior to sample collection in the field logbook.
- Measure and record the indicator parameter readings immediately prior to sample collection on both the stabilization form and in the field logbook.
- Record comments pertinent to the color and obvious odors (sulfur odor, petroleum hydrocarbons odor, etc.) associated with the purged groundwater.
- Arrange and label the sample bottles and ensure that preservatives are added, as required. Labeling must include a unique sample number, time and date of sampling, the initials of the sampler, and the requested analysis. Additionally, provide information pertinent to the preservation materials or chemicals used in the sample.
- Ensure that the pump tubing remains completely filled during sampling and that the water does not descend back into the well. Fill the pre-labeled sample bottles in the following order:
  - VOCs (see Section 3.3.1 below)
  - Semivolatile Organic Compounds (SVOCs)
  - Pesticides\PCBs
  - Total Petroleum Hydrocarbons (TPH)
  - Metals and Cyanide
  - Filtered Metals, if required
  - Other water-quality parameters
- Immediately cap/seal each sample and place the sample into a cooler containing wet bagged ice to maintain sample temperature preservation requirements in accordance with the procedures outlined in the Sample Labeling, Packing, and Shipping SOP (SOP 016).

## **LOW-FLOW (Reduced Drawdown) GROUNDWATER SAMPLING (Standard Operating Procedure 013)**

- Note the sample identification and sample collection time in field logbook and on the Chain-of-Custody record.
- Once sampling is completed, retrieve the pump and associated sampling equipment and decontaminate these items in accordance with the procedures outlined in the Decontamination of Equipment SOP (SOP 017).
- Close and secure the well. Clean up and remove materials left from the sampling event. Be sure that wastes are properly containerized and labeled.
- Review sampling records for completeness. Record additional notes and observations as appropriate.

### **3.3.1 Collection of Samples for VOC analysis**

- For VOC analysis, gently fill 40-mL glass vials supplied by the analytical laboratory so there is a reverse or convex meniscus at the top of the vial. The sample should be collected with as little agitation or disturbance as possible.
- After the cap is securely tightened, ensure there are no bubbles (headspace) present in the vial by inverting the vial and tapping it several times on the palm of one hand.
- If the sample is being field-preserved following collection and a "pea-sized" or larger bubble (*i.e.*, bubbles exceeding 1/4 inch or 6 millimeter in diameter) is present, discard the sample, refill the vial and add the appropriate preservative. If the vial is pre-preserved, discard the vial and recollect the sample using a new, pre-preserved vial.

**Note:** If effervescence due to the presence of carbonaceous material is anticipated or identified, samples for VOC analysis shall be collected in unpreserved vials and submitted to the laboratory as soon as possible. Notify the laboratory that the VOC samples are unpreserved. Unpreserved aqueous VOC samples have a holding time from sample collection to analysis of seven days.

### **3.4 Investigation-Derived Waste**

Investigation-derived waste (IDW) includes purge water, decontamination fluids, disposable sampling equipment, and disposable personal protective equipment (PPE). Containerize and manage IDW according to the Management of Investigation-Derived Waste SOP (SOP 018).

### **3.5 Sample Handling, Packing, and Shipping**

Samples will be marked, labeled, packaged, and shipped in accordance with the Sample Labeling, Packing, and Shipping SOP (SOP 016).

### **3.6 Field Quality Control Samples**

Field quality control (QC) samples may include trip blanks, equipment rinsate blanks, field duplicate samples, matrix spike and matrix spike duplicate samples. Refer to the Field Quality Control Sampling Procedures SOP (SOP 015) for a description of common field QC samples and the

## **LOW-FLOW (Reduced Drawdown) GROUNDWATER SAMPLING (Standard Operating Procedure 013)**

associated collection method.

### **3.7 Field Logbook Documentation**

Field logbooks will be maintained by the Field Team Leader (or designee) to record daily activities. The minimum requirements for field logbook documentation are discussed in the Field Documentation Procedures SOP (SOP 001).

The Low-Flow Indicator Parameter Stabilization Form (Attachment A) can be used to document the required information during purging and sampling. If used, include a reference to the Low-Flow Indicator Parameter Stabilization Forms in the field logbook.

The Field Team Leader will review the field logbook entries for completeness and accuracy. The Field Team Leader is also responsible for completion of the required data collection forms.

### **3.8 Decontamination and Cleanup**

Perform sampling equipment decontamination in a manner consistent with the Decontamination of Equipment SOP (SOP 017) and the Management of Investigation-Derived Waste SOP (SOP 018).

## **4.0 REFERENCES**

- Montrose Environmental Solutions, Inc., Field Documentation Procedures (SOP 001).
- Montrose Environmental Solutions, Inc., Field Screening Instrumentation and Procedures (SOP 002).
- Montrose Environmental Solutions, Inc., Field Quality Control Sampling Procedures (SOP 015).
- Montrose Environmental Solutions, Inc., Sample Labeling, Packing, and Shipping (SOP 016).
- Montrose Environmental Solutions, Inc., Decontamination of Equipment (SOP 017).
- Montrose Environmental Solutions, Inc., Management of Investigation-Derived Waste (SOP 018).
- US EPA, Region I. "Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells," *Revision 4*. September 19, 2017.
- US EPA, Office of Research and Development, Office of Solid Waste and Emergency Response. *Ground Water Issue*, "Low-Flow (Minimal Drawdown Sampling Procedures). Document Number EPA/540/S-95/504," April 1996.
- ASTM, "Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations," D 6771-18. 2018.
- New Jersey Department of Environmental Protection, Low Flow Purging and Sampling Guidance, December 2003.

**LOW-FLOW (Reduced Drawdown) GROUNDWATER SAMPLING  
(Standard Operating Procedure 013)**

<b>TABLE 1: LOW-FLOW (Reduced Drawdown) GROUNDWATER SAMPLING EQUIPMENT &amp; MATERIAL CHECKLIST</b>	
<b>Item Description</b>	<b>CHECK <input type="checkbox"/></b>
<b>Health &amp; Safety</b>	
Nitrile gloves	
Hard hat	
Steel-toed boots	
Hearing protection	
Field first-aid kit	
Eyewash	
Safety glasses	
Respirator and cartridges (if necessary)	
Saranex/Tyvek suits and booties (if necessary)	
<b>Paperwork</b>	
HASP	
Scope-of-work/project guidance documents	
Well construction data, location map, field data from previous sampling events	
Chain-of-custody forms and custody seals	
Field logbook	
<b>Measuring Equipment</b>	
Flow measurement supplies (e.g., graduated cylinder and stopwatch)	
Electronic water-level indicator capable of detecting non-aqueous phase liquid	
Photoionization detector	

**LOW-FLOW (Reduced Drawdown) GROUNDWATER SAMPLING  
(Standard Operating Procedure 013)**

<b>TABLE 1: LOW-FLOW (Reduced Drawdown) GROUNDWATER SAMPLING EQUIPMENT &amp; MATERIAL CHECKLIST (cont.)</b>	
<b>Item Description</b>	<b>CHECK <input type="checkbox"/></b>
<b>Sampling Equipment</b>	
Monitoring well keys	
Tools for well access (e.g., socket set, wrench, screwdriver, t-wrench)	
Laboratory-supplied certified-clean bottleware, preserved by laboratory (if necessary)	
Appropriate trip blanks and high-quality blank water	
Sample filtration device and filters	
Submersible pump	
Appropriate sample and airline tubing	
Stainless steel clamps to attach sample lines to pump	
Pump controller and power supply	
Oil-less air compressor, airline leads, and end fittings (if using bladder pump)	
In-line groundwater parameter monitoring device (e.g., YSI-556 Multi-Parameter meter and flow-through cell)	
Turbidity meter	
Calibration standards for monitoring devices	
<b>Decontamination and Waste Management Equipment</b>	
See Decontamination of Equipment SOP (SOP 017)	
<b>Packaging and Shipping Supplies</b>	
See Sample Packing, Shipping, and Labeling SOP (SOP 016)	

**LOW-FLOW (Reduced Drawdown) GROUNDWATER SAMPLING  
(Standard Operating Procedure 013)**

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Attachment A

Low-Flow Indicator Parameter Stabilization Form

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## Low Flow Indicator Parameter Stabilization Form

Date:	Initial DTW (ft):		<u>Stabilization Criteria:</u>	
Site:			Temperature: +/- 3 °C	pH: +/- 0.1 unit
Monitoring Well #:	Recharge Rate (sec):		SC: +/- 3%	ORP: +/- 10 mV
Pump Intake Depth (ft):	Discharge Rate (sec):		DO: +/-10%	Turbidity: +/-10% (+/- 1 NTU for values < 10)
Personnel:	Pressure (psi):			

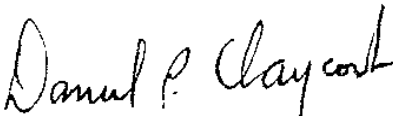
[illegible]


**INDOOR AIR AND AMBIENT AIR SAMPLING**

**(Standard Operating Procedure 014)**

Revision No: 1

Revision Date: November 26, 2013

Technical Review:  Date: 11/26/13  
Daniel P. Claycomb, Principal Geoscientist

  
Quality Assurance Officer: \_\_\_\_\_ Date: 11/26/13  
Gerald L. Kirkpatrick, Principal Geoscientist

**INDOOR AIR AND AMBIENT AIR SAMPLING**  
**(Standard Operating Procedure 014)**

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**TABLE**

Table 1 Equipment Checklist for Indoor Air and Ambient Air Sampling

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Attachment A - Indoor Air Building Survey

Attachment B – Air Sampling Timeline

# INDOOR AIR AND AMBIENT AIR SAMPLING (Standard Operating Procedure 014)

## 1.0 PURPOSE

This standard operating procedure (SOP) describes the requirements associated with indoor air and ambient air sampling techniques. The sampling techniques described herein must be followed to help ensure that air samples collected are representative and the resulting data useable. The requirements of this SOP are applicable to sampling of indoor or ambient (outdoor) air for volatile organic compounds (VOCs) using Summa® (or equivalent) canisters. This SOP supports the sampling method necessary for analysis of air samples by US Environmental Protection Agency (US EPA) Method TO-15.

## 2.0 GENERAL CONSIDERATIONS

Additional methods are available for conducting sampling (*i.e.*, tedlar bags) and screening of indoor air (*i.e.*, sorbent tubes); however, this SOP addresses Environmental Standards' procedures for the collection of VOCs in indoor air and ambient air samples.

Potential hazards associated with the planned tasks shall be thoroughly evaluated prior to conducting field activities. Refer to the site-specific Health and Safety Plan (HASP) for a description of potential hazards and associated safety and control measures.

Field sampling equipment shall be decontaminated in accordance with the Decontamination of Equipment SOP (SOP 017) prior to use.

The following information shall be reviewed prior to sampling and shall be made available for reference in the field as necessary.

- Information describing sample location(s) using site-specific maps.
- A list specifying the analytical requirements for each sampling location.
- Previous flow controller settings, if applicable.
- Previous analytical results, if available.

Obtain the equipment necessary to conduct the air sampling program (see Table 1).

## 3.0 PROCEDURES

This section documents general operating procedures and methods associated with indoor and ambient air sampling activities.

### 3.1 Sample Event Preparation

Ensure that the following activities have been completed prior to field mobilization:

- Provide the client representative with the sampling schedule and verify that site access has been authorized and arranged.
- Obtain and review the following project control documents with the Project Manager as appropriate: HASP, Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), Work Plan, site map(s), SOPs, site access agreement(s), and Indoor Air Building Survey and Sampling Form (Attachment A).

## **INDOOR AIR AND AMBIENT AIR SAMPLING (Standard Operating Procedure 014)**

- Order required equipment and supplies (e.g., Summa canisters, flow controllers, *etc.*) as listed on Table 1 of this SOP.
- Verify that the necessary equipment has been received and is in working order.
- Verify the initial vacuum of each canister against the value reported by the laboratory. If a discrepancy is noted between the reported and measured values, contact the laboratory and, if necessary, obtain replacement canisters.
- For indoor air sampling events, request the owner or occupant to remove containers of products potentially containing VOCs (e.g., paints, glues, solvents, thinners, petroleum products, lubricants, personal hygiene products, *etc.*) from the structure at least 48 hours prior to sampling. The containers shall be moved to a secure location outside of the building. If practicable, following removal of the items described above, the structure shall be ventilated (open windows, doors, increased HVAC circulation) for at least 24 hours. Following the ventilation period, the structure shall be sealed, to the extent practicable, for at least 24 hours prior to the sampling event. If the occupant refuses or is unable to remove these products, note the refusal and document the products appropriately. Subsequent reports to regulatory agencies shall identify that the materials were not removed at the request of the occupant.
- It is recommended that indoor air sampling be conducted concurrently with sub-slab soil gas sampling.
- For ambient air (outdoor) sampling events, evaluate the potential for precipitation and the need for protecting sampling equipment from precipitation. Additionally, the location of outdoor samples relative to potential sources of VOCs shall be evaluated and noted.

### **3.1.1 Building Survey**

Prior to conducting indoor air sampling, the investigator shall perform a Building Survey. The Indoor Air Building Survey and Sampling Form (Attachment A) shall be completed by the investigator to document pertinent information about the building, the occupants, and potential sources of indoor air contamination. Ideally, a building walk-through should be conducted approximately 1 week before the actual indoor air sampling event. The day before the sampling event, another visit to the site shall be conducted to confirm that the materials have been removed from the building. If it is not possible to visit the project site until the day of sampling, complete the Building Survey concurrently with the Site Assessment described in Section 3.2.1 of this SOP.

### **3.2 Indoor and Ambient Air Sampling (Operation)**

- Upon arrival at the site, the Field Team Leader will introduce the field team to the property owner and client representative, if present.
- The Field Team Leader is responsible for ensuring that the field team has read and signed the HASP and that visitors to the work area are familiar with the hazards, emergency evacuation routes, and the closest hospital or occupational health facility.

## **INDOOR AIR AND AMBIENT AIR SAMPLING** **(Standard Operating Procedure 014)**

### **3.2.1 Site Assessment**

Prior to collecting an indoor or ambient air sample, observe the sampling area for obvious odors and potential sources of VOCs. These sources may include, but are not limited to:

- Recently dry-cleaned clothes
- Carpet glue
- Paint
- Lubricants
- Fuels
- Paint thinners/strippers
- Upholstery cleaners
- Moth balls
- Furniture/floor polish
- Nail polish/nail polish remover
- Fungicide solutions
- Occupants who are smokers
- Degreasers
- Cleaning agents
- Wallpaper glue
- Solvents
- Waterproofers/epoxy
- Oven cleaners
- Insecticide solutions
- Hairspray
- Cologne/perfume
- Air fresheners
- Rug cleaners
- Pesticide/Herbicide solutions

Record visual observations of the sampling area and noticeable odors in the field logbook. Describe the locations of containers within the structure, their contents, volume, types and condition of containers, and brand names if this information has not already been obtained from the property owner/manager.

### **3.2.2 Sampling Apparatus Placement**

- With the exception of basement and crawl space samples, sampling apparatus shall be placed at a height proximal to the breathing zone of potential receptors (e.g., approximately 3 to 5 feet above the ground). In basements and crawl spaces, sampling apparatus shall be positioned on the ground as close as possible to the source area (e.g., near sumps, cracks).
- For a typical family residential dwelling (approximately 1,500 square feet), one indoor air sample will be collected in the basement and one indoor air sample will be collected on the first floor. In structures with no basements, one indoor air sample will be collected on the first floor and one indoor air sample will be collected on the second floor, both in the breathing zone. Multi-family residential units and commercial or retail buildings will require a more careful review of building features to optimize indoor air sampling locations.
- If conducting indoor air sample concurrently with sub-slab soil gas sampling, the sampling apparatus shall be placed immediately adjacent to the sub-slab soil gas sample entry point with collection at the appropriate height.

## **INDOOR AIR AND AMBIENT AIR SAMPLING**

### **(Standard Operating Procedure 014)**

#### **3.2.3 Sample Collection**

- Samples will be collected in Summa (or equivalent) canisters, that are certified-clean (batch or individual depending on project needs as indicated in the site-specific work plan) by the supplying laboratory. For samples collected for US EPA TO-15 analysis, 6-liter canisters will be used. Canisters will be delivered under a vacuum and care shall be taken not to open the canisters prior to the commencement of sampling. A canister that has been opened and its vacuum lost prior to sample collection cannot be used for the sampling event.
- Immediately prior to the beginning of sample collection, a vacuum gauge will be fitted to each canister to determine the starting and ending vacuum measurements within the canister. The gauge will be connected at the intake port on the canister. The vacuum gauge shall be hand-tightened and subsequently tightened an additional ¼ turn with a wrench. Once the gauge has been attached to the canister, assembly shall be checked to determine if it is sufficiently tight (*i.e.*, there is no play). Tighten further as necessary.
- Flow controllers, if used, will be connected to the vacuum gauge. Certified-clean flow controllers are supplied by the laboratory and pre-set to fill the canister within a specified amount of time. Care shall be taken not to disturb or adjust the flow controllers. Samples will be collected over an 8- to 24-hour period. Sampling time will depend on project-specific sampling objectives and shall be determined prior to ordering equipment from the laboratory and mobilizing to the field.
- In some cases, a particulate filter will also be supplied by the laboratory. The filter prevents particulate matter from fouling the valve or flow controller and entering the canister. The particulate filter shall be placed at the end of the sampling train.
- Sampling apparatus shall be kept out of direct sunlight to prevent significant temperature fluctuations that might affect the flow controller.
- Temperature and ambient pressure data will be measured and recorded at the beginning and at the end of each sampling period. Temperature data will be measured using a portable thermometer accurate to 0.1 degree (°C or °F). Temperature readings will be measured and recorded in the field logbook and the Chain-of-Custody at each sample location. Barometric pressure readings will be obtained from portable field meteorological equipment, the nearest weather reporting station, or websites that report local barometric pressure readings throughout the day.
- Once the canister and associated equipment are properly assembled and positioned, carefully open the canister valve. Record the initial canister vacuum measurement and sample start time in the field logbook in addition to the canister-specific information described in Section 3.3 of this SOP. Also record the vacuum measurement, canister number, and flow controller number on the Chain-of-Custody form. Allow the canister to fill for the predetermined sampling duration.
- Complete Part VI – Sampling Information of the Indoor Air Building Survey and Sampling Form (Attachment A).

## **INDOOR AIR AND AMBIENT AIR SAMPLING (Standard Operating Procedure 014)**

- Once the sampling period is complete, record the final canister vacuum measurement, ambient pressure, temperature, and sampling end time in the field logbook and close the canister valve tightly. Record the final vacuum measurement on the Chain-of-Custody form. The sampling train shall be disassembled prior to shipping.

### **3.2.4 Quality Assurance/Quality Control**

Quality Assurance (QA)/Quality Control (QC) samples associated with indoor and outdoor ambient air sampling may include background, duplicate, and trip (field) blank samples. See the site-specific work plan or sampling plan for QA/QC requirements, and refer to the Field Quality Control Sampling Procedures SOP (SOP 015) for additional information. At a minimum, the following QA/QC samples will be collected per indoor air or ambient air sampling event:

- One duplicate sample.
- One ambient (outdoor) air sample.
- One trip (field) blank.

For the purposes of collecting a duplicate sample, the duplicate canister shall be connected to the primary sample canister using a stainless-steel “T” fitting, which will provide a common inlet for both canisters. The fitting shall be attached to the flow controller (or particulate filter if supplied) on each canister. A minimum of one duplicate sample will be collected per indoor air sampling event to provide information on the consistency and reproducibility of field sampling procedures.

