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FINAL SAMPLING AND ANALYSIS PLAN SITE INSPECTION SITE 33 FORMER BUILDING
530 PAINT SHOP AND SAND BLASTING OPERATIONS NWS YORKTOWN VA
03/01/2015
CH2M HILL

SAP Worksheet #1—Title and Approval Page

Final

**Sampling and Analysis Plan
Site Inspection
Site 33 Former Building 530 Paint Shop and
Sand Blasting Operations**

**Naval Weapons Station Yorktown
Yorktown, Virginia**

Contract Task Order WE89

March 2015

Prepared for:

**Department of the Navy
Naval Facilities Engineering Command
Mid-Atlantic**

Under the

**NAVFAC CLEAN 8012 Program
Contract N62470-11-D-2012**

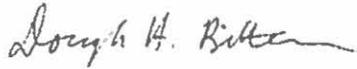
Prepared by:



Virginia Beach, Virginia

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Review Signature:



Digitally signed by Douglas H. Bitterman, PG
DN: cn=Douglas H. Bitterman, PG, o=CH2M
HILL, ou, email=doug.bitterman@ch2m.com,
c=US
Date: 2015.02.23 16:22:14 -05'00'

Doug Bitterman/CH2M HILL AQM

Date

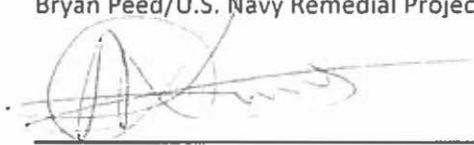
Approval Signatures:

PEED.BRYAN.K.125232
5707

Digitally signed by PEED.BRYAN.K.1252325707
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI,
ou=USN, cn=PEED.BRYAN.K.1252325707
Date: 2015.02.25 10:06:25 -05'00'

Bryan Peed/U.S. Navy Remedial Project Manager

Date



02/25/2015

Moshood Oduwole/USEPA Project Manager

Date



03/03/2015

Wade Smith/VDEQ Project Manager

Date



Digitally signed by renee.hunt@ch2m.com
DN: cn=renee.hunt@ch2m.com
Date: 2015.02.24 14:32:56 -06'00'

Renee Hunt/CH2M HILL Project Manager

Date

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Executive Summary

This site-specific Sampling and Analysis Plan (SAP) is being submitted to provide a systematic data collection and analysis structure for the Site 33 Former Sand Blasting Grit Area and Waste Disposal Areas Site Inspection (SI) at Naval Weapons Station (WPNSTA) Yorktown, Yorktown, Virginia. In accordance with the Guidance for Uniform Federal Policy (UFP) for Quality Assurance Project Plans (QAPP) (March 2005), this Department of the Navy (Navy)-specific SAP includes 37 worksheets that detail various aspects of the environmental investigation process and serve as guidelines for the field work and data quality. The field standard operating procedures (SOPs) are located in **Appendix A** of this SAP.

The Naval Facilities Engineering Command (NAVFAC), Mid-Atlantic, is conducting this SI under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). CERCLA work is being conducted with the United States Environmental Protection Agency (USEPA) Region 3 as the lead regulatory agency. The Virginia Department of Environmental Quality (VDEQ) is the state regulatory agency. Together, these three agencies are the stakeholder agencies for this project.

This document will help ensure that environmental data collected or compiled are scientifically sound, of known and documented quality, and are suitable for intended uses. The laboratory information cited in this SAP is for the analytical laboratories that are currently contracted to provide analytical services for this investigation. The analytical services for this investigation will be provided by Katahdin Analytical Services as the primary laboratory, with TestAmerica Laboratories in Burlington, Vermont as a third-tier laboratory. Data validation (DV) services will be provided by CH2M HILL.

The purpose of this SI is to determine if potential impacts from historical Site 33 activities warrant additional investigation at WPNSTA Yorktown. Although some data have been collected at Site 33 in the vicinity of Former Building 530, this investigation will evaluate the presence of potentially impacted media, determine if detected contamination may pose potentially unacceptable human health or ecological risk, and identify which receptors are potentially at risk. Elevated chlorinated volatile organic compound (VOC) and metals concentrations were previously detected in site groundwater near the Former Building 530, and waste dumping areas have been identified in the wooded portions of the site.