One ambient (outdoor) air sample will be collected per indoor air sampling event to assist in evaluating background conditions. The ambient air sample will be collected concurrently with the indoor air samples. The ambient air sample will be collected in a reasonably representative area (away from automobile traffic or other potential sources), preferably upwind of the site. The ambient air sampling canister will be situated at general breathing zone height (e.g., 3-5 feet above the ground surface; NJ DEP October 2005).

Trip (field) blanks will consist of evacuated canisters sent by the laboratory that accompany the other canisters to the sampling location and are then returned to the laboratory for analysis. Trip (field) blank canisters are the same as the canisters used for sampling, except that trip (field) blank canisters are never opened (the canister’s vacuum measurement should not change from the time of receipt through return to the laboratory for analysis). One trip (field) blank is required per sampling event.

### **3.3 Field Documentation**

Field logbooks will be maintained by the field team to record daily activities. The minimum requirements for field logbook documentation are discussed in the Field Documentation Procedures SOP (SOP 001).

In addition to the requirements of SOP 001, the following information must be recorded in the field logbook:

- Potential sources of indoor air VOCs removed from the structure.
- Summary of equipment preparation procedures on a daily basis, if appropriate.
- Time at start of sample collection.



## **INDOOR AIR AND AMBIENT AIR SAMPLING (Standard Operating Procedure 014)**

- Time at end of sample collection.
- Height of canister inlet from ground/floor surface.
- Location of canister within structure.
- Temperature at start of sample collection (accurate to 0.1°F or 0.1°C).
- Temperature at end of sample collection (accurate to 0.1°F or 0.1°C).
- Barometric pressure at the start of sample collection (if determined using field equipment).
- Barometric pressure at the end of sample collection (if determined using field equipment).
- Canister vacuum measurement at start of sample collection.
- Canister vacuum measurement at end of sample collection.
- Numbers and types of samples taken and sample identification numbers.
- Canister identification numbers, canister lot numbers, and flow controller numbers corresponding to sample identification numbers.

### **3.4 Sample Handling, Packing, and Shipping**

All samples will be marked, labeled, packaged, and shipped in accordance with the procedures listed below.

- Label the sample canister tag prior to sampling with the following information:
  - Sample identification code and/or number.
  - Collection date/time.
  - Laboratory analysis requested.
  - Name of sampler.
  - Canister serial number.
  - Cleaning lot number.
  - Date of cleaning certification.
  - Initial vacuum of canister (information supplied by the laboratory).
  - Name of individual responsible for sample collection and contact information.
- A Chain-of-Custody form will be initiated at the time of sample collection and will be included with the samples when shipped to the laboratory. The Chain-of-Custody form shall include the following information:
  - Sample start time and date.
  - Sample end time and date.
  - Initial canister vacuum measurement in field.
  - Final canister vacuum measurement in field.
  - Flow controller ID for each sample.
  - Canister ID for each sample.
  - Analytical parameters for each sample.

## **INDOOR AIR AND AMBIENT AIR SAMPLING (Standard Operating Procedure 014)**

- Sampler contact information.
  - Laboratory contact information.
  - Project name and location.
  - Temperature.
- Package, label, and ship/deliver the samples to the testing laboratory. Canisters and associated equipment should be packaged in a manner that will prevent damage to the equipment during shipment.
  - To maintain sample integrity during shipment to the laboratory, sample boxes will be sealed with a custody seal that bears the sampler's signature and date of shipment.
  - Refer to the Sample Labeling, Packing, and Shipping SOP (SOP 016) for additional information.

### **4.0 REFERENCES**

- Montrose Environmental Solutions, Inc., Field Documentation SOP (SOP 001).
- Montrose Environmental Solutions, Inc., Field Quality Control Sampling Procedures SOP (SOP 015).
- Montrose Environmental Solutions, Inc., Sampling Labeling, Packing, and Shipping SOP (SOP 016).
- Montrose Environmental Solutions, Inc., Decontamination of Equipment SOP (SOP 017).
- New Jersey Department of Environmental Protection Division of Remediation Management Response Site Remediation & Waste Management Program, SRWM Low Level US EPA TO-15 Method (NJDEP - LLTO-15-3/2007). March 2007.
- New Jersey Department of Environmental Protection Site Remediation and Waste Management Program and the Division of Science, Research and Technology, Vapor Intrusion Guidance. October 2005.
- Pennsylvania Department of Environmental Protection, Land Recycling Program Technical Guidance Manual – Section IV.A.4, Vapor Intrusion into Buildings from Groundwater and Soil under the Act 2 Statewide Health Standard. January 2004.
- US Environmental Protection Agency, Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Method TO-15 Second Edition. January 1999.
- US Environmental Protection Agency Office of Solid Waste and Emergency Response, Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils. November 2002.

**INDOOR AIR AND AMBIENT AIR SAMPLING**  
**(Standard Operating Procedure 014)**

<b>TABLE 1: Equipment Checklist for Indoor Air and Ambient Air Sampling</b>	
<b>Item Description</b>	<b>CHECK <input type="checkbox"/></b>
<b>Health &amp; Safety</b>	
Personal protective gear including, but not limited to, the following (see HASP):	
Saranex/Tyvek®	
Respirator, cartridges, wipes	
Gloves (Nitrile)	
Hard hat	
Steel-toed boots	
Rain gear	
Ear plugs	
Field first-aid kit	
Eyewash	
Safety glasses	
<b>Documentation:</b>	
Indoor Air Building Survey and Sampling Form	
SAP, SOPs, HASP, and QAPP	
Field logbook and indelible ink pens	
Site map	
Chain-of-Custody forms	
Custody seals	

**INDOOR AIR AND AMBIENT AIR SAMPLING**  
**(Standard Operating Procedure 014)**

<b>TABLE 1: Equipment Checklist for Indoor Air and Ambient Air Sampling</b>	
<b>Item Description</b>	<b>CHECK <input type="checkbox"/></b>
Measuring Equipment:	
Tape measure	
Digital thermometer (accurate to 0.1°C or .1°F)	
Clock/stopwatch	
Barometer	
Sampling equipment:	
Summa® (or equivalent) canister(s) – 6-liter	
Flow controller(s) set for specified sampling duration	
Particulate filter(s)	
Vacuum gauge(s)	
Stainless steel “T” (for duplicate sample collection)	
Miscellaneous:	
Digital camera for photo documentation	
Crescent wrench (9/16” or other size to fit)/adjustable wrench	
Appropriate locks and chains	
Duct tape	
Plastic bag (or other water-resistant material)	
Appropriate sized equipment to elevate Summa canister to required height	

## **ATTACHMENTS**

INDOOR AIR BUILDING SURVEY  
and SAMPLING FORM

Preparer's name: \_\_\_\_\_ Date: \_\_\_\_\_  
Preparer's affiliation: \_\_\_\_\_ Phone #: \_\_\_\_\_  
Site Name: \_\_\_\_\_ Case #: \_\_\_\_\_

Part I – Occupants

Building Address: \_\_\_\_\_  
Property Contact: \_\_\_\_\_ Owner / Renter / other: \_\_\_\_\_  
Contact's Phone: home ( ) \_\_\_\_\_ work ( ) \_\_\_\_\_ cell ( ) \_\_\_\_\_  
No. of Building occupants: Children under age 13 \_\_\_\_\_ Children age 13-18 \_\_\_\_\_  
Adults \_\_\_\_\_

Part II – Building Characteristics

Building type: residential / multi-family residential / office / strip mall / commercial /  
industrial  
Describe building: \_\_\_\_\_ Year constructed: \_\_\_\_\_  
Sensitive population: day care / nursing home / hospital / school / other (specify): \_\_\_\_\_  
Number of floors below grade: \_\_\_\_\_ (full basement / crawl space / slab on grade)  
Number of floors at or above grade: \_\_\_\_\_  
Depth of basement below grade surface: \_\_\_\_\_ ft. Basement size: \_\_\_\_\_ ft.<sup>2</sup>  
Basement floor construction: concrete / dirt / floating / stone / other (specify): \_\_\_\_\_  
Foundation walls: poured concrete / cinder blocks / stone / other (specify) \_\_\_\_\_  
Basement sump present? Yes / No Sump pump? Yes / No Water in sump? Yes / No  
Type of heating system (circle all that apply):  
hot air circulation      hot air radiation      wood stove      steam radiation  
heat pump      hot water radiation      kerosene heater  
electric baseboard      other (specify): \_\_\_\_\_

Type of fuel utilized (circle all that apply):

Natural gas / electric / fuel oil / wood / coal / solar / kerosene

Type of ventilation system (circle all that apply):

central air conditioning      mechanical fans  
bathroom ventilation fans      individual air conditioning units  
kitchen range hood fan      outside air intake  
other (specify): \_\_\_\_\_

Are the basement walls or floor sealed with waterproof paint or epoxy coatings? Yes/No

Is there a whole house fan? Yes / No

Septic system? Yes / Yes (but not used) / No

Irrigation/private well? Yes / Yes (but not used) / No

Type of ground cover outside of building: grass / concrete / asphalt / other (specify)

Existing subsurface depressurization (radon) system in place? Yes / No active / passive

Sub-slab vapor/moisture barrier in place? Yes / No

Type of barrier: \_\_\_\_\_

### Part III - Outside Contaminant Sources

NJDEP contaminated site ID(1000-ft. radius): \_\_\_\_\_

NJDEP PI No. \_\_\_\_\_ NJ DEP PI Name \_\_\_\_\_

Other stationary sources nearby (gas stations, emission stacks, etc.): \_\_\_\_\_

Heavy vehicular traffic nearby (or other mobile sources): \_\_\_\_\_

### Part IV – Indoor Contaminant Sources

Identify all potential indoor sources found in the building (including attached garages), the location of the source (floor and room), and whether the item was removed from the building 48 hours prior to indoor air sampling event. Any ventilation implemented after removal of the items should be completed at least 24 hours prior to the commencement of the indoor air sampling event.

Potential Sources	Location(s)	Removed (Yes / No / NA)
Gasoline storage cans		
Gas-powered equipment		
Kerosene storage cans		
Paints / thinners / strippers		
Cleaning solvents		
Oven cleaners		
Carpet / upholstery cleaners		
Other house cleaning products		
Moth balls		
Polishes / waxes		
Insecticides		
Furniture / floor polish		
Nail polish / polish remover		
Hairspray		
Cologne / perfume		
Air fresheners		
Fuel tank (inside building)		
Wood stove or fireplace		
New furniture / upholstery		
New carpeting / flooring		
Hobbies - glues, paints, etc.		



#### Part V – Miscellaneous Items

Do any occupants of the building smoke? Yes / No How often? \_\_\_\_\_

Last time someone smoked in the building? \_\_\_\_\_ hours / days ago

Does the building have an attached garage directly connected to living space? Yes / No

If so, is a car usually parked in the garage? Yes / No

Are gas-powered equipment or cans of gasoline/fuels stored in the garage? Yes / No

Do the occupants of the building have their clothes dry cleaned? Yes / No

If yes, how often? weekly / monthly / 3-4 times a year

Do any of the occupants use solvents in work? Yes / No

If yes, what types of solvents are used? \_\_\_\_\_

If yes, are their clothes washed at work? Yes / No

Have any pesticides/herbicides been applied around the building or in the yard? Yes/No

If so, when and which chemicals? \_\_\_\_\_

Has there ever been a fire in the building? Yes / No If yes, when? \_\_\_\_\_

Has painting or staining been done in the building in the last 6 months? Yes / No

If yes, when \_\_\_\_\_ and where? \_\_\_\_\_

#### Part VI – Sampling Information

Sample Technician: \_\_\_\_\_ Phone number: \_\_\_\_\_

Sample Source: Indoor Air / Sub-Slab / Near Slab Soil Gas / Exterior Soil Gas

Sampler Type: Tedlar bag / Sorbent / Stainless Steel Canister / Other (specify):  
\_\_\_\_\_

Analytical Method: TO-15 / TO-17 / other: \_\_\_\_\_ Cert. Laboratory: \_\_\_\_\_

Sample locations (floor, room):

Field ID # \_\_\_\_\_ - \_\_\_\_\_ Field ID # \_\_\_\_\_ - \_\_\_\_\_

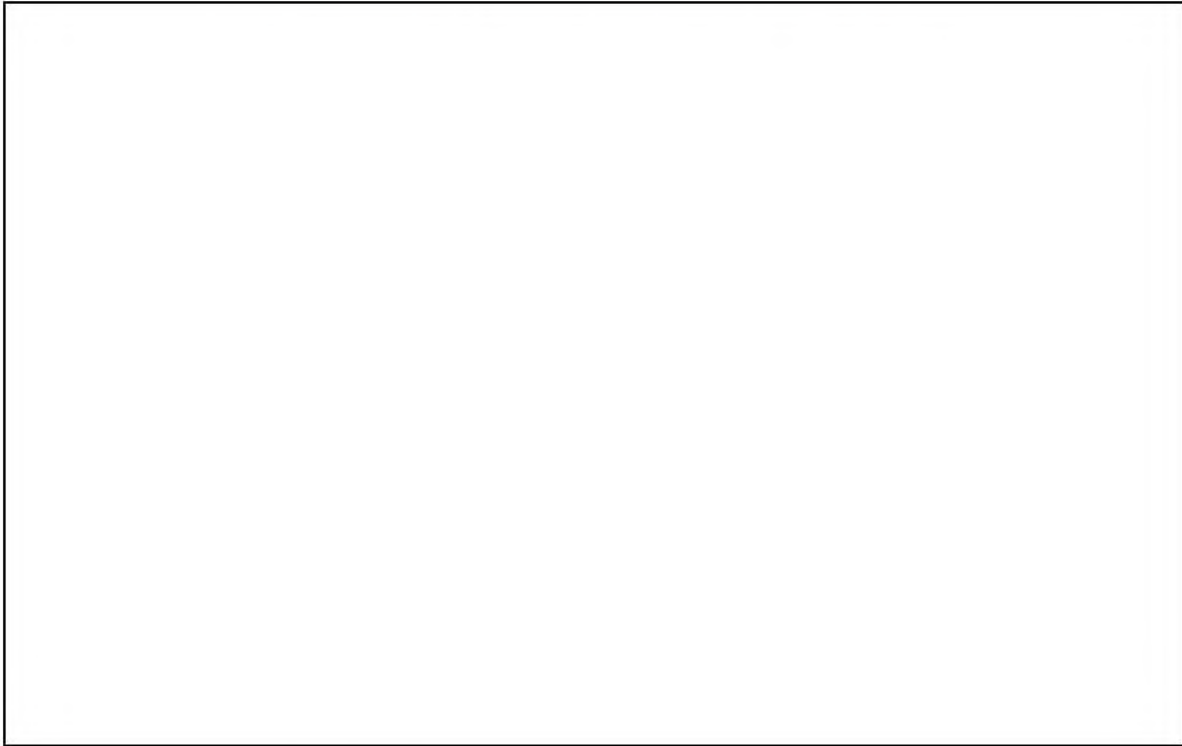
Field ID # \_\_\_\_\_ - \_\_\_\_\_ Field ID # \_\_\_\_\_ - \_\_\_\_\_

Were "Instructions for Occupants" followed? Yes / No

If not, describe modifications: \_\_\_\_\_



Provide Drawing of Sample Location(s) in Building



Part VII - Meteorological Conditions

Was there significant precipitation within 12 hours prior to (or during) the sampling event?      Yes / No

Describe the general weather conditions:

---

---

Part VIII – General Observations

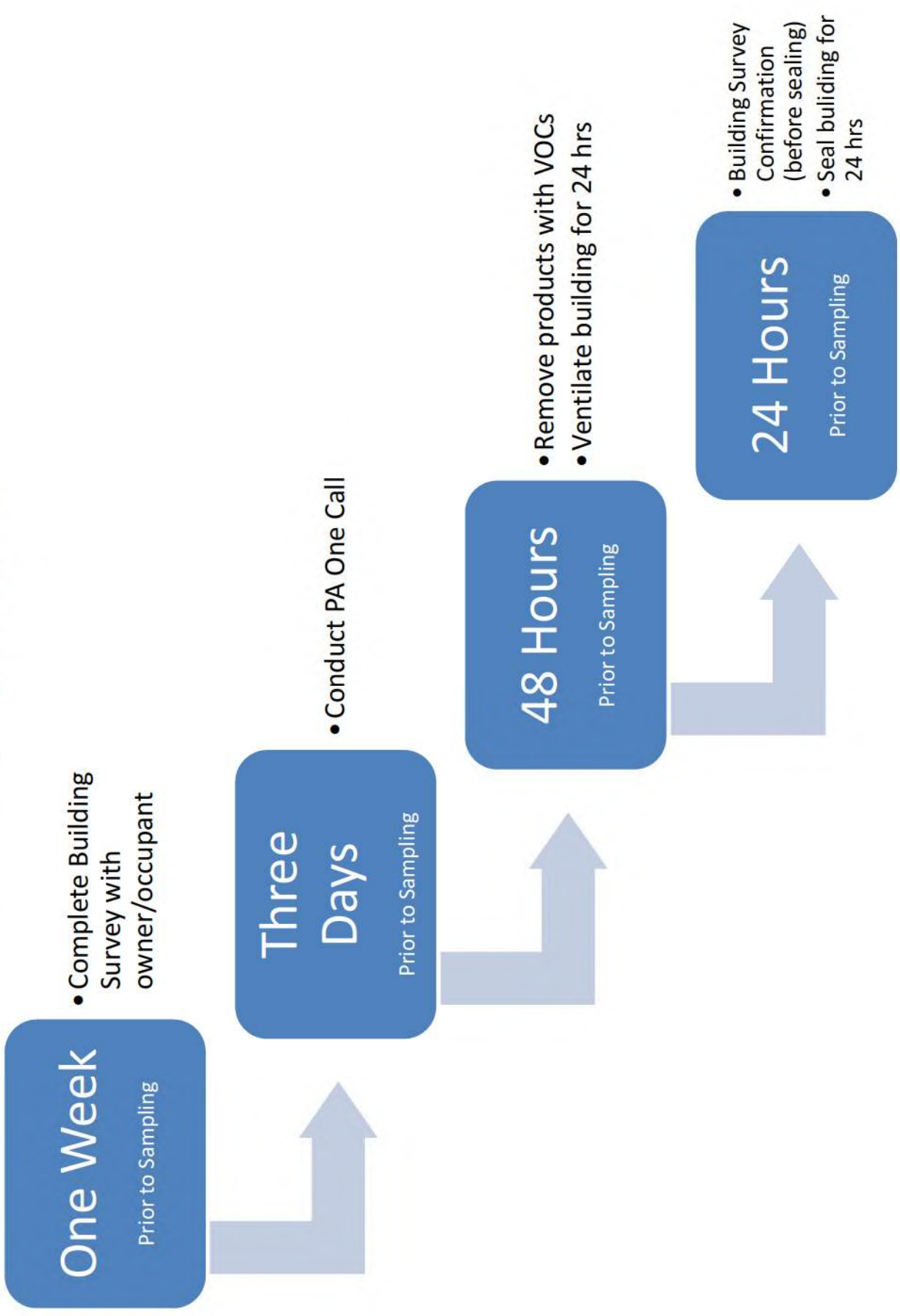
Provide any information that may be pertinent to the sampling event and may assist in the data interpretation process.

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## Attachment B

### Air Sampling Preparation Timeline





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**FIELD QUALITY CONTROL SAMPLING PROCEDURES**  
**(Standard Operating Procedure 015)**

**Revision No: 2**

Revision Date: May 5, 2021

Original Date: December 2, 2008

SOP Approval: Stephen D. Brower Date: 5/05/2021  
Stephen D. Brower, Principal Geoscientist

SOP Approval: Daniel P. Claycomb Date: 5/05/2021  
Daniel P. Claycomb, Principal Geoscientist

**FIELD QUALITY CONTROL SAMPLING PROCEDURES**  
**(Standard Operating Procedure 015)**

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**TABLE**

Table 1	Field Quality Control Sampling Equipment & Material Checklist
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# **FIELD QUALITY CONTROL SAMPLING PROCEDURES**

## **(Standard Operating Procedure 015)**

### **1.0 PURPOSE**

This standard operating procedure (SOP) describes the requirements associated with field quality control samples.

### **2.0 GENERAL CONSIDERATIONS**

Quality assurance (QA) will be verified by maintaining site logs, by documenting field activities, and by collecting and analyzing quality control (QC) samples. QC samples will be used to assess laboratory performance and to gauge the likelihood of cross-contamination associated with both field and laboratory activities. QC samples will be collected and analyzed in conjunction with samples designated for laboratory analysis using US EPA methods.

The QC samples and associated frequencies presented in this SOP are to be used as guidance. The specific type of QC samples and frequencies will be determined on a project-specific basis depending on data objectives and regulatory requirements. Project guidance documents shall be reviewed prior to initiating field activities to determine QC sampling requirements.

### **3.0 PROCEDURES**

Standard analytical QC checks that may be instituted by field personnel include, but are not limited to, the following:

- Trip blanks
- Field blanks
- Equipment rinsate blanks
- Field duplicate samples
- Matrix spike/matrix spike duplicate (MS/MSD) samples

#### **3.1 Trip Blanks**

Trip blanks are prepared in the laboratory using analyte-free deionized water. Trip blanks are analyzed for volatile organic compounds (VOCs) only to assess the potential for contamination of samples during transport to the site, during sample collection, and during transport to the laboratory.

- Trip blank containers will be the same type of sample container as those used for VOC samples (VOA vials).
- Prior to collection of the first investigative sample, place a laboratory-supplied trip blank sample in each sample cooler that will be used to hold/transport investigative sample containers submitted for VOC analysis.
- Label the trip blank samples as "Trip Blank" followed by the date (e.g., Trip Blank 011521) and record the trip blank samples on the Chain-of-Custody (COC). When multiple trip blanks are used on the same day, use the suffix A, B, C, etc. in the sample identification (i.e., Trip Blank 011521A). The date and time associated with the trip blank is the date and time the trip blank is placed in the cooler.
- Ship the trip blank(s) with the associated VOC investigative samples to the analytical laboratory.
- At no time after preparation and prior to arriving at the laboratory should trip blanks be opened.

## **FIELD QUALITY CONTROL SAMPLING PROCEDURES** **(Standard Operating Procedure 015)**

### **3.2 Field (Ambient) Blanks**

Field blanks are used to assess the potential for cross-contamination during the sampling process due to ambient conditions and to validate the cleanliness of sample containers. The collection of field blanks is recommended if known or suspected sources of contamination are present close to the sampling activities or if field instruments indicate the presence of contamination above background levels. Consult project-specific guidance as to whether collection of field blank is required.

- Field blanks are typically not necessary if equipment blanks are collected.
- Field blanks are collected by pouring analyte-free deionized water directly into certified clean, laboratory-supplied and preserved (if necessary) bottleware at the sample collection site.
- Fill the field blank sample containers in the following relative order:
  - VOCs
  - Semivolatile organic compounds (SVOCs)
  - Pesticides\PCBs
  - Total Petroleum Hydrocarbons (TPHs)
  - Metals and cyanide
  - Filtered metals, if required
  - Other water-quality parameters
- After sample collection, close the sample containers and immediately place upright in a cooler containing bagged wet ice.
- Ship the field blanks with the associated investigative samples to the analytical laboratory.
- When this type of quality control sample is used, the standard frequency in South Carolina is minimum one field blank for each analytical group (SHDHEC 2008).

### **3.3 Equipment Rinsate Blanks**

Equipment rinsate blanks are used to assess the effectiveness of field equipment decontamination procedures in preventing cross-contamination between samples. Consult project-specific control documents as to whether collection of equipment rinsate blanks are required.

- Equipment rinsate blanks are collected by pouring analyte-free deionized water into/through/over clean sampling equipment after decontamination procedures. Ideally, water shall be passed into/through/over all sampling equipment that contacts the sample media.
- Collect/containerize the rinsate that has contacted the sampling equipment in appropriate certified clean, laboratory-supplied preserved (if necessary) bottleware.
- Fill the sample containers in the same relative order as specified for field blanks.
- After sample collection, close the containers and immediately place upright in a cooler containing bagged wet ice.
- Ship the equipment rinsate blank with the associated investigative samples to the analytical laboratory.
- For each sampling event that uses this type of quality control sample, the standard frequency is a minimum of one equipment rinsate blank per matrix per day (SHDHEC 2008).
- At the discretion of the Project Manager, equipment rinsate blanks may not be required when pre-cleaned dedicated or disposable sampling equipment is used.

### **3.4 Field Duplicate (Replicate) Samples**

## **FIELD QUALITY CONTROL SAMPLING PROCEDURES**

### **(Standard Operating Procedure 015)**

Field duplicate samples are used to assess the overall field and laboratory precision. Field duplicates are typically collected and submitted to the laboratory as “blind” samples labeled with a false time of collection.

**Note:** to avoid the potential for analyzing samples outside of holding time, the false time of collection shall be shortly after the time of collection of the associated investigative sample (within 15 minutes). Consult project-specific control documents as to whether collection of duplicate samples is required. The procedures for collecting duplicate samples in soil and aqueous media are provided below:

- Collect duplicate samples for VOCs in soil by alternately filling each investigative and duplicate sample container (*i.e.*, Terra Core® or similar sampler) completely until both sample sets are filled. Grab samples for VOCs in soil shall be collected as close together as possible within the same sample area. Do not composite or homogenize grab samples for VOCs.
- Prior to collecting investigative and duplicate samples for non-VOC parameters, composite and homogenize soil samples. Fill the investigative and duplicate sample bottleware in alternating thirds from the homogenized composite until both sets of bottleware are filled. Duplicate samples are collected one parameter at a time.
- Collect duplicate samples for VOCs in aqueous media by alternately filling each investigative and duplicate sample container (*i.e.*, 40-ml VOC vial) completely until both sample sets are filled.
- When collecting aqueous samples for non-VOC parameters, fill the investigative sample and duplicate sample bottleware in alternating thirds until both sets of bottleware are filled. Duplicate samples are collected one parameter at a time.
- Fill sample containers in the same relative order as specified for field blanks.
- After sample collection, close the containers and immediately place upright in a cooler containing bagged wet ice.
- Ship the field duplicate samples with the associated investigative samples to the analytical laboratory.
- For each sampling event that uses this type of quality control sample, the standard frequency is a minimum 5% per analytical group per matrix for each sampling team (SHDHEC 2008).

### **3.5 Matrix Spike/Matrix Spike Duplicate Samples**

MS/MSD samples are investigative samples to which known amounts of compounds are added (spiked) in the laboratory before extraction and analysis. The matrix spike analysis is used to assess the performance of the method by measuring the effects of interferences caused by the sample matrix and reflects the bias of the method for the particular matrix in question. Consult project-specific control documents as to whether collection of MS/MSD samples is required.

- Collect MS/MSD samples by collecting triple volume of an investigative sample.
- Collect MS/MSD samples for VOCs in soil by alternately filling each investigative, MS, and MSD sample container (*i.e.*, Terra Core or similar sampler) completely until the three sets are filled. Collect grab samples for VOCs in soil as close together as possible within the same sample area. Do not composite or homogenize grab samples for VOC analysis.
- Prior to collecting investigative and MS/MSD samples for non-VOC parameters, composite and homogenize the soil sample. Fill investigative, MS, and MSD sample bottleware in alternating thirds from the composite until the three sets of bottleware are filled. MS/MSD samples are collected one parameter at a time.

## **FIELD QUALITY CONTROL SAMPLING PROCEDURES**

### **(Standard Operating Procedure 015)**

- Collect MS/MSD samples for VOCs in aqueous media by alternately filling each investigative, MS, and MSD sample container (*i.e.*, 40-ml VOC vial) completely until these sample sets are filled.
- For aqueous samples that will be analyzed for non-VOC parameters, fill the investigative, MS, and MSD sample bottleware in alternating thirds until the three sets of bottleware are filled. MS/MSD samples are collected one parameter at a time.
- Fill sample containers in the same relative order as specified for field blanks.
- Label MS/MSD samples by appending a “MS” and “MSD” to the investigative sample ID and record on the COC. For example, the MS and MSD samples associated with sample “MW15 011521” would be identified as “MW15 011521 MS” and “MW15 011521 MSD”.
- For each sampling event that uses this type of quality control sample, the standard frequencies are one set of MS/MSD samples for each batch of 20 investigative samples per matrix type (US EPA, 2014).
- After sample collection, close the containers and immediately place upright in a cooler containing bagged wet ice.
- Ship the MS/MSD samples with the associated investigative samples to the analytical laboratory.

### **3.6 Investigation-Derived Waste**

Investigation-derived waste (IDW) includes excess samples, cuttings, decontamination fluids, disposable sampling equipment, and disposable personal protective equipment (PPE). IDW shall be containerized according to the Management of Investigation-Derived Waste SOP (SOP 018).

### **3.7 Sample Handling, Packing, and Shipping**

Samples will be marked, labeled, packaged, and shipped in accordance with the Sample Labeling, Packing, and Shipping SOP (SOP 016).

### **3.8 Field Logbook Documentation**

Field logbooks will be maintained by the Field Team Leader to record daily activities. The minimum requirements for field logbook documentation are discussed in the Field Documentation Procedures SOP (SOP 001).

The Field Team Leader will review the field logbook entries for completeness and accuracy. The Field Team Leader is responsible for completion of the required data collection forms.

### **3.9 Decontamination and Cleanup**

Sampling equipment decontamination will be performed in a manner consistent with the Decontamination of Equipment SOP (SOP 017) and the Management of Investigation-Derived Waste SOP (SOP 018).

## **4.0 REFERENCES**

- Montrose Environmental Solutions, Inc. Field Documentation Procedures SOP (SOP 001).
- Montrose Environmental Solutions, Inc. Sample Labeling, Packing, and Shipping SOP (SOP 016).
- Montrose Environmental Solutions, Inc. Decontamination of Equipment SOP (SOP 017).



**FIELD QUALITY CONTROL SAMPLING PROCEDURES**  
**(Standard Operating Procedure 015)**

- Montrose Environmental Solutions, Inc. Management of Investigation-Derived Waste SOP (SOP 018).
- South Carolina Department of Health and Environmental Control. Guidance Document for Preparing Quality Assurance Project Plans (QAPPs) for Environmental Monitoring Project Studies, September 2008.
- US EPA, Method SW-846 – “Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.” Chapter 1 – Revision 8, July 2014.  
<https://www.epa.gov/hw-sw846/sw-846-compendium#chapters>

**FIELD QUALITY CONTROL SAMPLING PROCEDURES**  
**(Standard Operating Procedure 015)**

<b>TABLE 1: FIELD QUALITY CONTROL SAMPLING EQUIPMENT &amp; MATERIAL CHECKLIST</b>	
<b>Item Description</b>	<b>CHECK <input type="checkbox"/></b>
<b>Health &amp; Safety</b>	
Nitrile gloves	
Hard hat	
Steel-toed boots	
Hearing protection	
Field first-aid kit	
Eyewash	
Safety glasses	
<b>Sampling Equipment</b>	
Portable table	
Plastic sheeting	
Laboratory supplied analyte-free deionized water	
Tape measure	
Digital camera	
Groundwater sampling equipment	
Soil sampling equipment	
Laboratory-supplied bottleware	
Chain-of-Custody forms and custody seals	
Packing tape	
Field logbook	
Permanent marker and indelible ink pen	



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**SAMPLE LABELING, PACKING, AND SHIPPING**  
**(Standard Operating Procedure 016)**

**Revision No: 2**

Revision Date: May 5, 2021

Original Date: December 2, 2008

SOP Approval: Stephen D. Brower Date: 5/05/2021  
Stephen D. Brower, Principal Geoscientist

SOP Approval: Daniel P. Claycomb Date: 5/05/2021  
Daniel P. Claycomb, Principal Geoscientist

**SAMPLE LABELING, PACKING, AND SHIPPING**  
**(Standard Operating Procedure 016)**

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**TABLE**

Table 1	Sample Labeling, Packing, and Shipping Equipment & Material Checklist
---------	---

# **SAMPLE LABELING, PACKING, AND SHIPPING**

## **(Standard Operating Procedure 016)**

### **1.0 PURPOSE**

This standard operating procedure (SOP) provides the general technical requirements and operational guidelines for the proper labeling, packing, and shipping of environmental samples to an analytical laboratory for analysis or storage. These procedures have been developed to reduce the risk of damage to the samples (e.g., breakage of the sample containers) and to maintain sample temperature and integrity. This SOP references the guidance and regulatory requirements that help ensure proper labeling, packing, and shipping of environmental samples classified as non-hazardous cargo and environmental samples classified as “hazardous material” in accordance with the following documents (see section 4.0 for full reference):

- 49 Code of Federal Regulations (CFR) Parts 171-180.
- US Department of Transportation (US DOT).
- International Air Transport Association (IATA) standards as detailed in the most current edition of the IATA Dangerous Goods Regulations.
- International Civil Air Organization (ICAO) Technical Instructions.
- International Maritime Organization (IMO).
- International Maritime Dangerous Goods (IMDG) Code.

IATA and ICAO regulations apply strictly to commercial air transportation, both domestic and international. The IMDG regulations cover the international transport of dangerous goods by waterway. US DOT regulations apply to domestic and international shipments originating in or imported to the United States.

### **2.0 GENERAL CONSIDERATIONS**

Potential hazards associated with the planned tasks shall be thoroughly evaluated prior to conducting field activities. Refer to the site-specific Health and Safety Plan (HASP) for a description of potential hazards and associated safety and control measures.

Protocols for sample temperature maintenance and sample packing are applicable to the collection of samples year-round. The intent is to ensure that samples arrive at the laboratory in good condition - both physically intact and appropriately preserved.

### **3.0 PROCEDURES**

#### **3.1 Sample Labeling**

When feasible, pre-label sample containers prior to sample collection and protect the labels with a clear tape covering (unless the sample container requires a tare weight, such as a TerraCore® kit). When pre-labeling is infeasible, clean, and dry the container after sample collection with a clean rag or paper towel and then the apply the label. Include the following information on the sample label:

- Unique monitoring well or sample identification
- Parameter(s) to be analyzed
- Date and time of sample collection
- Sampler's initials
- Preservative(s), if any
- Site name or location

## SAMPLE LABELING, PACKING, AND SHIPPING (Standard Operating Procedure 016)

### 3.2 Sample Temperature Maintenance

Environmental samples requiring preservation by chilling (per the analytical method) must be cooled to an appropriate temperature (typically  $< 6^{\circ}\text{C}$  but not frozen) and maintained at this temperature from the point of collection through transport and receipt at the analytical laboratory. Samples that are required to be frozen must be cooled to an appropriate temperature (typically  $\leq -10^{\circ}\text{C}$ ) following collection and maintained in a frozen state through transport and receipt at the analytical laboratory.

**Note:** Unless specifically required by project-specific control documents, do not use Blue Ice® or similar media to chill or freeze aqueous or soil/sediment samples. Blue Ice is used for temperature preservation of air filter sample media.

#### 3.2.1 Chilling Samples

Samples requiring preservation by chilling are cooled to an appropriate temperature and maintained at this temperature from the point of collection through transport and receipt at the laboratory. To achieve this chilling and temperature maintenance:

- Following sample collection and labeling, wipe off each sample container with a clean paper towel and place each individual container in a new resealable plastic bag (sample sets of three 40-mL vials can be placed in one bag).
- Place the sealed sample containers in a sample cooler. Place an adequate amount of wet ice contained in doubled, resealable bags inside the cooler to cool and maintain the temperature of the samples to  $< 6^{\circ}\text{C}$  but not frozen. To the extent possible, keep the cooler lid closed.
- Keep samples in the cooler with ice until preparations are made for packing the samples for shipment.

Consider using the ice bath procedure listed below when samples are collected during warm weather (*i.e.*, high temperatures above  $80^{\circ}\text{F}$ ) or when there will be a short period of time between sample collection and delivery of the samples to the analytical laboratory.

- Prepare an ice bath(s) prior to sample collection. Obtain wet ice and potable water and mix approximately equal parts ice and water in a container large enough to accommodate several sample jars (*e.g.*, a clean 5-gallon bucket or a sample cooler). Depending on the number of sample containers anticipated, it may be necessary to prepare more than one ice bath.
- Place trip blank vials (as appropriate) and the temperature blank bottle (sealed in resealable plastic bags) in the ice bath prior to the collection of the first investigatory sample. Whenever possible, keep the ice bath(s) out of direct sunlight.
- Immediately after sample collection, wipe off each sample container with a clean paper towel and place each individual container in a new resealable plastic bag (sample sets of three

## **SAMPLE LABELING, PACKING, AND SHIPPING** **(Standard Operating Procedure 016)**

40-mL vials can be placed in one bag). Place the sealed sample containers in the ice bath. Avoid placing too many sample containers in an ice bath at one time.

- If feasible, allow samples to remain in the ice bath for a minimum of 30 minutes in order for the samples to be sufficiently chilled.
- After icing, the samples may be removed and placed into a dry cooler containing bagged wet ice in order to maintain the samples in a chilled condition ( $< 6^{\circ}\text{C}$  but not frozen). Keep samples in the iced cooler until preparations are made for packing the samples for shipment.

### **3.2.2 Frozen Sample Maintenance**

Samples requiring frozen preservation are maintained at a temperature of  $\leq -10^{\circ}\text{C}$  with the use of dry ice as follows:

- Don leather gloves before handling dry ice or placing hands inside a cooler containing dry ice.
- Place samples in a freezer or in a clean, dry cooler containing a sufficient amount of dry ice to maintain the samples at  $\leq -10^{\circ}\text{C}$ . Maintain samples on dry ice or in a freezer until preparations are made for packing the samples for shipment.

**Note:** If a cooler containing dry ice is used, do not place your head near the inside of the cooler as the sublimation of dry ice can cause asphyxiation.

### **3.3 Sample Packing**

The following is a summary of steps required for packing the samples for shipment.

- If packaging aqueous samples or using wet ice for temperature preservation in a cooler that will be shipped via commercial carrier (e.g., Fed Ex, UPS), place a garbage bag or liner in the cooler.
- If appropriate, place a temperature blank in the center of the cooler.
- Place individual sample containers into the cooler.
- Place wet ice contained in doubled resealable bags inside the garbage bag/liner in cooler. As needed, place bubble wrap or other inert packing material around the garbage bag/liner in the cooler.

**Note:** Blue Ice is used for temperature maintenance of air filter sample media.

- Seal the garbage bag/liner with duct tape. This is to ensure that if the contents were to spill that the garbage bag/liner would contain the spill.
- One Chain-of-Custody (COC) form shall be included in each cooler, placed in a large, resealable plastic bag, and taped to the inside lid of the cooler. The shipper's tracking

## SAMPLE LABELING, PACKING, AND SHIPPING (Standard Operating Procedure 016)

number (e.g., courier and courier air bill number, if applicable) shall also be written on the COC form.

- If the sample volume is such that the samples must be packaged in multiple coolers, make copies of the COC and place a copy in each cooler. If it is not possible to make a copy of the COC, place the original COC in one cooler and a note in the remaining cooler(s) cross-referencing the COC identification number.
- Tape the cooler(s) closed with strapping tape and seal with custody tape on two sides such that opening the cooler will break the custody tape.