In order to evaluate the presence of groundwater contamination previously observed at the site, groundwater samples will be collected from new monitoring well locations. Based on the historical use of Site 33, groundwater samples will be analyzed for VOCs, semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), pesticides, cyanide, and total and dissolved metals.

In order to evaluate the presence of soil contamination associated with Former Building 530 activities, surface and subsurface soil samples will be collected in the vicinity of the building. Additionally, test pits and surface and subsurface soil samples will be collected in the wooded portions of Site 33 to evaluate the waste dumping areas. Soil samples collected at Site 33 will be analyzed for VOCs, SVOCs, PCBs, pesticides, cyanide, pH, total organic carbon (TOC) and total metals.

The Partnering Team will evaluate the results of the groundwater and soil sampling activities and historical site data, to determine where sediment and surface water samples are needed and which analytical constituents those samples should be analyzed for to evaluate impacts related to historical Site 33 operations. Additionally, samples from groundwater-fed seeps/sediment pore water may be collected at Site 33 should groundwater or soil sample results indicate that these media maybe impacted by site-related constituents.

Laboratory data will be compared to human health and ecological risk-based screening values and facility-specific background upper tolerance limits (UTLs) (where available). COPCs will be identified where analytes are detected that exceed their respective screening values. Groundwater data will also be compared to maximum contaminant levels (MCLs). Background concentrations will be taken into account when selecting ecological COPCs.

A human health risk screening and an ecological risk screening will be performed to identify human health and ecological COPCs, respectively. Based on the results of the risk screenings, the Partnering Team will evaluate the need for a quantitative Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (ERA). If needed, the risk assessments will be performed for all identified human health and ecological COPCs. Whether further investigation at Site 33 is warranted will be evaluated based on the results of the risk screenings/assessments, MCL exceedances, and the presence of waste material at the site.

Data, results, conclusions, and recommendations regarding the path forward for Site 33 will be documented in the SI Report. If the nature and extent of contamination is sufficiently defined and risks have been quantified, an RI Report may be completed in lieu of an SI Report.

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- A Field Standard Operating Procedures
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- C Ecological Screening Values

Table

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- 2 Site 33 Topographic Map
- 3 Site 33 Site Map
- 4 Site 33 Historical Building Configuration
- 5 Site 33 Conceptual Site Model
- 6 Site 33 Proposed Sample Locations
- 7 Sediment, Surface Water, and Seep Sampling Decision Tree
- 8 Test Pitting Decision Tree

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Acronyms and Abbreviations

°C	degree Celsius
µg/kg	microgram per kilogram
µg/L	microgram per liter
µm	micrometer
µmol/g	micromoles per gram
%D	percent difference; percent drift
%R	percent recovery
%RSD	percent relative standard deviation
AES	atomic emission spectrometer
AM	Activity Manager
AOC	area of concern
AQM	Activity Quality Manager
AVS	acid volatile sulfide
BFB	4-bromofluorobenzene
bgs	below ground surface
BHC	benzene hexachloride
CA	corrective action
CAS	Columbia Analytical Services
CCC	calibration check compound
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CLEAN	Comprehensive Long-term Environmental Action—Navy
CLLE	continuous liquid-liquid extraction
COC	constituent of concern
COPC	constituent of potential concern
CSM	conceptual site model
CTO	Contract Task Order
CV	calibration verification
CVAA	cold vapor atomic absorption
DBCP	1,2-dibromo-3-chloropropane
DCA	dichloroethane
DCE	dichloroethene
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DFTPP	decafluorotriphenylphosphine
DL	detection limit
DNT	dinitrotoluene
DO	dissolved oxygen
DoD	Department of Defense
DPT	direct-push technology
DQI	data quality indicator
DQO	data quality objective
DV	data validation