### **3.3.1 Shipping Samples Using Dry Ice**

In addition to the steps identified in Section 3.3, the following steps are required for packing and sealing frozen samples for shipment on dry ice:

- Place inert material (such as bubble wrap and/or cardboard) in the bottom of the cooler.
- Place samples requiring frozen preservation in the cooler on top of the inert material.
- Place an additional piece of inert material on top of the samples to prevent the samples from contacting the dry ice.
- Don leather gloves and place one layer of dry ice (approximately 2 inches thick) on top of the second layer of inert material, covering as much surface area as possible.

**Note:** Do not place more than one layer of the dry ice in the cooler. The weight of the dry ice may cause container breakage.

- If using a commercial courier to transport the cooler with dry ice by domestic air freight, place a placard on the outside of the cooler following the 49CFR and IATA regulations presented below:
  1. For non-medical, non-hazardous US domestic air packages with  $\leq 2.5$  kg, ( $\leq 5.5$  pounds) of dry ice, mark the outside of the cooler with the words “Dry Ice” or “Carbon Dioxide, Solid.”
  2. For non-medical US domestic packages with  $> 2.5$ kg ( $>5.5$  pounds) of dry ice, the following are required under 49CFR and IATA:
    - Hazardous materials shipping papers are completed.
    - The package is properly marked as containing “Dry Ice” (or “Carbon Dioxide, Solid”), “UN184”, and with a class 9 diamond label.
    - The net weight of dry ice is indicated (in kg) on the shipping papers and is also marked on the outer package.



## **SAMPLE LABELING, PACKING, AND SHIPPING (Standard Operating Procedure 016)**

### **3.4 Shipping Procedures for Environmental Samples**

#### **3.4.1 *Environmental Samples Shipped as Non-hazardous Cargo***

Environmental samples will be shipped as non-hazardous cargo unless the samples meet the established US DOT criteria for a “hazardous material” or the IATA, ICAO Technical Instructions, and IMDG Code definition of “dangerous goods” (see Section 3.4.2). When preparing the cooler for shipment, remove all labels from the outside of the container. When completing the paperwork for shipment, complete the standard non-hazardous shipping forms provided by the carrier.

#### **3.4.2 *Environmental Samples Shipped as Dangerous Goods or Hazardous Material***

US DOT, the IATA and IMDG regulations governing the shipment of hazardous materials and dangerous goods must be followed. These regulations (49 CFR Parts 171 -through 180 and the Dangerous Goods Regulations (DGR) for IATA and IMDG) describe proper marking, labeling, placarding, packaging, and shipping of hazardous materials. IATA regulations apply strictly to commercial air transportation - both domestic and international. The IMDG regulations apply to the international transport of dangerous goods by waterway. US DOT regulations apply to domestic and international shipments originating in or imported to the United States.

The definitions of dangerous goods and hazardous materials, as defined by IATA, IMDG and US DOT, respectively, are presented below.

**Dangerous Goods** – “Articles or substances that are capable of posing a significant risk to health, safety, or to property when transported by air and that are classified according to” the UN hazard classes.

**Hazardous Material** – “A substance or material that has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and that has been so designated. The term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials.”

Quantities of certain dangerous goods may be transported as “Small Quantity Exception” or “Limited Quantity Exception.”

Shippers and transporters of hazardous materials or dangerous goods are required to have specialized training (DGR, 1.5.0.2 and 49 CFR Part 172, Subpart H). Hazardous material or dangerous goods shall only be shipped by appropriately trained personnel.

### **3.5 Field Logbook Documentation**

In addition to the minimum requirements discussed in the Field Documentation Procedures SOP (SOP 001), record the following information in the field logbook:

- Method of transportation
- Commercial carrier tracking number (if applicable)
- Material shipped (e.g., sample ID numbers) associated with each courier tracking number.
- Date shipped.

## **SAMPLE LABELING, PACKING, AND SHIPPING**

### **(Standard Operating Procedure 016)**

Retain the shipper's copies of the manifest or the shipper's copy of the commercial carrier's air bill.

#### **4.0 REFERENCES**

- Montrose Environmental Solutions, Inc. Field Documentation Procedures SOP (SOP 001).
- International Air Transport Association, "Dangerous Goods Regulations," 49<sup>th</sup> Edition, Montreal, 2008.
- "International Maritime Dangerous Goods Code," 2006 Edition.
- Office of the Federal Register, National Archives and Records Administration, 49 CFR Parts 171-179, US Government Printing Office, Washington, DC, 2006.
- "The International Civil Aviation Organization Technical Instructions on the Safe Transport of Dangerous Goods by Air," 2007 - 2008 Edition.

**SAMPLE LABELING, PACKING, AND SHIPPING**  
**(Standard Operating Procedure 016)**

<b>TABLE 1: SAMPLE PACKING, SHIPPING, AND LABELING EQUIPMENT &amp; MATERIAL CHECKLIST</b>	
<b>Item Description</b>	<b>CHECK <input type="checkbox"/></b>
<b>Health &amp; Safety</b>	
Nitrile gloves	
Steel-toed boots	
Field first-aid kit	
Eyewash	
Safety glasses	
Leather gloves	
<b>Paperwork</b>	
HASP	
Scope-of-work/project control documents	
Shipping forms (or courier forms)	
Chain-of-custody	
Field logbook	
<b>Labeling, Packing and Shipping Supplies</b>	
Packing tape	
Custody seals	
Coolers	

**SAMPLE LABELING, PACKING, AND SHIPPING**  
**(Standard Operating Procedure 016)**

<b>TABLE 1: SAMPLE PACKING, SHIPPING, AND LABELING EQUIPMENT &amp; MATERIAL CHECKLIST (cont.)</b>	
<b>Item Description</b>	<b>CHECK <input type="checkbox"/></b>
<b>Labeling, Packing, and Shipping Supplies (cont.)</b>	
Ice (wet and dry)	
Paper Towels	
Indelible Ink Pen/Permanent markers	
Sample labels	
Resalable plastic bags (gallon and pint sizes)	
Bubble wrap and other inert packing materials	
Scale	
IATA Dangerous Goods Regulations Manual (and other regulatory guidance documents)	



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**DECONTAMINATION OF EQUIPMENT  
(Standard Operating Procedure 017)**

**Revision No: 2**

Revision Date: April 29, 2021

Original Date: December 2, 2008

SOP Approval: Stephen D. Brower Date: 4/29/2021  
Stephen D. Brower, Principal Geoscientist

SOP Approval: Daniel P. Claycomb Date: 4/29/2021  
Daniel P. Claycomb, Principal Geoscientist

**DECONTAMINATION OF EQUIPMENT  
(Standard Operating Procedure 017)**

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**TABLE**

Table 1	Decontamination of Equipment & Materials Checklist
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## **DECONTAMINATION OF EQUIPMENT (Standard Operating Procedure 017)**

### **1.0 PURPOSE**

This Standard Operating Procedure (SOP) describes the procedures and requirements associated with decontaminating field equipment that has had or has the potential to contact impacted media (e.g., soil, groundwater, surface water, sediment, free product). It is important to follow these procedures to ensure that environmental data generated in the field are of the highest possible quality and do not misrepresent the sampled media due to cross-contamination.

### **2.0 GENERAL CONSIDERATIONS**

Thoroughly evaluate potential hazards associated with the planned tasks prior to conducting field activities. Refer to the site-specific Health and Safety Plan (HASP) for a description of potential hazards and associated safety and control measures.

Prior to field activities, the field team must consider how investigation-derived waste (IDW) is to be handled. Refer to Section 3.3 of this SOP for additional procedural guidance. Decontamination of large/heavy equipment requires additional resources and coordination than hand-held equipment. If decontamination of large equipment is required, ensure that appropriate coordination with the subcontractor operating the equipment occurs prior to mobilization.

### **3.0 PROCEDURES**

This section provides general operating procedures and methods associated with equipment decontamination activities.

#### **3.1 Preparation**

Set up the decontamination area upwind from the sampling area(s), if possible. The set-up for decontamination will vary depending on the type of equipment used at the site.

For decontamination of hand-held sampling equipment, spread plastic sheeting on the ground and organize decontamination tubs and/or buckets and rinse bottles in order of use on top of the plastic. Prepare an adequate volume of decontamination solution containing a non-phosphate detergent, such as Liquinox and potable water. Document the source of the potable water in the field logbook.

For decontamination of heavy equipment, establish an area for decontamination that allows for the collection of solids and liquids generated during the cleaning process. If the containerization of fluids associated with decontamination of larger equipment such as drill rigs, backhoes, *etc.* is required, ensure that the subcontractor will have the appropriate supplies available at the project site. This equipment may include a portable electric generator, potable water source, a high-pressure steam-cleaner, *etc.* In addition, direct the subcontractor to construct a decontamination pad to contain and collect the solids and liquids generated during decontamination. Typical decontamination pads are constructed of plastic sheeting draped over hay bales or a wooden frame that is sloped inward to collect solids and liquids generated during the cleaning process.

## DECONTAMINATION OF EQUIPMENT (Standard Operating Procedure 017)

### 3.2 Decontamination

Reusable equipment that is used for sampling, testing, or measuring, including heavy equipment, that comes in contact with potentially impacted media, will be decontaminated prior to use and between sampling locations. Disposable sampling equipment does not require decontamination before use provided it is sterile and individually wrapped. Discard disposable equipment after use and do not use at more than one sampling location.

Sampling equipment, such as pumps that are dedicated to a specific monitoring well, will be decontaminated prior to deployment and will not require decontamination between sampling events. If a dedicated pump is removed from a well (e.g., for maintenance), the pump requires decontamination prior to re-deployment.

#### 3.2.1 *Manual Sampling Equipment*

The following general decontamination steps are applicable to reusable, hand-held equipment. Site-specific project control documents may specify modifications to these procedures and take precedent to this SOP when applicable. Do not use acids or solvents to decontaminate electronic instrumentation, unless specified by the manufacturer.

- Physically remove visible dirt and debris from the sampling equipment, to the extent practical. If this material appears to be impacted based on visual observation or instrument readings, collect and manage the material in accordance with SOP 018. Otherwise, the material may be returned to the area from which it originated.
- To the extent practicable, immerse the equipment in a phosphate-free detergent and potable water solution. Scrub the equipment thoroughly with a stiff brush until visible residual material is removed and the equipment is visibly clean. Circulate the detergent solution through equipment that cannot be disassembled, such as submersible pumps (ASTM 2015).
- Rinse the equipment thoroughly with potable water.
- Rinse the equipment thoroughly with reagent-grade deionized (DI) water from a known source.
- Rinse the equipment with an organic desorbing agent such as isopropyl alcohol. This step may be omitted if samples are not being analyzed for organic compounds (ASTM, 1990).
- Rinse the equipment thoroughly with DI water.
- To the extent practicable, allow the equipment to air dry in a clean area (equipment does not need to be completely dry before reuse; under certain weather conditions, complete air-drying may not be possible).



## **DECONTAMINATION OF EQUIPMENT (Standard Operating Procedure 017)**

If decontaminated equipment will not be used immediately, the equipment may be wrapped in aluminum foil (if used for organics only) or sealed in a plastic bag for storage. Document the decontamination activities, including date, time, and reagents used, in the field logbook.

At a minimum, change the decontamination solution daily and/or between sites. More frequent solution changes may be necessary.

### **3.2.2 Decontamination of Heavy Equipment**

Use the following general decontamination steps for heavy equipment. Site-specific project control documents may specify modifications to these procedures and should be followed when applicable.

- Physically remove as much loose material as possible from the heavy equipment. If contaminated material is suspected, as determined by visual observations or instrument readings, then materials must be collected in an appropriate container (e.g., US DOT-approved drum). Otherwise, return the material to the area where it originated.
- Place the heavy equipment on the decontamination pad. Ensure that the decontamination pad is constructed properly and does not leak.
- Steam-clean/pressure wash all parts of the equipment that have contacted potentially-contaminated material (tires, backhoe bucket, augers, back of drill rig, *etc.*).
- Containerize decontamination fluids from the decontamination pad.

### **3.3 Investigation-Derived Waste**

Investigation-derived waste (IDW) includes excess sample materials, cuttings, decontamination fluids, plastic sheeting, disposable sampling equipment, and disposable personal PPE. Containerize and manage IDW according to the Management of Investigation-Derived Waste SOP (SOP 018).

### **3.4 Documentation**

Field logbooks will be maintained by the Field Team Leader (or designee) to record daily activities. The minimum requirements for field logbook documentation are discussed in the Field Documentation Procedures SOP (SOP 001).

The Field Team Leader will review the field logbook entries for completeness. The Field Team Leader is also responsible for completion of the required data collection forms.

## DECONTAMINATION OF EQUIPMENT (Standard Operating Procedure 017)

### 4.0 REFERENCES

- ASTM International, *Standard Practice for Decontamination of Field Equipment Used at Waste Sites*: D 5088-15a. 2015.
- Montrose Environmental Solutions, Inc. Field Documentation Procedures SOP (SOP 001).
- Montrose Environmental Solutions, Inc. Management of Investigation-Derived Waste SOP (SOP 018).

**DECONTAMINATION OF EQUIPMENT  
(Standard Operating Procedure 017)**

<b>TABLE 1: DECONTAMINATION OF EQUIPMENT &amp; MATERIALS CHECKLIST</b>	
<b>Item Description (when applicable)</b>	<b>CHECK ✓</b>
<b>Health &amp; Safety</b>	
Nitrile gloves	
Hard hat (if required by HASP)	
Steel-toed boots	
Hearing protection	
Field first-aid kit	
Eyewash	
Safety glasses	
Barricades, cones, flashing lights, signs	
Respirator and cartridges (if necessary)	
Saranex/Tyvek suits and booties (if necessary)	
<b>Paperwork</b>	
Health & safety plan	
Sampling plan/scope-of-work/project guidance documents	
Field logbook	
Potable water (record source in field logbook)	
Drums (with labels)	

**DECONTAMINATION OF EQUIPMENT  
(Standard Operating Procedure 017)**


<b>TABLE 1: DECONTAMINATION OF EQUIPMENT &amp; MATERIALS CHECKLIST</b>	
<b>Item Description</b>	<b>CHECK ✓</b>
<b>Equipment</b>	
Laboratory-grade detergent (Liquinox or Alconox)	
Decontamination fluids ( <i>i.e.</i> , isopropyl alcohol, methanol)	
Buckets or washtubs	
Spray bottles	
Plastic sheeting	
Brushes	
Steam cleaner/generator	
Deionized water (record source in field logbook)	

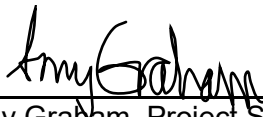
**MANAGEMENT OF INVESTIGATION-DERIVED WASTE  
(Standard Operating Procedure 018)**

**Revision No: 3**

Revision Date: April 23, 2024

Original Date: December 2, 2008

SOP Approval:  Date: 4/23/2024  
Adam Doubleday, Quality Assurance Scientist

SOP Approval:  Date: 4/23/2024  
Amy Graham, Project Scientist III

**MANAGEMENT OF INVESTIGATION-DERIVED WASTE**  
**(Standard Operating Procedure 018)**

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**TABLE**

Table 1	Management of Investigation-Derived Waste Equipment & Material Checklist
---------	--

# **MANAGEMENT OF INVESTIGATION-DERIVED WASTE (Standard Operating Procedure 018)**

## **1.0 PURPOSE**

The purpose of this Standard Operating Procedure (SOP) is to describe the requirements for managing investigation-derived waste (IDW). The requirements of this procedure are applicable to the management of wastes generated during field sampling and characterization activities.

## **2.0 GENERAL CONSIDERATIONS**

Thoroughly evaluate potential hazards associated with the planned tasks prior to conducting field activities. Refer to the site-specific Health and Safety Plan (HASP) for a description of potential hazards and associated safety and control measures.

Prior to commencing the investigation program, the Field Team Leader, in consultation with client representatives, will select a secure area for staging IDW. It is preferable for the staging area to have an impervious floor (concrete or pavement) and to be roofed, although this is often not possible. Store IDW in an area where damage to the containers is unlikely (e.g., away from vehicle/equipment high-traffic areas).

Totes or drums containing IDW are to be stored in rows with labels facing outward, for identification purposes. Drums shall not be stored more than two high with a pallet between the drums. In some cases, 55-gallon drums may not be necessary. In these cases, smaller waste containers may be substituted for drums. If possible, drummed IDW will be stored in a secure area pending characterization and disposal.

## **3.0 PROCEDURES**

### **3.1 Office Preparation**

Complete the following activities prior to site mobilization.

- Estimate the number and type of US DOT-approved drums or other suitable containers that will be required to containerize wastes generated during investigation activities.
- Obtain the required supplies listed on Table 1 of this SOP.

### **3.2 Management of Investigation-Derived Waste (Operation)**

- Containerize different waste media (e.g., soil, water, and personal protective equipment [PPE]) in separate drums or containers.
- Evaluate if IDW material is potentially impacted based on the following:
  - Previous analytical results, if available.
  - Visual or olfactory evidence of impacts.
  - Field-screening using a photoionization detector (PID) to evaluate the potential presence of volatile organic compounds (VOCs) and relative concentrations (if present). For additional information regarding field-screening procedures, see Field Screening Instrumentation and Procedures SOP (SOP 002).

## **MANAGEMENT OF INVESTIGATION-DERIVED WASTE (Standard Operating Procedure 018)**

- Additional field tests (*i.e.*, pH, color, and other chemical or physical characterizations).
- Containerize IDW with similar levels of contamination (based on field screening or previous analytical results) together.

### **3.2.1 Residual Soils**

Manage residual soils that are considered IDW in the following manner:

- Containerize drill cuttings and excess sample material in US DOT-approved drums or other appropriate containers.
- If possible, segregate materials based on level of impact and containerize materials with similar levels of impact together.
- Seal and label the drums or containers in accordance with Section 3.3.1 of this SOP.
- Periodically remove and containerize residual soil and/or sludge that accumulates in decontamination containment areas.
- Store drums or containers on site in a low-traffic area (ideally with a roof and impervious floor, although this is often not possible), and when possible, will be stored in a secure area pending waste characterization analysis. Collect samples for waste characterization based on requirements of the disposal facility or at the direction of the transportation and disposal subcontractor.
- Arrange for the proper transportation and disposal of the drummed residual material at an appropriate treatment facility based on the analytical waste characterization results.

### **3.2.2 Residual Liquids**

Manage residual liquids that are considered IDW in the following manner:

- Containerize liquid IDW, such as water from well development and decontamination fluids, in US DOT-approved drums or other appropriate containers.
- If possible, segregate liquids based on level of impact and containerize liquids with similar levels of impact together.
- Seal and label the drums or containers in accordance with Section 3.3.1 of this SOP.
- Store drums or containers on site in a low-traffic area (ideally with a roof and impervious floor, although this is often not possible), and when possible, will be stored in a secure area pending waste characterization analysis. Collect samples for waste characterization based on requirements of the disposal facility or at the direction of the transportation and disposal subcontractor.
- Arrange for the proper transportation and disposal of the drummed liquid IDW at an appropriate treatment facility based on the analytical waste characterization results.



## **MANAGEMENT OF INVESTIGATION-DERIVED WASTE (Standard Operating Procedure 018)**

### **3.2.2.1 On-Site Treatment of Purged Groundwater with Activated Carbon**

As an alternative to the procedure described in Section 3.2.2, purged groundwater may be treated on-site with activated carbon and discharged to the ground surface adjacent to the monitoring well. This option may first require regulatory approval.

- Do not treat groundwater containing non-aqueous phase liquids (NAPL), inorganic contaminants, elevated PID readings, or excessive solids with activated carbon.
- Determine the amount of carbon required and the retention time of the water within the carbon treatment device based on the manufacturer's specific recommendations and the site-specific concentration levels.
- Retention times will vary for individual applications, but a contact time of 10 to 15 minutes is normally adequate (Carbtrol® Corporation, 1992) for most low-concentration, dissolved organics. If site-specific groundwater data are not available, purged groundwater shall have a minimum of 15 minutes contact with the carbon.
- Conduct carbon change-out in accordance with manufacturer's recommendations and based on the amount of water passed through the carbon and contaminant concentrations.
- When discharging treated groundwater, use care to avoid discharge to surface water, erosion, hazards associated with freezing, and migration of the water off site. Discharge the treated groundwater to the ground surface or, with prior written approval, to the local sewage/wastewater treatment plant.
- Conduct periodic sampling and analysis of the carbon-treated groundwater effluent to document that the activated carbon is effectively treating purged groundwater prior to discharge.

### **3.2.3 Residual Disposables**

Manage disposable IDW in the following manner:

- Containerize disposable IDW, such as plastic bags, gloves and other PPE, paper towels, and rags separate from other IDW.
- Based on field screening with a PID, determine if disposable IDW may be potentially contaminated.
- Bag non-contaminated, disposable IDW (e.g., PPE, towels, and rags) and dispose of the material as municipal waste.
- Bag and drum potentially contaminated disposable IDW. Seal drums and label in accordance with Subsection 3.3.1 of this SOP.
- Drums or containers will remain on site in a secure area pending waste characterization analysis. Collect samples for waste characterization based on requirements of the disposal facility or at the direction of the transportation and disposal subcontractor.

## **MANAGEMENT OF INVESTIGATION-DERIVED WASTE (Standard Operating Procedure 018)**

- Arrange for the proper transportation and disposal of the drummed IDW at an appropriate treatment facility based on the analytical waste characterization results.

### **3.3 Documentation**

Field logbooks will be maintained by the field team to record daily activities. The minimum requirements for field logbook documentation are discussed in the Field Documentation Procedures SOP (SOP 001). Maintain a drum log detailing the number of drums staged at the site, contents, and accumulation date.

The Field Team Leader will review the field logbook entries for completeness and accuracy. The Field Team Leader is responsible for completion of the required data collection forms.

#### **3.3.1 Drum and Container Labeling**

Drums and containers will be appropriately labeled with the following information:

- Site Name
- Client or Site Contact Name and Phone Number
- Type of Material
  - Soil
  - Sediment
  - Groundwater
  - Decontamination Rinsate
  - Process Water/Sludge
  - Unknown Chemicals
  - Other
- Accumulation Date(s)
- Additional Comments

In addition, affix a “Non-classified Waste” label to the outside of the drum. Use a “Non-Hazardous Waste” or “Hazardous Waste” label if appropriate based on analytical results.

#### **3.3.2 Weekly Inspection**

While field personnel are on site, inspect the drummed or stored waste materials on a weekly basis. Document the results of these inspections in the field logbook.

### **4.0 REFERENCES**

- Montrose Environmental Solutions, Inc. Field Documentation Procedures SOP (SOP 001).
- Montrose Environmental Solutions, Inc. Field Screening Instrumentation and Procedures SOP (SOP 002).
- Carbtrol® Corporation. “Granular Activated Carbon for Water and Wastewater Treatment,” September 1992.



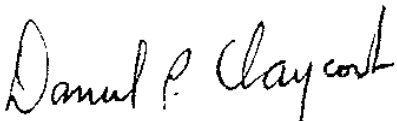
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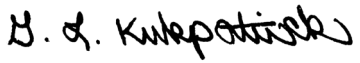
## SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION

(Standard Operating Procedure 023)

Revision No: 1

Revision Date: May 2, 2014

Technical Review:  Date: 5/2/14  
Daniel P. Claycomb, Principal Geoscientist

  
Quality Assurance Officer: \_\_\_\_\_ Date: 5/2/14  
Gerald L. Kirkpatrick, Principal Geoscientist

**SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION**  
**(Standard Operating Procedure 023)**

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**SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION**  
**(Standard Operating Procedure 023)**

**TABLE**

Table 1 – Equipment Checklist for Exterior Soil Gas Sampling Point Construction and Sample Collection

**ATTACHMENTS**

Attachment A – Soil Gas Sampling - PRT System Operation

Attachment B – Implants Operation

# **SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION**

## **(Standard Operating Procedure 023)**

### **1.0 INTRODUCTION**

The soil gas assessment techniques described herein shall be followed to obtain soil gas samples representative of the environment the samples are intended to characterize. This Standard Operating Procedure (SOP) is applicable to soil gas sampling point construction and soil gas sample collection utilizing canisters at exterior and sub-slab locations. This SOP is consistent with the necessary requirements for soil gas samples submitted for United States Environmental Protection Agency (US EPA) Method TO-15 analysis. This SOP does not discuss sample collection for semi-volatile organic compounds.

### **2.0 GENERAL CONSIDERATIONS**

#### **2.1 Health and Safety**

Potential hazards associated with the planned tasks shall be thoroughly evaluated prior to conducting field activities. Refer to the site-specific Health and Safety Plan (HASP) for a description of potential hazards and associated safety and control measures. The Field Team Leader is responsible for ensuring that the field team reads and signs the HASP and that any visitors to the work areas are familiar with the hazards, emergency evacuation routes, and nearest hospital or occupational health facility.

#### **2.2 National 811 One Call**

Prior to conducting intrusive subsurface activities, the appropriate utility notifications (*i.e.*, National 811 One Call) must be made and the dates of intrusive activities must be within the lawful dates provided by the One Call Center. Typically 3 business days (72 hours) notice must be given prior to beginning any type of subsurface activities. The Field Team Leader shall verify, to the extent practicable, that the utilities have responded to the One Call request and have either marked their respective utilities or have indicated in writing that they do not have a utility conflict in the work area. If there is uncertainty regarding potentially unmarked utilities, the Field Team Leader shall suspend work until the issues can be resolved. Refer to the Utility Clearance SOP (SOP 003) for additional information.

#### **2.3 Suspected Asbestos Containing Material**

When performing sub-slab soil gas activities, samplers shall be prepared to encounter asbestos containing (AC) floor tiles and mastics in facilities (including residential homes) constructed prior to 1980. It is not within the scope of this document to provide guidance identifying AC floor tiles and mastics; however, the following website provides some photos of common AC floor tiles and associated information may be reviewed if older floor tiles are encountered, [http://inspectapedia.com/hazmat/Asbestos\\_Floor\\_Tile\\_ID.php](http://inspectapedia.com/hazmat/Asbestos_Floor_Tile_ID.php). If samplers do encounter suspect AC floor tiles and mastics, samplers shall contact their supervisor before disturbing these materials.

#### **2.4 Exterior Versus Sub-Slab Soil Gas Points**

Interstate technology and regulatory council (ITRC) defines exterior as > 10 feet from building foundation (including both horizontal and vertical) shallow, may be near slab.

## **SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION** **(Standard Operating Procedure 023)**

### **3.0 PROCEDURES**

#### **3.1 Office Preparation**

Prior to mobilizing to the site, the Field Team Leader shall perform the following activities:

- Verify that the appropriate utility clearance service has been contacted and that utility companies have responded indicating they have no utility conflicts in the work area. If the utility clearance service reports “conflicts” or “do not dig”; arrange to meet the corresponding utility company on site. Refer to the Utility Clearance SOP (SOP 003) for additional information.
- Provide the client representative with both the on-site field work schedules to ensure access to the site.
- Obtain and review the following project control documents with the project manager as necessary:
  - Work Plan
  - Site map(s) with proposed soil gas points clearly identified
  - HASP
  - Sampling and Analysis Plan (SAP)
  - Quality Assurance Project Plan (QAPP)
  - Appropriate SOPs
  - Site access agreement(s)
- Review project control documents for general soil gas point construction specifications to be used at the site.
- Obtain the equipment to complete the field activities (an example list is provided as Table 1 in this SOP).
- Canisters (such as Summa®) shall be ordered from the analytical laboratory, which is performing the analysis, along with flow controllers and vacuum gauges. The laboratory will need to know the intended flow rate to properly set the flow controllers. When requesting flow controllers, a setting of 200 milliliters per minute (ml/min; or less) shall be used in the absence of a project-specific guidance document. Certain local regulatory agencies specify a maximum soil gas collection duration (e.g., Tennessee specifies that soil gas sample duration shall not exceed 30 minutes).
- After the canisters are received, verify the initial vacuum of each canister against the vacuum reported by the laboratory, typically on the Chain-of-Custody. If a discrepancy is noted between the reported and measured value, contact the laboratory and, if necessary, obtain replacement canisters.

## **SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION**

### **(Standard Operating Procedure 023)**

- Charge pumps that may be utilized in the field for purging or sampling activities. An appropriate pump shall be chosen that is capable of producing the desired flow rate (*i.e.*, less than 200 ml/min).

The activities described above may take several days to complete. Verify that site access has been obtained and allow sufficient time for completion prior to mobilizing to the site.

### **3.2 On-Site Preparation**

- The Field Team Leader shall locate the proposed sampling points and verify that there are no conflicts with utility mark-outs and that suspect AC floor tiles and mastic is not present if performing sub-slab sampling.
- Decontaminate down-hole equipment prior to installing the first sampling point and between sampling points. Down-hole equipment shall be decontaminated in accordance with SOP 017. To the extent practical, sample equipment shall be new and constructed of inert material.

### **3.3 Soil Gas Sampling Point Installation**

There are 4 methods discussed in this SOP for installing soil gas points:

- Temporary soil gas points installed using Geoprobe® System: Ideal for initial characterization sampling and non-regulatory driven sampling. Typically installed and sampled with little to no equilibration period. The sampling interval is typically less than 0.25 feet through open borehole space.
- Permanent soil gas points installed using Geoprobe System: Ideal for satisfying multi-season or multi-event sampling programs. Utilizing construction techniques and materials similar to monitoring well installation. Soil gas point installation typically utilizes a screened interval 0.5 to 3 feet in length for the sampling interval.
- Manually installed soil gas points using a hand auger or hammer drill. This is less common than the previous two methods but ideal for locations that are inaccessible to a Geoprobe or drill rig.
- Sub-slab soil gas point installed at a slab location: Ideal for assessing vapors nearest the point of intrusion; most representative. Sub-slab soil gas points typically require the least amount of construction equipment and are easiest to install.

Provided below are some general considerations for installing temporary, permanent, and manual soil gas points:

#### Equilibration Period (Waiting Period)

Consider employing an equilibration period between installation and sampling; some state regulatory agencies may require a waiting period when conducting soil gas sampling under their respective program. Sandy and gravelly soil require shorter equilibration periods while most silty and clayey soils require longer periods (up to several weeks).



## **SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION (Standard Operating Procedure 023)**

### Tubing Material

Vinyl and tygon tubing should be avoided for soil gas point installation and sampling. Polyethylene tubing may be used for shorter sample lengths (less than 20 feet). Preferably stainless, Teflon® or Nylaflow® should be used to obtain the most representative sample.

### Permitting

Some states require a well (or similar) permit to install soil gas points. Local regulations shall be thoroughly reviewed prior to soil gas point installation.

### Installation Depth

Some state regulatory authorities require a minimum soil gas point installation depth (typically greater than three to five feet depending on the soil material type; five feet per VA DEQ 2008 and US EPA 2002) to avoid short-circuiting the sampling point (*i.e.*, drawing above-ground air through the ground and into the sampling point). Review the respective state and local regulatory guidance regarding minimum installation depth.

### Water Infiltration

Soil gas sampling points must not be installed in saturated zones or areas subject to excessive drainage. This includes permanent points that may be subject to seasonal variations in groundwater levels. Historical groundwater data should be thoroughly reviewed to ensure the soil gas sampling point will not be inundated with groundwater (if available). Similarly, samplers should avoid installing and sampling from soil gas points (except sub-slab points) following excessive rain events (for example, not within 48-hours of a rain event where greater than 0.5 inches has fallen within 24-hours; TN DEC 2008). Review the respective state and local regulatory guidance regarding minimum installation depth above the groundwater surface (greater than two feet, TN DEC 2008) and whether rain criteria exist.

### ***3.3.1 Temporary Soil Gas Point Installation Using the Geoprobe System***

The temporary soil gas point installation system developed by Geoprobe Systems is known as the post-run tubing (PRT) system. The PRT system is designed to facilitate soil gas sampling through the standard Geoprobe probe rods. The probe rods are advanced to a desired depth and sampling tubing is then inserted through the probe rods and attached to a PRT adapter which in turn is attached to a sacrificial expendable probe point. The probe rods are raised slightly (typically less than 0.25 feet; TN DEC 2008) to allow the PRT adapter to disengage from the expendable point exposing the desired sampling point for soil gas collection.

The procedure for installing temporary soil gas sampling points using the PRT system from Geoprobe Systems is presented as Attachment A.

AMS Inc. (AMS) and other vendors offer similar temporary soil gas point installation systems. Samplers shall verify that the probe point of the Geoprobe and others systems is not larger in diameter than the probe rods to avoid short-circuiting. If the probe point is larger in diameter the annulus must be backfilled (see Section 3.3.2).

Decontaminate downhole Geoprobe equipment prior to use consistent with SOP 017.

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### ***3.3.2 Permanent Soil Gas Point Installation Using Geoprobe***

The permanent soil gas point installation system developed by Geoprobe Systems functions similar to the PRT system but utilizes screened metal pipe (also called a sampling implant) to obtain a soil gas sample. The probe rods are advanced to a desired depth/interval and the sampling implant and sampling tubing are then inserted through the probe rods and attached to a PRT adapter which in-turn is attached to a sacrificial expendable probe point. The probe rods are raised and the exposed annulus of the borehole is simultaneously backfilled with an implant funnel through the probe rods. The annulus around the sampling implant is filled with inert glass beads (or sand) and the annulus above the sampling implant is filled with hydrated bentonite to prevent short-circuiting. Typically the top several inches of annulus are filled with cement and finished in a manner similar to monitoring well construction (e.g., utilizing road boxes, pipe protectors, and flush mount caps to protect the soil gas point).

The procedure for installing permanent soil gas sampling points with sampling implants is described in the Implant Operation Manual from Geoprobe Systems, presented as Attachment B.

Decontaminate downhole Geoprobe equipment prior to use consistent with SOP 017.

### ***3.3.3 Temporary and Permanent Soil Gas Point Installation Using Manual Methods (Hand Auger and Digging)***

Temporary and permanent soil gas points may also be installed using techniques similar to those mentioned in Section 3.3.1 and Section 3.3.2 but by manual methods. Manual methods include hand augering and hand digging, or using a rotary hammer, hammer drill, or a slide hammer. Manual methods are ideal for locations inaccessible to a Geoprobe or for projects with cost constraints.

#### **Hand Augering and Hand Digging**

Hand augering (or bucket augering) and hand digging soil gas points is not preferred for temporary soil gas since the ensuing borehole diameter is typically larger than the soil gas sample equipment and therefore, the annulus must be backfilled. Using hand augering and digging is typically reserved for areas requiring the use of only intrinsically safe tools (even in these locations air powered drills can often be used). Hand augering and digging techniques are subject to the greatest possibility of short-circuiting due to over-excavating the soil gas point.

Hand augering and digging includes excavating a borehole to the desired sample depth, placing the soil gas point equipment in the borehole, then backfilling the soil gas point. Due to the typically larger diameter of the borehole compared to the soil gas point equipment, back-filling must be performed using sealing materials such as hydrated bentonite at least 1 foot thick above the sampling zone. The sampling zone shall be back-filled with inert porous materials such as glass beads or filter sand.

#### **Rotary Hammer, Hammer Drill, and Slide Hammer**

Soil gas point equipment may be installed using a rotary hammer, hammer drill, or slide hammer. A rotary hammer is typically more powerful and expensive than a hammer drill but

## **SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION (Standard Operating Procedure 023)**

transfers less hammer impact to the user, providing easier use. Both can be used to drill through an asphalt or concrete surface covering.

Utilizing a rotary hammer, hammer drill, or slide hammer involves directly installing soil gas equipment into the subsurface. Typically a drive point and drive string are utilized to drive the soil gas point equipment (mesh screen or open inlet) into the subsurface.

AMS's Retract-A-Tip system is designed to be directly driven into the subsurface with a rotary hammer, hammer drill, or slide hammer. Much like the Geoprobe System's PRT, system the drive string (as opposed to the probe rods) are raised several inches (typically less than 0.25 feet) after insertion to expose a mesh sampling screen that is connected to the surface with tubing inside the drive string.

A generic procedure for using a rotary hammer, hammer drill, or slide hammer is presented below.

1. Insert a drive rod hammer into a decontaminated metal conduit. The conduit should be constructed of thin walled galvanized steel instead of plastic, which may collapse during the driving process.
2. The drive rod diameter shall be slightly smaller than the inside diameter of the conduit. The drive rod shall extend three to six inches below the bottom of the conduit so that when the conduit is advanced to the target depth, removal of the drive rod leaves at least a three (3) inch section of soil open for soil gas to migrate into the conduit.
3. Connect tubing to the top of the conduit (using reducers or other barbed connectors as necessary) after the slide hammer drive rod is removed.

Decontaminate downhole equipment including drill bits, prior to use and in accordance with SOP 017.

### **3.3.4 Sub-Slab Soil Gas Point Installation**

Sub-slab soil gas points are installed in order to collect the soil gas that has accumulated directly beneath a concrete slab typically found beneath residential homes and buildings. Installing a sub-slab soil gas point consists of drilling a pilot hole through the slab and installing a vapor probe through the drilled hole. The vapor probe typically used is a male to female stainless steel connector. The male section is usually 1 inch long and ¼ inch diameter and either tube, threaded, or barbed; the female section is usually a ¼ inch compression fitting or threaded female hex.

Presented below is a generic sub-slab soil gas point installation procedure.

1. Decontaminate masonry drill bits prior to use, consistent with SOP 017.
2. If a floor covering is present (*i.e.*, carpet, tile, linoleum, *etc.*), verify with the PM, property owner, and/or client that they are aware that a portion of the floor covering will be removed during soil gas point installation (see note in Section 2.3 regarding suspect AC material). If carpet is present, full removal may not be necessary; the sampler can cut a

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minimum 2-inch square flap that can be glued back down after the sampling event is complete.

3. Drill a large diameter hole (typically 1-1/4 inch diameter) centered over the intended soil gas point to a depth of approximately 1 inch using a rotary hammer or hammer drill with a masonry drill bit.
4. Drill a second smaller diameter hole (typically 1/4 inch diameter) centered in the larger hole drilled in the previous step, completely through the concrete slab using a rotary hammer or hammer drill with a masonry drill bit. The diameter of the hole shall be slightly larger than the diameter of the vapor probe that will be used.
5. Advance the drill bit through the concrete slab and approximately 3-6 inches (NJ DEP 2013) into the sub-slab material (gravel or soil) to create an open cavity. Drilling will become noticeably easier once the bottom of the slab is penetrated.
6. Vacuum the drill cutting from in and around the holes. Test fit the vapor probe in the drill holes so it is at the desired location, and alter the drill hole depth and diameter if required. Clean the outer diameter hole with a damp towel
7. Insert the vapor probe flush with the top of the concrete slab.
8. Using a non-volatile emitting material, such as pottery or modeling clay, seal the base of the vapor probe where the smaller diameter drill hole starts. Non-volatile emitting caulk may also be cautiously used. Perform this step as soon as reasonably possible, limiting the amount of time that the drill hole is open between the sub-slab and building area.
9. Cap the vapor probe with Teflon tape or a threaded cap.
10. Avoiding the vapor probe threads, pour cement or hydrated bentonite around the annular space of the vapor probe. Tap water is typically treated with chlorinated compounds, as such, deionized water should be used to mix cement or bentonite.
11. Allow the cement or bentonite to cure for the recommended time by the manufacturer (typically up to 2 hours).