ECATTS	Environmental Compliance Assessment, Training, and Tracking System
EDB	1,2-dibromoethane
EICP	extracted ion current profile
ELAP	Environmental Laboratory Accreditation Program
ERA	Ecological Risk Assessment
ERP	Environmental Restoration Program
FTL	Field Team Leader
Freon-11	Trichlorofluoromethane
Freon-12	Dichlorodifluoromethane
Freon-113	1,1,2-Trichloro-1,2,2-trifluoroethane
g	gram
GC/ECD	gas chromatography/electron capture detector
GC/MS	gas chromatograph/mass spectrometer
H&S	health and safety
HCl	hydrochloric acid
HHRA	Human Health Risk Assessment
HNO ₃	Nitric Acid
HS&E	health, safety, and environment
HSO	Health and Safety Officer
HSP	Health and Safety Plan
ICAL	initial calibration
ICP	inductively coupled plasma
ICS	interference check solution
ICV	initial calibration verification
ID	identification
IDW	investigation-derived waste
IS	internal standard
L	liter
LCL	lower control limit
LCS	laboratory control sample
LIMS	Laboratory Information Management Systems
LOD	limit of detection
LOQ	limit of quantitation
MCL	maximum contaminant level
MDL	method detection limit
MEK	2-butanone
mg/kg	milligrams per kilogram
ml	milliliter
mm	millimeter
MPC	measurement performance criteria
MS	matrix spike
MSA	method of standard additions
MSD	matrix spike duplicate
MTBE	methyl-tert-butyl ether
N/A	not applicable
NaOH	sodium hydroxide
NAVFAC	Naval Facilities Engineering Command

Navy	Department of the Navy
NB	nitrobenzene
NC	no criterion
ORP	oxidation-reduction potential
oz	ounce
PAH	polynuclear aromatic hydrocarbon
PAL	project action limit
PC	Project Chemist
PCB	polychlorinated biphenyl
PDF	portable document format
PDS	post-digestion spike
PID	photoionization detector
PIL	project indicator level
PM	Project Manager
POC	point of contact
PPE	personal protective equipment
ppm	part per million
PQL	practical quantitation limit
PQO	project quality objective
PVC	polyvinyl chloride
QA	quality assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plans
QC	quality control
QL	quantitation limit
QSM	Quality Systems Manual
r	correlation coefficient
r ²	coefficient of determination
RF	response factor
RI	Remedial Investigation
RL	reporting limit
ROD	Record of Decision
RPD	relative percent difference
RPM	Remedial Project Manager
RSD	relative standard deviation
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SDG	sample delivery group
SEM	simultaneously extracted metals
SI	Site Inspection
SIM	selected ion monitoring
SOP	standard operating procedure
SPCC	system performance check compound
SSA	site screening area
STC	Senior Technical Consultant
SVOC	semivolatile organic compound

TAL	Target Analyte List
TBD	to be determined
TCA	trichloroethane
TCE	trichloroethene
TCL	Target Compound List
TCMX	tetrachloro-m-xylene
TNT	trinitrotoluene
TOC	total organic carbon
UCL	upper control limit
UFP	Uniform Federal Policy
USEPA	United States Environmental Protection Agency
UST	underground storage tank
UTL	upper tolerance limit
VC	vinyl chloride
VDEQ	Virginia Department of Environmental Quality
VOA	volatile organic analyte
VOC	volatile organic compound
WPNSTA	Naval Weapons Station

SAP Worksheet #2—Sampling and Analysis Plan Identifying Information

[\(UFP-QAPP Manual Section 2.2.4\)](#)

Site Name/Number: Site 33 – Former Building 530 Paint Shop and Sand Blasting Operations Area

Operable Unit: Not applicable (N/A)

Contractor Name: CH2M HILL

Contract Number: N62470-08-D-1000

Contract Title: Comprehensive Long-term Environmental Action—Navy (CLEAN) 1000

Work Assignment Number (optional): N62470-08-D-1000, Contract Task Order (CTO)-068

1. This Sampling and Analysis Plan (SAP) was prepared in accordance with the requirements of the:

- *Uniform Federal Policy for Quality Assurance Plans* (UFP-QAPP) (USEPA, 2005)
- *Guidance for Quality Assurance Project Plans, EPA QA/G-5* (USEPA, 2002).

2. Identify regulatory program:

- Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)

3. This SAP is a project-specific SAP.

4. List organizational partners (stakeholders) and identify the connection with lead organization:

Lead Organization: Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic Division

Land Owner: Department of Defense (DoD)

Lead Regulatory Agency: United States Environmental Protection Agency (USEPA) Region 3

State Regulatory Agency: Virginia Department of Environmental Quality (VDEQ)

5. If any required SAP elements and required information are not applicable to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion as follows:

All SAP elements required for this project are described herein. Therefore, the crosswalk table is not necessary for this project.