In addition to the notes listed in Section 3.3.8 and Section 3.6, the following shall also be recorded:

- Identify cracks or slab openings, penetrations, and riser pipes for utilities that may result in preferred vapor pathways into a building.
- Note if sumps, drywells, or cisterns are present or if evidence of these features exists.
- Identify whether any part of the basement is earthen and determine if the basement is slab on grade or floating floor (*i.e.*, the slab was poured separate from the basement walls).
- Note whether the basement is unfinished or finished.

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- Document other building characteristics such as depth below grade, number of floors, *etc.*
- Document the external weather conditions including temperature, approximate wind speed, and recent precipitation data.
- Describe the HVAC system (*i.e.*, forced air, radiant, source of return, *etc.*)
- Surface cover around the building.

### **3.3.5 Conduct Leak Check**

After the soil gas point has been installed, perform a leak test to verify that short-circuiting is not occurring. A leak test is performed utilizing a tracer gas (typically helium) introduced into a sealed box or dome over the soil gas point at the ground surface. The presence of the tracer gas in the vapor stream indicates that there is connectivity between the atmosphere at the ground surface and the subsurface soil gas sampling zone, typically through the annulus of the soil gas point into a sealed box or dome over the soil gas point at the ground surface. Short circuiting will result in a less than representative soil gas sample from the subsurface sampling zone and shall be addressed prior to commencing soil gas sample collection activities. Usually additional bentonite or other sealing material may be used around the soil gas point to address short-circuiting.

Performing a leak check is accomplished utilizing a leak dome. The dome is placed over the soil gas point. The dome has a port to inject the tracer gas into the dome and an exterior port to connect the soil gas point to the exterior of the dome. While injecting the tracer gas into the dome, connect the soil gas point to the exterior port and then connect the exterior port to a pump and a tracer gas meter.

The vacuum pump shall not exceed 10 inches of mercury (inHg) or exceed 200 ml/min. A vacuum gauge or flow meter shall be used on the sample train to determine the vacuum or flow rate being applied. High flow rates can cause preferential pathways, short-circuiting, and soil gas point collapse during leak check activities.

If a positive leak check is found there are two likely causes; short circuiting from the soil gas point annulus or non-airtight fittings and connections. The soil gas point annulus can be sealed using hydrated bentonite or cement. Fitting and connections can be retightened; conversely a vacuum check may be performed. A vacuum check is performed used a valve at the beginning of the sample train that can be closed. Close the valve and using a vacuum pump to create a vacuum between 8 to 10 inHg. Monitor the vacuum gauge for 30 to 60 seconds and observe if a measurable drop in vacuum occurs. This indicates that the connections and fittings are not airtight in the sample train. Retightening fittings and applying Teflon tape to screwed fittings may be necessary to create air-tight connections. Samplers may also want to consider switching from screwed to Swagelok connections.

At a minimum a leak-check shall be performed prior to soil gas sample collection. As an additional quality control check, a post sample collection and concurrent leak-check may also be performed. Concurrent leak-checks are performed to maintain the most assurance that break-through has not

## SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION (Standard Operating Procedure 023)

occurred. When performing a concurrent leak-check the tracer gas shall be added to the requested analytical analysis list.

### 3.3.6 Soil Gas Point Purging

After the soil gas point has been checked for leaks, purge the dead air from the sample train pathway. Ideally three to five volumes of the sample train shall be purged prior to sample collection. Purging the soil gas point is necessary to remove surface gasses and air that may have been forced down into the soil gas point; additionally, purging ensures that a collected soil gas sample is representative of the subsurface conditions. The volume of soil gas removed during the leak check may be added to the total removal volume calculated during this purging process (unless leaks were identified). Soil gas point purging shall be conducted using a flow rate similar to the actual flow rate that will be used during soil gas sample collection (typically less than 200 ml/min). High flow rates can cause preferential pathways, short-circuiting, and soil gas point collapse during purging activities. Typically the purged soil gas is screened with a photoionization detector (PID) for relative qualitative volatile organic compound (VOC) presence.

Calculate soil gas point purge volumes by accounting for the total volume of the sample train. The following calculation shall be used:

mls of air to purge =  $\text{tubing length} \times \text{tubing radius}^2 \times \pi$ ; length and radius are in centimeters.

NOTE: For sub-slab soil gas point construction the purge volumes are essentially zero; as such, performing the leak check process is sufficient to meet the purging requirement.

Soil gas point purging conducted using a vacuum pump shall not exceed 10 inHg or exceed 200 ml/min. A vacuum gauge or flow meter shall be used on the sample train to determine the vacuum or flow rate being applied.

### 3.3.7 Vacuum or Lung Box

A vacuum or lung box may also be used with a Tedlar bag to perform soil gas point leak checks, purging, and performing PID measurements. A vacuum box allows the sampler to indirectly apply a vacuum to the soil gas point avoiding contamination from the vacuum pump. To operate a vacuum box:

- Place the Tedlar bag inside the box and attached tubing from the sampling port of the Tedlar bag the inlet of the box and the quick connect fitting.
- Attach the soil gas point to the quick connect fitting with tubing.
- Attach tubing from the vacuum pump to the evacuation port of the box.
- Applying a vacuum to the box will cause the Tedlar bag to inflate.
- Utilize a vacuum gauge to keep the vacuum below 10 inHG. If using a vacuum gauge is not feasible, do not exceed a fill rate of 200 ml/min.
- Break the vacuum to the box by removing the tubing from the evacuation port.

## **SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION (Standard Operating Procedure 023)**

- Close the valve on the Tedlar bag. The Tedlar bag may be used to measure for the presence of the tracer gas during the leak check, keep track of purge volumes, and measure PID response.

### **3.3.8 Background Reconnaissance**

Prior to collecting an air sample, observe the sampling area for potential VOC contributors such as individuals that are smoking, running vehicles, and operating heavy equipment and generators. Record visual observations of the sampling area and any noticeable odors in the field logbook. When collecting sub-slab soil gas samples (*i.e.*, inside a building) it is necessary also identify stored chemicals, operating boilers and HVAC systems, and newly dry-cleaned clothing, if applicable. Refer to Indoor Air and Ambient Air Sampling SOP (SOP 013) for a full list of potential background contaminants in indoor areas.

### **3.4 Soil Gas Sampling (Operation)**

VOC soil gas samples are typically collected in canisters, which are certified clean by the supplying laboratory. For samples collected for US EPA TO-15 analysis, 6-liter canisters are typically used. One-liter canisters may also be used; however, the sampler shall verify that the detection limits will meet the data quality objectives of the sampling program. Canisters are delivered by the laboratory under vacuum and must not be opened prior to the commencement of sampling. A canister that has been opened prior to sample collection cannot be used for the sampling event.

Prior to the beginning of sample collection, a vacuum gauge shall be fitted to each canister to determine the canister vacuum reading (typically provided by the laboratory). The vacuum gauge will be connected at the intake port on the canister. Make sure the vacuum gauge is hand tight and then tighten an additional ¼ turn using a wrench. Once the vacuum gauge has been attached to the canister, check to make sure that the assembly is tight (*i.e.*, there is no play). Tighten further as necessary. Verify that the initial vacuum is the same (less than 10% difference; NJ DEP 2008) as the vacuum reported by the laboratory. If a difference is measured, contact the Project Manager or laboratory or use a different canister.

Flow controllers will be connected to the vacuum gauge. Certified-clean flow controllers are supplied by the laboratory and pre-set to fill the canister at a specified flow rate (typically 200 ml/min). Care should be taken not to disturb or adjust the flow controllers. Flow rate (and subsequently sample collection duration) will depend on project-specific sampling objectives and should be determined prior to ordering the equipment and mobilizing to the field. Canister vacuum readings are often coupled to a particular flow controller and indicated as such on the Chain-of-Custody. If this is the case, use the flow controller with the vacuum gauge for which the initial vacuum reading was measured.

A particulate filter will also be supplied by the laboratory. The filter prevents particulates from fouling the valve or flow controller and entering the canister. The particulate filter should be attached to the end of the sampling train if not part of the vacuum gauge or flow controller assembly.



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Temperature and ambient barometric pressure data shall be collected at the beginning and at the end of each sampling period. Temperature data shall be collected using a calibrated or NIST-traceable device accurate to 0.1 degree (°C or °F). Temperature readings shall be measured and recorded at each sample location. Barometric pressure readings shall be obtained from portable field meteorological equipment, the nearest weather reporting station, or websites that report local barometric pressure readings throughout the day.

Connect the soil gas point to the canister utilizing clean, new stainless, polyethylene, Teflon, or Nylaflow tubing (depending on data quality objectives). The tubing is typically connected to the soil gas point and the Summa canister by means of Swagelok fittings. Once the canister and associated equipment are properly assembled and positioned, carefully open the canister valve. Record the initial canister vacuum and sample start time (to the nearest minute) in the field logbook in addition to canister-specific information as detailed in Section 3.6. Allow the canister to fill until the vacuum gauge reads approximately 5 inHg vacuum. It is important to leave a measurable vacuum so that an accurate sample collection duration can be determined. This requirement can be ignored if collecting an instantaneous soil gas grab sample (instantaneous soil gas grab samples are not recommended). The vacuum gauge shall be monitored for the duration of soil gas sample collection.

The filling time can be calculated by dividing the canister volume by the flow rate. Certain local regulatory agencies specify a maximum soil gas collection duration (e.g., Tennessee specifies that soil gas sample duration shall not exceed 30 minutes).

Once sampling has been completed, record the final canister vacuum, ambient barometric pressure, temperature, and sampling end time in the field logbook and close the canister valve tightly. The sampling train should then be disassembled prior to shipping.

Typically a photoionization detector (PID) measurement is recorded prior to and immediately after soil gas sample collection.

### **3.4.1 Quality Assurance/Quality Control**

Quality Assurance/Quality Control (QA/QC) samples associated with air sampling may include background/indoor air, duplicate, co-located, and trip blank samples. See the project control documents for specific QA/QC sample requirements.

If collecting a duplicate (from the same soil gas point) soil gas sample, a "T" fitting will provide a common inlet for both canisters. Special care should be taken when collecting duplicate canisters due to the increased flow rate and vacuum being placed on the sub-surface sample interval. Typically, deploying a duplicate canister will require flow rates half the ideal flow rate for soil gas collection (i.e., 100 ml/min). Refer to the Field Quality Control Sampling Procedures SOP (SOP 015) for additional information.

### **3.5 Probe Abandonment**

After obtaining the soil gas sample at each soil gas point location, all equipment that can be removed from each location shall be removed. If the tubing or other downhole equipment cannot be removed, then it shall be cut flush with the surface and plugged to prevent surface



## **SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION**

### **(Standard Operating Procedure 023)**

water infiltration. The boring shall be filled with powdered bentonite to the maximum extent practicable and then hydrated. If the probe is installed through asphalt or concrete, then asphalt or cement grout may be used to finish the upper portion of the probe boring. The probe may also be removed by breaking the annular seal with a chisel or rotary hammer with a bull point chisel. Once the probe is removed, seal the hole with concrete to the original level and replace the flooring that was removed during installation or glue the carpet “flap” to the floor.

### **3.6 Sample Documentation**

Field logbooks will be maintained by the field team to record daily activities, field data, and sample collection and tracking information. Information will be entered into the field logbook by the appropriate field team member. The logbooks will contain the following information in addition to the minimum requirements presented in the Field Documentation Procedures SOP (SOP 001):

- Location of canister and soil gas point.
- Soil gas point construction details.
- Temperature at start of sample collection (accurate to 0.1°F or 0.1°C).
- Temperature at end of sample collection (accurate to 0.1°F or 0.1°C).
- Barometric pressure at start of sample collection (from an on-site barometer, nearest weather reporting station, or local weather website).
- Barometric pressure at the end of sample collection (from an on-site barometer, nearest weather reporting station, or local weather website).
- Canister vacuum at start of sample collection.
- Canister vacuum at end of sample collection.
- Canister identification numbers, canister lot numbers, and flow controller numbers corresponding to sample identification numbers.
- Weather conditions including temperature, wind velocity, and recent precipitation data.
- Details of leak check.
- Details of soil gas purge including volumes.
- Volume of soil gas extracted.
- PID measurements (if taken).
- Building condition information listed in Section 3.3.4 above.

### **3.7 Sample Handling, Packing, and Shipping**

All samples will be marked, labeled, packaged, and shipped in accordance with the procedures listed below and consistent with the Sample Packing, Shipping, and Labeling SOP (SOP 016).

- Label the sample canister tag prior to sampling with the following information:

## **SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION (Standard Operating Procedure 023)**

- Sample identification code and/or number.
- Collection date/time.
- Laboratory analysis requested.
- Name of sampler.
- Canister serial number.
- Cleaning lot number (provided by the laboratory).
- Date of cleaning certification.
- Initial vacuum of canister (information supplied by the laboratory).
- Name of individual responsible for sample collection and contact information.

A Chain-of-Custody form will be initiated at the time of sample collection and will be included with the samples when shipped to the laboratory. The Chain-of-Custody form shall include the following information:

- Sample start time and date.
- Sample end time and date.
- Initial canister vacuum in field.
- Final canister vacuum in field.
- Flow controller ID for each sample.
- Canister ID for each sample.
- Initial and final temperature and barometric pressure information.

Refer to the Sample Packing, Shipping, and Labeling SOP (SOP 016) for additional information. In general, canisters and other sample media are not required to be chilled after collection. Refer to method specific requirements for additional details.

### **4.0 REFERENCES**

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- Virginia Department of Environmental Quality (VA DEQ). "Vapor Intrusion Screening Fact Sheet," Virginia Voluntary Remediation Program. August 2008.

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<b>TABLE 1: Equipment Checklist for Exterior Soil Gas Sampling Point Construction and Sample Collection</b>	
<b>Item Description</b>	<b>CHECK <input type="checkbox"/></b>
<b>Health &amp; Safety</b> (as required by HASP):	
Saranex/Tyvek®	
Respirator, cartridges, wipes	
Nitrile gloves	
Duct tape	
Hard hat	
Steel-toed boots	
Ear plugs	
Field first-aid kit	
Eyewash	
Safety glasses	
<b>Decontamination Items:</b>	
Plastic sheeting	
Rinse bottles/spray bottles	
Trash bags	
Paper towels	
Deionized water	
Acetone, isopropyl alcohol, 10% nitric acid	
Potable water	
Decontamination tubs (deionized water)	
Long-handled brushes	
Nonphosphate detergent (such as Liquinox®)	

**SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION**  
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<b>TABLE 1: Equipment Checklist for Exterior Soil Gas Sampling Point Construction and Sample Collection</b>	
<b>Item Description</b>	<b>CHECK <input type="checkbox"/> <input type="checkbox"/></b>
<b>Paperwork:</b>	
Site-specific Work Plan	
Field logbook	
Indelible ink pens	
SAP, SOPs, HASP, and QAPP	
Site map	
Indoor Air Building Survey and Sampling Form	
Chain-of-Custody forms	
Custody seals	
<b>Measuring Equipment:</b>	
100-foot fiberglass tape measure marked in tenths of an inch	
Thermometer (accurate to 0.1°F or 0.1°C)	
Clock/stopwatch	
Barometer	
PID	

**SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION**  
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<b>TABLE 1: Equipment Checklist for Exterior Soil Gas Sampling Point Construction and Sample Collection</b>	
<b>Item Description</b>	<b>CHECK <input type="checkbox"/> <input type="checkbox"/></b>
Soil Gas Installation and Sampling Equipment:	
Summa Canisters	
Flow controller(s) set for specified sampling duration	
Particulate filter(s)	
Pressure gauge(s)	
Vacuum pump for purging	
Vacuum or Lung Box	
Tubing (polythylene, Teflon, Nylaflow, or stainless)	
Rotary Hammer, Hammer Drill, Slam bar, bucket auger, or shovel	
Masonry bits	
Bentonite and/or Cement and DI water for hydrating./mixing	
Non-volatile emitting modeling clay or caulk	
Vapor probe	
Leak check dome	
Helium Tank and Helium meter (or other tracer gas if applicable).	

**SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION**  
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<b>TABLE 1: Equipment Checklist for Exterior Soil Gas Sampling Point Construction and Sample Collection</b>	
<b>Item Description</b>	<b>CHECK <input type="checkbox"/> <input type="checkbox"/></b>
Miscellaneous:	
Camera	
Flagging tape	
Caution tape	
Crescent wrench/adjustable wrench	
Duct tape	

**SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION**  
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**ATTACHMENT A**



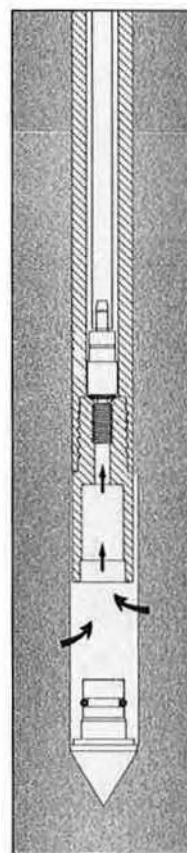
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# Soil Gas Sampling – PRT System Operation

from Geoprobe Systems®

[www.geoprobe.com](http://www.geoprobe.com)

1-800-436-7762



Soil Gas Sampling using the Post-Run Tubing (PRT) System.



# Soil Gas Sampling — PRT System Operation

## Basics

Using the Post-Run Tubing System, one can drive probe rods to the desired sampling depth, then insert and seal an internal tubing for soil gas sampling. The usual Geoprobe probe rods and driving accessories and the following tools are required:

- PRT Expendable Point Holder
- PRT Adapter
- Selected PRT Tubing

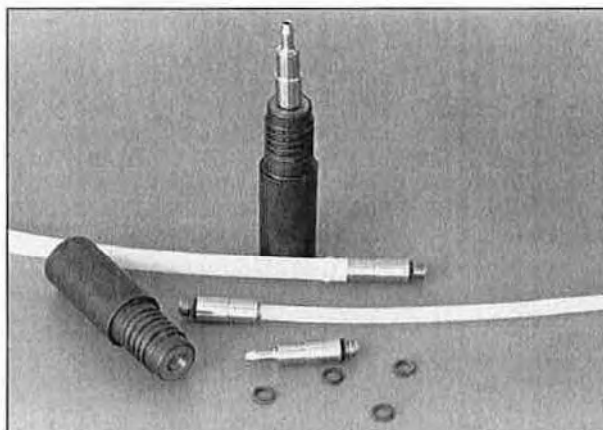
## Preparation

1. Clean all parts prior to use. Install O-rings on the PRT Expendable Point Holder and the PRT adapter.
2. Inspect the probe rods and clear them of all obstructions.
3. TEST FIT the adapter with the PRT fitting on the expendable point holder to assure that the threads are compatible and fit together smoothly.

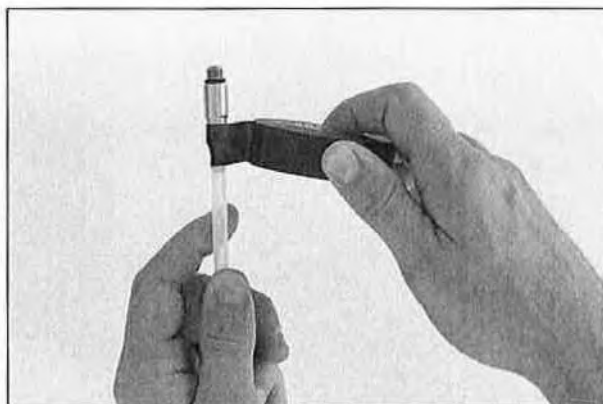
**NOTE:** PRT fittings are left-hand threaded.

4. Push the adapter into the end of the selected tubing. Tape may be used on the outside of the adapter and tubing to prevent the tubing from spinning freely around the adapter during connection – especially when using Teflon tubing (Figure 1).

**REMEMBER:** The sample will not contact the outside of the tubing or adapter.



**PRT SYSTEM PARTS**  
PRT Expendable Point Holder, PRT Adapters, Tubing, and O-rings.



**Figure 1.** Securing adapter to tubing with tape. **NOTE:** Tape does not contact soil gas sample.

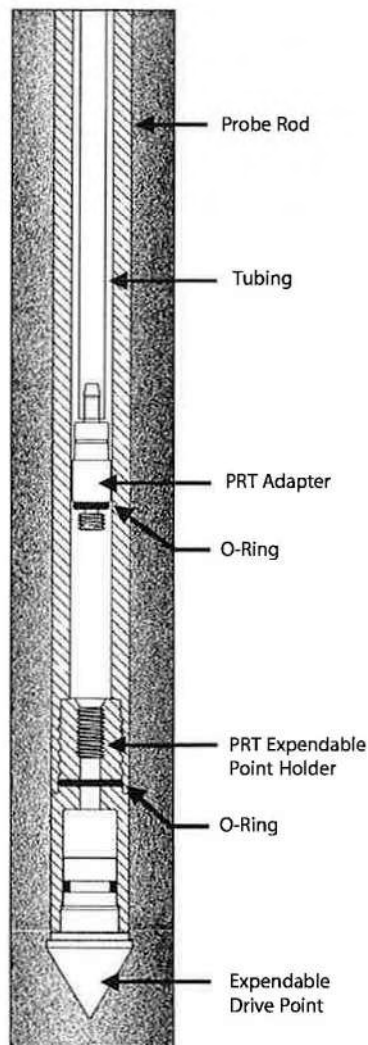


**Figure 2.** Insertion of tubing and PRT adapter.



**Figure 3.** Engaging threads by rotating tubing.

# Soil Gas Sampling — PRT System Operation



A cross section of probe rods driven to depth and then retracted to allow for soil gas sampling. The PRT adapter and tubing are now fed through the rods and rotated to form a vacuum-tight connection at the point holder. The result is a continuous run of tubing from the sample level to the surface.

## Probing

Drive the PRT tip configuration into the ground. Connect probe rods as necessary to reach the desired depth. After depth has been reached, disengage the expendable point by pulling up on the probe rods. Remove the pull cap from the top probe rod, and position the Geoprobe unit to allow room to work.

## Connection

1. Insert the adapter end of the tubing down the inside diameter of the probe rods (**Figure 2**).
2. Feed the tubing down the rod bore until it hits bottom on the expendable point holder. Allow about 2 ft. (610 mm) of tubing to extend out of the hole before cutting it.
3. Grasp the excess tubing and apply some downward pressure while turning it in a counterclockwise motion to engage the adapter threads with the expendable point holder (**Figure 3**).
4. Pull up lightly on the tubing to test engagement of the threads. (Failure of adapter to thread could mean that intrusion of soil may have occurred during driving of probe rods or disengagement of drive point.)



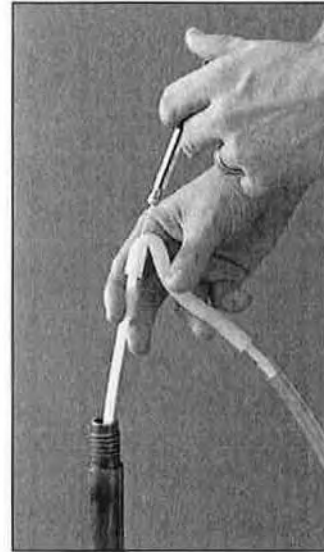
# Soil Gas Sampling — PRT System Operation

## Sampling

1. Connect the outer end of the tubing to the Silicone Tubing Adapter and vacuum hose (or other sampling apparatus).
2. Follow the appropriate sampling procedure for collecting a soil gas sample (**Figure 1**).

## Removal

1. After collecting a sample, disconnect the tubing from the vacuum hose or sampling system.
2. Pull up firmly on the tubing until it releases from the adapter at the bottom of the hole. (Taped tubing requires a stronger pull.)
3. Remove the tubing from the probe rods. Dispose of polyethylene tubing or decontaminate Teflon tubing as protocol dictates.
4. Retrieve the probe rods from the ground and recover the expendable point holder with the attached PRT adapter.
5. Inspect the O-ring at the base of the PRT adapter to verify that proper sealing was achieved during sampling. The O-ring should be compressed. This seal can be tested by capping the open end of the point holder applying vacuum to the PRT adapter.
6. Prepare for the next sample.



**Figure 1. Taking a soil gas sample for direct injection into a GC with the PRT system.**

**SOIL GAS SAMPLING POINT INSTALLATION AND SAMPLE COLLECTION**  
**(Standard Operating Procedure 023)**

**ATTACHMENT B**

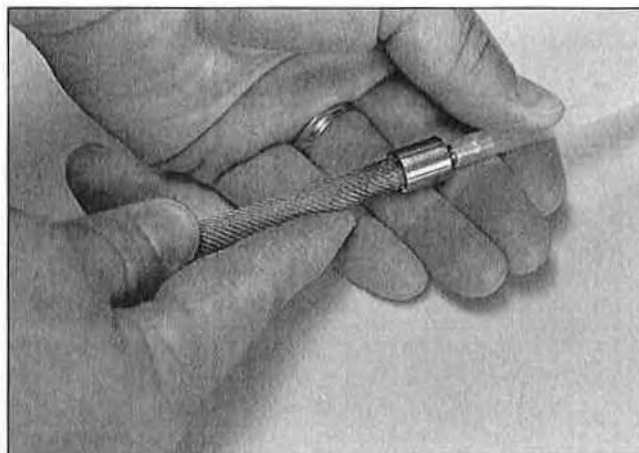
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# Implants Operation

from Geoprobe Systems®

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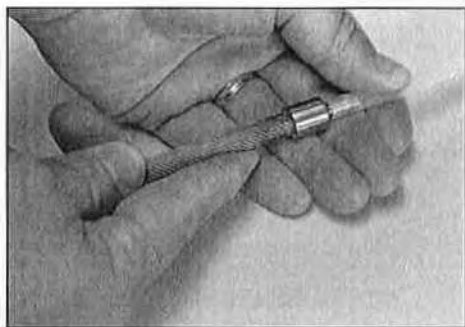
Attaching polyethylene tubing to the sampling implant.



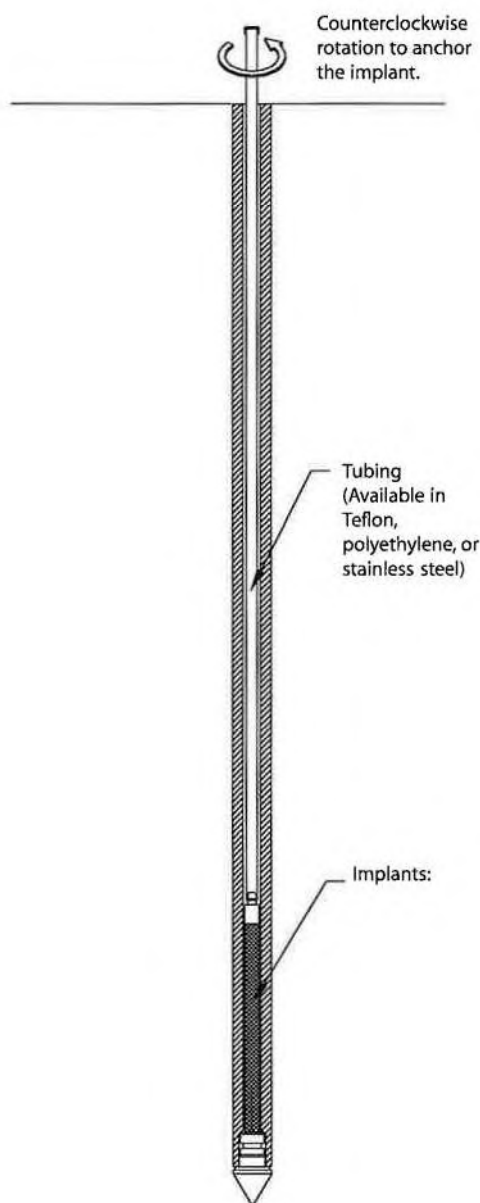
# Sampling Implants – Operation

## Installation Instructions for Soil Gas Implants

1. Drive probe rods to the desired depth using a Point Holder (AT-13B) and an Implant Anchor/Drive Point (PR-14). DO NOT disengage the drive point when depth has been reached.
2. Attach appropriate tubing to the implant (**Figure 1**). If tubing is pre-cut, allow it to be approximately 48 in. (1219 mm) longer than the required depth of the implant. Cover or plug the open end of the tubing.
3. Remove pull cap and lower the implant and tubing down inside the diameter of the probe rods until the implant hits the top of the Anchor/Drive Point. Note the length of the tubing to assure that proper depth has been reached.
4. Rotate tubing counterclockwise while exerting a gentle downward force to engage the PRT threads (**Figure 2**). Pull up on the tubing lightly to test the connection. DO NOT cut excess tubing.
5. Position a Probe Rod Pull Plate or Manual Probe Rod Jack on the top probe rod. Exert downward pressure on the tubing while pulling the probe rods up. Pull up about 12 in. (305 mm).
6. If using 1/4-in. (6.4 mm) O.D. tubing or smaller, thread the excess tubing through the Implant Funnel and position it over the top probe rod. If using larger tubing, it may not be possible to install the glass beads.



**Figure 1. Attaching tubing to the sampling implant.**



**Figure 2. Once depth is achieved, the selected implant and tubing are inserted through the rods. The tubing is rotated to lock the implant into the drive point.**

# Sampling Implants – Operation

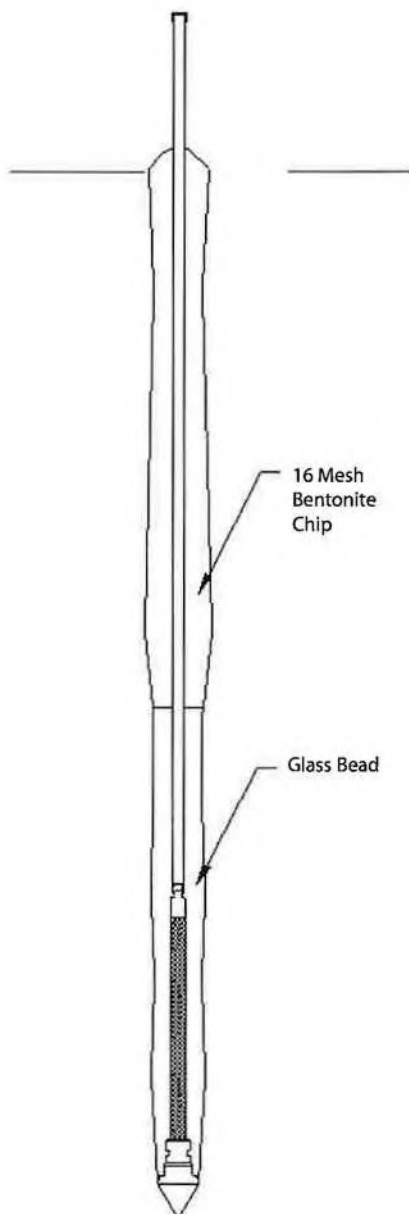


Figure 4. After the implant has been secured, the rods are removed and the annulus backfilled as appropriate.

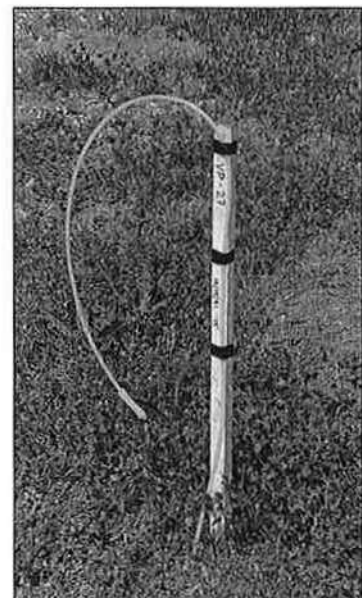
7. Pour glass beads down the inside diameter of the probe rods around the outside of the tubing. Use the tubing to "stir" the glass beads into place around the implant. Do not lift up on tubing. It should take less than 150 mL of glass beads to fill the space around the implant.

**NOTE:** Backfilling through the rods with glass beads or glass beads/bentonite mixes can only be performed in the Vadose Zone, not below the water table.

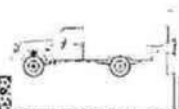
8. Lift up an additional 18 to 24 in. (457 to 610 mm) and pour the bentonite seal mixture into place as in Step 7. The volume to be filled is about 154 mL per foot. It may be necessary to "chase" the seal mixture with distilled water to initiate the seal.
9. Pull the remaining rods out of the hole as in Step 5. Backfilling with sackcrete (cement/sand) or bentonite/sand may be done while removing the rods (Figure 4). If the PR-14 Implant Anchor is used, the tubing may be cut flush with the top probe rod and a regular pull cap may be used to remove the remaining probe rods after Step 8.
10. After the probe rods have been removed, cut the tubing at the surface, attach a connector or plug, and mark the location with a pin flag or stake. The point is ready for sampling now.



Figure 3. Glass Beads create a permeable layer around vapor sample implants.

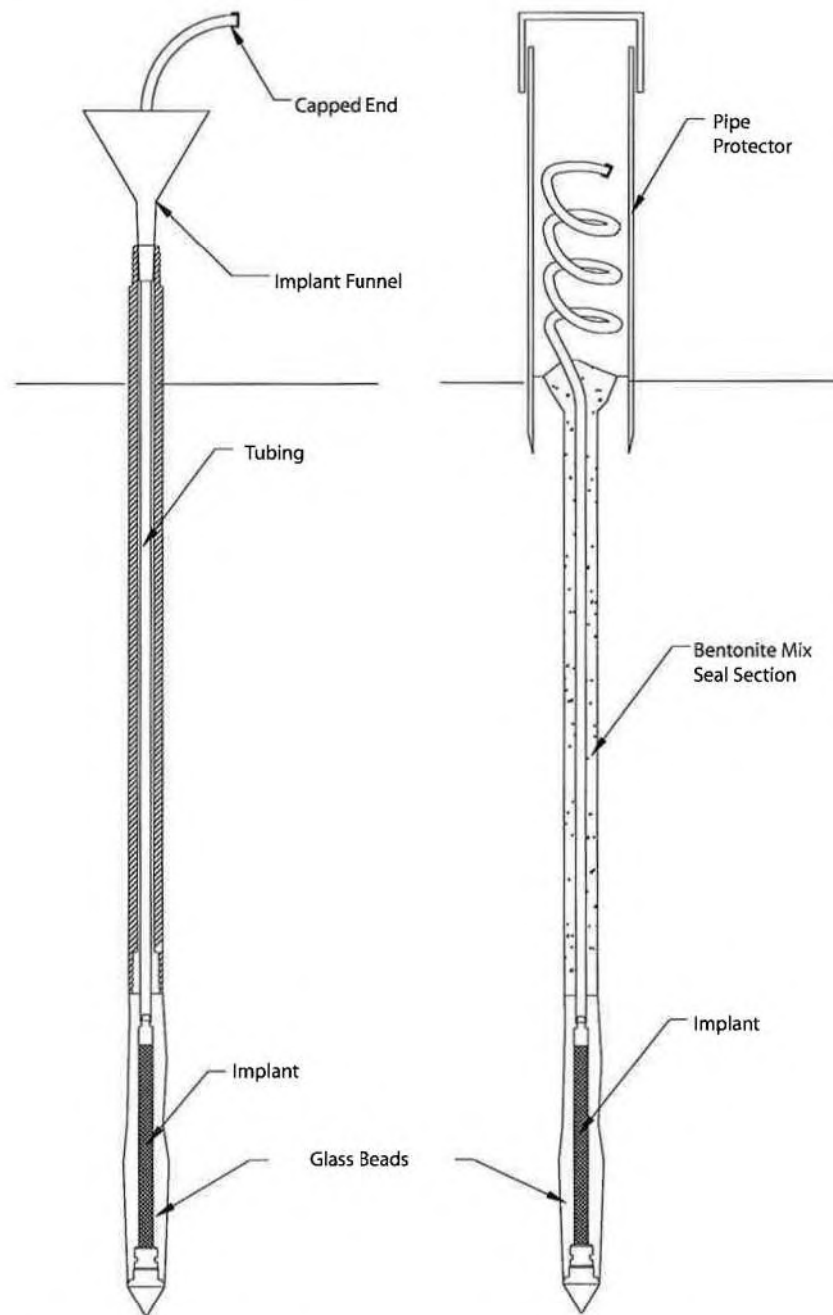


A vapor implant location.





## Sampling Implants – Operation



Backfill materials include glass beads and bentonite sealants.

Example of completed permanent soil gas monitoring point.



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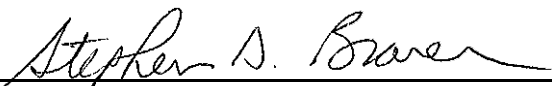
**MONITORING WELL DRILLING, INSTALLATION, AND DEVELOPMENT  
(Standard Operating Procedure 010)**


**Revision No: 2**

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Original Date: November 17, 2008

SOP Approval:  Date: 5/3/2023  
Stephen D. Brower, Principal Geoscientist

SOP Approval:  Date: 5/3/2023  
Daniel P. Claycomb, Principal Geoscientist

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## TABLE

Table 1	Monitoring Well Drilling, Installation, and Development Equipment & Materials Checklist
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## ATTACHMENT

Attachment 1	Monitoring Well Log Template
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# **MONITORING WELL DRILLING, INSTALLATION, AND DEVELOPMENT (Standard Operating Procedure 010)**

## **1.0 PURPOSE**

This standard operating procedure (SOP) provides the general technical requirements and operational guidelines to be followed during the installation and development of monitoring wells that will be used to collect groundwater samples and to monitor groundwater levels.

## **2.0 GENERAL CONSIDERATIONS**

Thoroughly evaluate potential hazards associated with the planned tasks prior to conducting field activities. Refer to the site-specific Health and Safety Plan (HASP) of the project for a description of potential hazards and associated safety and control measures.

Prior to conducting intrusive subsurface activities, the appropriate underground utility notifications (*i.e.*, National 811 One Call) must be made and the well installation activities must occur within the lawful dates provided by the One Call Center. Typically, 3 business days (72 hours)-notice must be given prior to beginning any type of intrusive activities. Refer to the Utility Clearance SOP (SOP 003) for additional information.

Prior to field activities, the field team should consider how investigation-derived waste (*i.e.*, drill cuttings and development water, decontamination fluids, *etc.*) is to be handled. Refer to the Management of Investigation-Derived Waste (IDW) SOP (SOP 018) for specific IDW handling procedures.

Verify with the drilling subcontractor that the necessary well permits have been obtained, if applicable.

Consult project control documents for guidance regarding the number and locations of groundwater monitoring wells to be installed as well as construction specifications.