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SAP Worksheet #3—Distribution List

[\(UFP-QAPP Manual Section 2.3.1\)](#)

SAP Recipients	Title	Organization	Telephone Number (optional)	E-mail Address or Mailing Address
Bryan Peed	Remedial Project Manager (RPM)	NAVFAC Mid-Atlantic	(757) 341-0480	Bryan.Peed@navy.mil
Moshood Oduwole	RPM	USEPA Region 3	(215) 814-3362	Oduwole.Moshood@epamail.epa.gov
Wade Smith	RPM	VDEQ	(804) 698-4125	Wade.Smith@deq.virginia.gov
Bonnie Capito	Librarian	NAVFAC Atlantic	(757) 322-4785	Bonnie.Capito@navy.mil
Bill Friedmann	Contractor Activity Manager (AM)	CH2M HILL	(757) 671-6223	William.Friedmann@ch2m.com
Renee Hunt	Contractor Project Manager (PM)	CH2M HILL	(414) 847-0349	Renee.Hunt@ch2m.com
Herb Kelly	Contractor Data Validation (DV)	CH2M HILL	(352) 384-7100	Herb.Kelly@ch2m.com
Kelly Perkins	Laboratory Subcontractor PM	Katahdin	(207) 874-2400	kperkins@katahdinlab.com
Kathryn Kelly	Laboratory Third-Tier Subcontractor PM	TestAmerica-Burlington	(802) 660-1990	kathryn.kelly@testamericainc.com
Roni Warren	Contractor Human Health Risk Assessor	CH2M HILL	(814) 364-2454	Roni.Warren@ch2m.com
William Kappleman	Contractor Ecological Risk Assessor	CH2M HILL	(703) 376-5152	William.Kappleman@ch2m.com
Clairette Campbell	Contractor Project Chemist (PC)	CH2M HILL	(757) 671-6335	Clairette.Campbell@ch2m.com
Doug Bitterman	Contractor Activity Quality Manager (AQM)	CH2M HILL	(757) 671-6209	Doug.Bitterman@ch2m.com
To be determined (TBD)	Contractor Field Team Leader (FTL)	CH2M HILL	TBD	TBD

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SAP Worksheet #4—Project Personnel Sign-Off Sheet

[\(UFP-QAPP Manual Section 2.3.2\)](#)

The responsibility of implementing the SAP will vary depending upon the role of the people and their organization. It is anticipated that the lead PM from each organization will be responsible for the overall SAP implementation. However, technical support staff, support contractors, and additional stakeholders may have input to the SAP and are also listed as potential signers, if applicable. The table is broken into two areas; those that will be responsible for the complete SAP implementation and the supporting staff, contractors or stakeholders who may sign the SAP. Personnel will indicate which sections of the SAP they reviewed.

The Naval Weapons Station (WPNSTA) Yorktown, Virginia Partnering Team has an established system of receiving and reviewing documents. This document review system is also extended to individual agency technical support. Distribution of draft, draft final, and final versions of reports are made to the respective PM of each agency (NAVFAC, USEPA Region 3, and VDEQ). The deliverables are provided in two formats; a hard copy as well as access to an electronic portable document format (PDF) version of the document. Prior to the distribution of the documents, each agency provides CH2M HILL with the number of copies that is required for the document. This is done to ensure that enough copies are provided so that the agencies may provide copies of the deliverable to any technical support staff. Comments are then returned to CH2M HILL by the PM of each agency in either letter or e-mail format. The agencies may also provide any comments received by their technical support staff. Review periods for each version of the document varies by report, but is expected to follow: draft - 60 days, draft final - 14 days, and final - 14 days. However, the Department of the Navy (Navy), USEPA Region 3, and VDEQ expedite reviews whenever possible. The deadlines for reviews and comments are tracked by the Partnering Team using a document tracking tool maintained by CH2M HILL. This tracking sheet is provided to the partnering team following each update at Tier 1 Partnering Meetings. All comments received are uploaded to the Yorktown Administrative Record.