## **3.0 PROCEDURES**

### **3.1 General Borehole Advancement/Monitoring Well Installation Procedures**

The following general procedures apply to the advancement of boreholes and installation of groundwater monitoring wells.

- Decontaminate all down-hole tools and equipment prior to use in accordance with the Decontamination of Equipment SOP (SOP 017). Investigation-derived waste generated during decontamination will be managed in accordance with SOP 018 (Management of Investigation-Derived Waste).
- Mobilize the drilling rig to the marked drilling location. Set up an exclusion or safety zone around the equipment and work area using items such as traffic cones and caution tape. Where there is a potential for drilling or formation fluids to collect on the ground surfaces as a result of drilling (*e.g.*, air rotary drilling), direct the subcontractor to construct a plastic-lined fluid collection area.
- If required, obtain the anticipated number of 55-gallon drums needed to contain the overburden and rock cuttings, drilling fluids, development water, and decontamination fluids. For larger projects containment vessels (*e.g.*, rolloff box) may be used instead of

## **MONITORING WELL DRILLING, INSTALLATION, AND DEVELOPMENT** **(Standard Operating Procedure 010)**

drums. Position the drums so they can be removed or staged at another location by the subcontractor.

- During drilling and well installation activities, use a photoionization detector (PID) to monitor organic vapor levels in the worker breathing zone and at the borehole.
- Shrouds, canopies, or directional pipes can be used to contain and direct the drill cuttings and fluids into the fluid collection area, 55-gallon drums, or roll-off boxes as necessary.
- Using a PID, field screen soil cuttings and liquids generated during drilling for indications of impact and note pertinent observations in the field logbook. If necessary, retain representative samples for subsequent inspection until completion of the characterization activities.
- If a borehole is not completed the same day that it is started, it must be secured overnight to prevent surface intrusion of contamination and/or tampering with the borehole.
- The use of joint lubrication compounds should be minimized. If lubrication compounds are required, however, a record of the joint compound used (*i.e.*, brand name, chemical composition, and amount used) must be entered into the field logbook. Petroleum-based lubrication compounds are not acceptable for use as joint lubrication. Vegetable shortening (*e.g.*, Crisco) may be used in lieu of joint compound.
- Weld or flush thread metal casing joints. A protective steel casing with a lockable cap will be installed at least 3 feet into the grout seal of each monitoring well installed with a stickup casing. Flush-mounted casings will be constructed using a flush-mounted steel vault mounted within a concrete skirt. Flush-mounted wells will be fitted with a locking, watertight cap and a padlock. Keys to locks will be maintained by the Field Team Leader or designee. Take care to allow for an appropriate vertical clearance between the inner casing and well cap to allow for installation of down-hole monitoring equipment.
- The annulus between the casing and the borehole or between any two casings must be a minimum of 2 inches to allow emplacement of a sufficient volume of filter pack material and/or annular seal materials. Use a tremie pipe to place grouts or slurries used for annular seals. Bentonite pellets may be poured in from the top of the well but must be poured slowly to prevent bridging. Intermittently sound the top of solid annular materials using a weighted tape measure and document the measurements.
- Following the completion of well construction, install a protective concrete well pad around the well. Pads will typically be 2 to 2.5 feet in diameter, finished flush with the ground surface, and sloped in a manner as to encourage surface drainage away from all sides of the well. If the well is completed as a stickup, pour the concrete to the outside edge of the outer casing. If the well is to be completed inside a flush-mounted roadbox, install the roadbox over the protective casing of the well prior to installing the protective well pad. Document the well number, depth, yield (if known), and completion date in the field logbook and record the well number on the inside cover of the well. Mark the well number (and permit number, if applicable) on the outer protective casing, if possible.

## **MONITORING WELL DRILLING, INSTALLATION, AND DEVELOPMENT** **(Standard Operating Procedure 010)**

After the well is completed, subcontract a licensed land surveyor to measure and document the horizontal and vertical position of the well relative to an established horizontal and vertical datum. Alternatively, the well may be surveyed by Environmental Standards and reference to a site-specific datum at the Project Manager's discretion. Refer to the Surveying SOP (SOP 019) for additional information.

### **3.2     Overburden Monitoring Well Installation Using Hollow-Stem Auger**

At project sites where groundwater is anticipated to be present in unconsolidated overburden material, monitoring wells can be installed using hollow-stem augers. Collect a minimum of one 2-foot split-barrel sample per each 5-foot interval. More frequent sampling may be necessary if changes in subsurface lithology or a water-bearing horizon are encountered. In general, continuous split-barrel samples should be collected at a minimum of one well boring associated with each site area.

The vertical placement of the well screen within a borehole is dependent upon the purpose of the well, site hydrogeologic conditions, and the physical and chemical characteristics of potential constituents-of-concern. Generally, the monitoring wells installed in unconsolidated materials will be designed to screen the water table (spanning a range of approximately 3 feet above to 7 feet below the water table) in such a manner as to account for seasonal fluctuations in water table depth and to ensure that free-phase floating product will be detected, if present.

After the borehole is drilled to the desired depth, gently lower the well screen and casing assembly through the augers to the bottom of the borehole. Next, gradually remove the auger string from the borehole while simultaneously filling the annulus with clean, uniform sand. If the borehole walls are unstable, or flowing sands are present, a plug may be used at the bottom of the auger string to prevent native material from entering the annulus. This plug must be "punched out" prior to lowering the well screen and casing through the augers. Place a cap or cover over the top of the well casing or riser before pouring the sand pack to prevent filter pack materials or sealing materials from falling inside the well. The annulus around the screen will ultimately be filled with filter pack material to a minimum of 2 feet above the top of the screen (PA DEP, 2021). Reasonable force can be applied if the screen is stuck in the auger; however, too much force can cause damage to the screen. If the screen becomes stuck while withdrawing the augers, pull the screen for inspection. To ensure that the sand pack adequately covers the screen, measure the depth to the top of the sand pack with a weighted tape periodically during sand placement. Consideration will also be given to the use of engineered screens (prepacked) to ensure proper well installation.

When the sand filter pack is at the desired level, place a minimum 2-foot thick layer of bentonite above the sand pack. Place the bentonite either via tremie pipe or by slowly pouring pellets (coated, if placed below the water table) down the annulus to minimize bridging. If the pellets are placed above the water table, add potable water to the annulus, after the pellets have been emplaced, to hydrate the bentonite seal. If the sides of the borehole are unstable or there are problems with using pellets, mix a bentonite slurry at a ratio of approximately 1.5 pounds of bentonite per 1 gallon of water and place the slurry using a tremie pipe. The slurry will be initially directed into a bucket to determine if the mixture is pumpable. Measure depth to the top of the bentonite seal with a weighted tape to verify that the proper thickness of seal has been placed in the annulus.

## **MONITORING WELL DRILLING, INSTALLATION, AND DEVELOPMENT** **(Standard Operating Procedure 010)**

Fill the remaining annular space above the bentonite seal with a Portland cement/bentonite grout mixture to the ground surface. The grout mixture will consist of approximately 4 pounds of bentonite per 94-pound bag of Portland cement mixed with approximately 6 to 7 gallons of potable water. Pump the grout mixture through a tremie pipe until undiluted grout rises from the annulus to the ground surface.

### **3.3     Air-Rotary Drilling/Bedrock and Overburden Monitoring Well Construction**

Air-rotary or percussion drilling techniques can be used to install both shallow and deep bedrock monitoring wells and overburden wells. Filter the air from the compressor on the drilling rig through an air filter or an oil/air separator to remove oil and other impurities. Potable water can be added to the borehole, if necessary, for dust control. If used, note the source of the potable water and its rate of addition in the field logbook. However, adding water for dust control prior to encountering the first water-bearing zone may mask the appearance of low-yield zones that are encountered. This is especially true if the well is required to monitor the water table or first water-bearing zone that is encountered. In these cases, the addition of water should be considered very carefully.

#### **3.3.1         Shallow Bedrock Well Construction**

A shallow bedrock monitoring well is typically located in the first significant water-bearing zone encountered in bedrock. To construct a shallow bedrock monitoring well, use air-rotary techniques to drill a minimum 8-inch diameter borehole, unless specified otherwise in project control documents, through the overburden to a minimum of 3 feet into competent bedrock. Collect drill cuttings every 5 feet, or more frequently as necessary, to describe the subsurface conditions. If saturated conditions are observed near the soil/bedrock interface and the objective is to monitor the uppermost water-bearing unit, a waiting period may be required prior to casing installation to evaluate static groundwater conditions. In this case, blow the water out of the borehole using the air from the drilling rig, then cease drilling. Monitor the borehole closely to evaluate whether it recharges with groundwater and its rate of recharge. As appropriate, the borehole may be completed as a single-screened well if water is observed to enter the borehole after a waiting period.

If water is not observed in the borehole after a waiting period, continue drilling into bedrock. Evaluate the need for a 6-inch-diameter surface casing to protect the overburden material from cave-ins. If a surface casing is used, install the casing at least 3 feet into competent bedrock to approximately 2.5 to 3 feet above ground surface.

If a surface casing is installed, seal the annular space around the surface casing by pumping grout through a tremie pipe from the base of the borehole to ground surface. The grout will consist of approximately 4 pounds of powdered bentonite for each 94-pound bag of Portland cement, mixed with approximately 6 to 7 gallons of potable water. Allow the grout to cure for a minimum of 24 hours before drilling resumes. The Project Manager (or designee) will determine when drilling can proceed.

Continue drilling until a water-bearing zone is identified. Complete the well as a screened well with a 2-inch diameter casing and screen, depending on the diameter of the borehole that was drilled. Pack the annulus around the screen with clean, uniform, commercially-bagged sand to a minimum depth of 2 feet above the top of the screen. Next, place a minimum 2-foot thick layer of

## **MONITORING WELL DRILLING, INSTALLATION, AND DEVELOPMENT** **(Standard Operating Procedure 010)**

bentonite pellets immediately above the sand pack. Tremie-grout the remaining annulus to the surface with a cement-bentonite slurry, as described in Section 3.3.1 of this SOP.

It is also possible to complete a monitoring well in bedrock as an open borehole well without a PVC screen. If an open borehole well is installed, the surface casing must extend a minimum of 5 feet into competent bedrock (PA DEP 2021). Other jurisdictions may require this casing to be set deeper into competent bedrock (i.e., NJDEP Requires 10 feet minimum in their 2021 Guidance Document).

In the case of a very low-yielding formation, it may be necessary to allow the borehole to recover for several hours or overnight, if appropriate, to determine if water-bearing zones have been intercepted, to evaluate the static depth to water, and the appropriate placement of the well screen.

### **3.3.2 Deep Bedrock Well Construction**

A deep bedrock monitoring well is commonly located in a water-bearing zone below the shallow bedrock water-bearing zone. In some cases, deep bedrock monitoring wells may require the installation of more than one casing if multiple aquifers are present.

Advance a borehole through the unconsolidated material to at least 3 feet into competent bedrock. Collect cuttings a minimum of every 5 feet, or more frequently as required, to describe and document the subsurface conditions.

Install a 6-inch diameter (minimum), flush-joint steel surface casing and tremie-grout the casing in place from the base of the borehole to the ground surface. After the grout has been allowed to cure, cut off the top of this casing approximately 6 inches above ground surface prior to resumption of drilling. Grout mixtures and curing times will be consistent with the shallow well construction methods described in Section 3.3.1 of this SOP.

After the grout has cured properly, continue drilling from the bottom of the surface casing to the top of the deep interval to be monitored. Complete the well as a screened well with a 2-inch diameter casing and screen, depending on the diameter of the borehole that was drilled. Pack the annulus around the screen with clean, uniform, commercially-bagged sand to a minimum depth of 2 feet above the top of the screen. Next, place a minimum 2-foot thick layer of bentonite pellets immediately above the sand pack. Tremie-grout the remaining annulus to the surface with a cement-bentonite slurry, as described in Section 3.3.1 of this SOP.

It is also possible to complete a monitoring well in bedrock as an open borehole well without a PVC screen. If an open borehole well is installed, the surface casing must extend a minimum of 5 feet (or deeper as per jurisdictional guidance) into competent bedrock (PA DEP 2021).

### **3.4 Well Development**

If well development occurs after the annular grout has been emplaced, do not begin development sooner than 24 hours after grouting is completed to ensure the grout is adequately cured. Develop the monitoring well until the formation water discharged from the well is as visually clean and free of sand and fines as practicable to ensure that the well provides representative groundwater samples. The determination to terminate development will be based



## **MONITORING WELL DRILLING, INSTALLATION, AND DEVELOPMENT (Standard Operating Procedure 010)**

on groundwater characteristics reaching steady state conditions as measured by the following criteria (as appropriate):

- Groundwater turbidity (10 NTUs).
- Groundwater appearance (opaque, transparent, or clear).
- Flow rate (maximum stabilized flow rate attained).

The monitoring wells can be developed using surge-block techniques, pumping, over pumping, or a combination of these techniques.

Do not add water to assist with well development without the approval of the Project Manager. If a monitoring well has an insufficient yield that prevents removal of fine materials during development, small amounts of potable water may be injected to help facilitate development. If this is done, document the volume and source of potable water in the field logbook.

During development, record the following information in the field logbook or on a well development form:

- Development time
- Development method
- Rate and volume of discharge water
- pH, temperature, specific conductance and turbidity of discharge water, if required by project control documents
- Description of water color, clarity, and odor prior to, during, and after well development
- Depth to water-level readings before and after well development
- Estimated well yield

Effective well development requires the movement of water in both directions through screen openings (or water-producing bedrock fractures, in the case of wells completed as open boreholes). Reverse flow helps to reduce bridging of sand and fines in the well screen.

### **3.4.1 Over Pumping**

Over pumping involves pumping a well at a higher rate than the well will be pumped when put into service or during sampling. Use a surface or submersible pump for well development using this method. To ensure proper development, initially set the pump intake at the bottom of the well and then move the pump intake toward the top of the water column or screen as development proceeds. This method is most effective when used in conjunction with the surge-block development technique.

### **3.4.2 Surging and Pumping Techniques**

This development method forces fluids into the formation as a tight-fitting surge block is lowered or pushed down the borehole and through the water column. The upstroke motion through the water column creates a suction that loosens the solids and pulls loose sediment from the formation into the well. For small diameter wells (e.g., 2-inches), a submersible pump can serve as both the surge block and pump. Purge the well by pumping as often as possible between

## **MONITORING WELL DRILLING, INSTALLATION, AND DEVELOPMENT (Standard Operating Procedure 010)**

surging to remove loose sediment. If possible, measure the drawdown in nearby wells during development to evaluate possible hydraulic communication between the wells.

### **3.5     Investigation-Derived Waste (IDW)**

IDW includes excess samples, drill cuttings, drilling mud, development water, decontamination fluids, disposable sampling equipment, and disposable personal protective equipment. Containerize and manage IDW according to the Management of Investigation-Derived Waste SOP (SOP 018).

### **3.6     Field Logbook Documentation**

Field logbooks will be maintained by the Field Team Leader (or designee) to record daily activities and to provide an accurate and complete lithologic log of the well and its construction. The minimum requirements for field logbook documentation are discussed in the Field Documentation Procedures SOP (SOP 001).

In addition to these requirements, document the following information in the field logbook during drilling, well installation, and development activities as appropriate:

- A complete and detailed soil and lithologic log of the borehole using the Unified Soil Classification System (USCS), including the starting and ending depth where each lithologic unit is encountered.
- The depths and thicknesses of fracture zones to the extent that they can be identified during drilling, stains on fracture faces (if observed), water-bearing zones, and zones of less resistant/more resistant drilling.
- Estimates of the amount of water produced during drilling and whether additional water was produced when fractures are encountered.
- PID readings and the depths at which they are measured and depths at which odors are encountered, if observed.
- Blow counts/6 inches that the sampler is driven with the drop hammer; the number of feet of recovered material in each split spoon; and whether free water is present in the recovered soil or on the outside of the split-barrel.
- A detailed construction log of the monitoring well that includes the following information (use the Environmental Standards monitoring well construction log template [attached] as a guide to record the required information)
  - Total borehole depth, diameter, outer casing (e.g. steel manhole with bolt-on lid), top plug (e.g. expandable 2" locking), and top of well (e.g. flush mount or road box).
  - Screen depth, placement, length, slot size, diameter, type of material (e.g. stainless-steel or PVC), connection (e.g. threaded), and thickness (e.g. schedule 40).
  - Riser length, diameter, type of material, and thickness.
  - Filter pack depth and thickness and sand size (e.g., No. 2 sand).
  - Bentonite seal depth and thickness.
  - Annular grout seal, composition, depth, and thickness.
  - Bottom plug type (e.g. schedule 40 PVC) and connection (e.g. slip-on).
  - Use the Environmental Standards monitoring well construction log template (attached) as a guide to record the required information.

## **MONITORING WELL DRILLING, INSTALLATION, AND DEVELOPMENT (Standard Operating Procedure 010)**

- Static water level following the completion of drilling, following well construction, and following the completion of well development.

### **3.7     Decontamination and Cleanup**

Perform sampling equipment decontamination in a manner consistent with the Decontamination of Equipment SOP (SOP 017) and the Management of Investigation-Derived Waste SOP (SOP 018).

## **4.0     REFERENCES**

- Driscoll, Fletcher G., *Groundwater and Wells*, Second Edition, Johnson Division, St. Paul, MN, 1986.
- Montrose Environmental, Field Documentation Procedures (SOP 001).
- Montrose Environmental, Field Screening Instrumentation and Procedures (SOP 002).
- Montrose Environmental, Utility Clearance (SOP 003)
- Montrose Environmental, Decontamination of Equipment (SOP 017).
- Montrose Environmental, Management of Investigation-Derived Waste (SOP 018).
- Montrose Environmental, Surveying (SOP 019)
- Pennsylvania Department of Environmental Protection. Groundwater Monitoring Guidance Manual, March 27, 2021.
- New Jersey Department of Environmental Protection. Well Construction and Maintenance; Sealing of Abandoned Wells, September 7, 2021.

**MONITORING WELL DRILLING, INSTALLATION, AND DEVELOPMENT**  
**(Standard Operating Procedure 010)**

<b>TABLE 1: MONITORING WELL DRILLING, INSTALLATION, AND DEVELOPMENT EQUIPMENT &amp; MATERIALS CHECKLIST</b>	
<b>Item Description</b>	<b>CHECK ✓</b>
<b>Health &amp; Safety</b>	
Nitrile gloves	
Hard hat	
Steel-toed boots	
Hearing protection	
Field first-aid kit	
Eyewash	
Safety glasses	
Barricades, cones, flashing lights, signs, caution tape	
Respirator and cartridges (if necessary)	
Saranex/Tyvek suits and booties (if necessary)	
<b>Paperwork</b>	
Health & Safety Plan	
Sampling plan/scope-of-work/project guidance documents	
Existing well construction data, location map, field data from previous sampling events	
Field logbook	
Drum labels	
Waterproof marker for completing drum label	
Flags for marking well locations	

**MONITORING WELL INSTALLATION AND DEVELOPMENT**  
**(Standard Operating Procedure 010)**

<b>TABLE 1: MONITORING WELL INSTALLATION AND DEVELOPMENT EQUIPMENT &amp; MATERIALS CHECKLIST (continued)</b>	
<b>Item Description</b>	<b>CHECK ✓</b>
<b>Equipment</b>	
Photoionization Detector/Multi-gas Detector	
Dremmel tool for labeling outside of well casing	
Drums	
Grainsize Chart/Color Table	
Digital camera	
Dilute HCl	
Water level/Interface probe	
Measuring tape/ruler	
Stopwatch	
Bucket	
Handheld strainer to collect drill cutting samples for logging (air-rotary drilling)	