The following is a list of people who are responsible for ensuring overall implementation of the SAP:

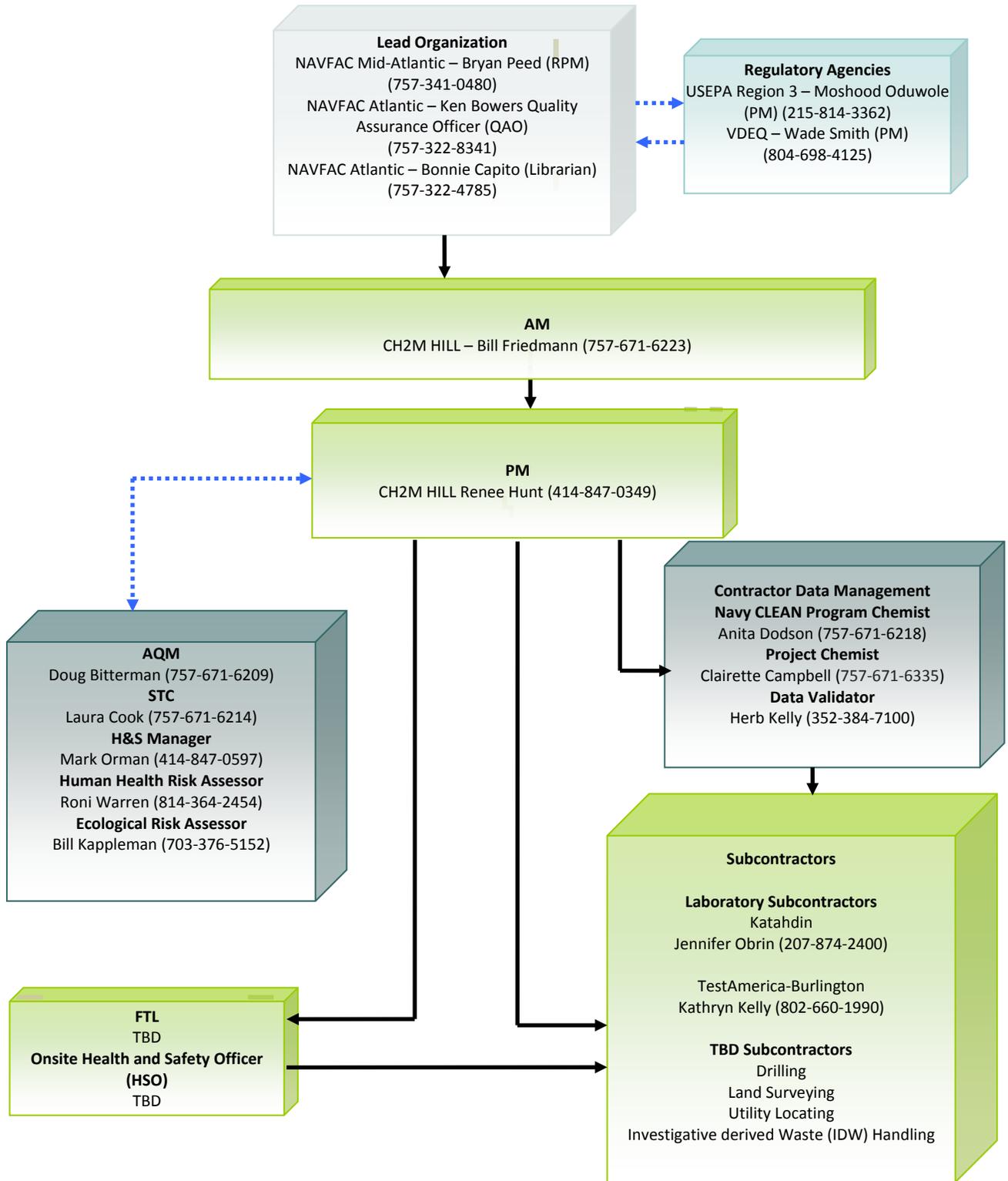
Name	Organization/Title/Role	Telephone Number	Signature/e-mail receipt	SAP Section Reviewed	Date SAP Read
Jamie Butler	CH2M HILL SAP Quality Reviewer	(757) 671-6212			
Bill Friedmann	CH2M HILL AM	(757) 671-6223			
Anita Dodson	CH2M HILL Navy CLEAN Program Chemist	(757) 671-6218			
Laura Cook	Senior Technical Consultant (STC)	(757) 671-6214			
Doug Bitterman	CH2M HILL AQM	(757) 671-6209			
Renee Hunt	CH2M HILL PM	(414) 847-0349			

SAP Worksheet #4—Project Personnel Sign-Off Sheet (continued)

The following is a list of people who may provide input and therefore review portions or all of the SAP:

Name	Organization/Title/Role	Telephone Number	Signature/e-mail receipt	SAP Section Reviewed	Date SAP Read
Bonnie Capito	NAVFAC Atlantic Librarian	(757) 322-4785			
Clairette Campbell	CH2M HILL PC	(757) 671-6335			
Roni Warren	CH2M HILL Human Health Risk Assessor	(814) 364-2454			
William Kappleman	CH2M HILL Ecological Risk Assessor	(703) 376-5152			
TBD	CH2M HILL FTL	TBD			
Herb Kelly	CH2M HILL Data Validator	(352) 384-7100			
Jennifer Obrin	Katahdin PM	(207) 874-2400			
Kathryn Kelly	TestAmerica-Burlington PM	(802) 660-1990			

SAP Worksheet #5—Project Organizational Chart



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SAP Worksheet #6—Communication Pathways

[\(UFP-QAPP Manual Section 2.4.2\)](#)

The communication pathways for the SAP are shown as follows.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, and so forth)
Regulatory Agency Interface	RPM, NAVFAC Mid-Atlantic	Bryan Peed	(757) 341-0480	All materials and information pertaining to the project will be forwarded to Moshood Oduwole and Wade Smith
Stop Work due to Safety Issues	CH2M HILL FTL	TBD	TBD	Communicate directly with the field team at the time the safety issue is identified. Provide verbal and/or written documentation of the stop work to the CH2M HILL AM and PM immediately after work is stopped and personnel are removed from any potential hazards.
Implement SAP and manage all phases of the project	CH2M HILL PM	Renee Hunt	(414) 847-0349	Communicate directly (verbal and/or in writing) with the AM and NAVFAC as necessary
SAP/Work Plan Changes prior to Field/Laboratory work	CH2M HILL PM	Renee Hunt	(414) 847-0349	Communicate directly (verbal and/or in writing) with the AM and NAVFAC as necessary
SAP/Work Plan Changes in the Field	CH2M HILL FTL	TBD	TBD	Communicate directly (verbal and/or in writing) with CH2M HILL AM or PM with daily meetings. Documentation of deviations from the UFP-SAP made in field logbooks; deviations made only with approval of PM, who will communicate with the AM, Navy RPM, and regulators. The FTL will ensure SAP requirements are met by field staff.
Data tracking from collection through upload to database	CH2M HILL PC	Clairette Campbell	(757) 671-6335	The PC tracks the data and informs the PM and Program Chemist of potential problems or issues. The PM and AM are informed within 24 hours to pass on communications to Navy and regulators as appropriate.
Sample Receipt Variances	Katahdin PM TestAmerica-Burlington PM	Jennifer Obrin Kathryn Kelly	(207) 874-2400 (802) 660-1990	All sample receipt variances will be communicated to the PC by the subcontracted laboratory within 1 day of discovery.
Reporting Lab Quality Variances	Katahdin PM TestAmerica-Burlington PM	Jennifer Obrin Kathryn Kelly	(207) 874-2400 (802) 660-1990	All quality assurance (QA)/quality control (QC) issues with project field samples will be reported by the subcontracted laboratory, who will relay them to the PC and Contractor Quality Assurance Officer (QAO) within 2 days of discovery.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, and so forth)
Field and Analytical Corrective Actions (CAs)	CH2M HILL Program Chemist, PC, and FTL	Anita Dodson Clairette Campbell TBD	(757) 671-6218 (757) 671-6335 TBD	The need for CA for field and analytical issues will be determined by the FTL, PC, senior support staff, and/or Contractor QAO as necessary. The senior support will ensure Quality Assurance Project Plans (QAPP) requirements are met by field staff. The PC will ensure QAPP requirements are met by the laboratory. The FTL will notify the PM of any needed field CAs. The PM will notify the Navy RPM of any field quality issues that would negatively impact data quality or schedule. The PM will have 24 hours to respond to the request for field CA. CA with laboratories will be coordinated by PC. The Navy RPM and Navy Chemist may be notified of any lab issues that render data quality objectives (DQOs) unattainable or cause delivery issues such that project schedule cannot be met.
Reporting DV Issues	CH2M HILL Data Validator	Herb Kelly	(352) 384-7100	All completeness and data issues will be addressed with the laboratory. The Data Validator should copy the CH2M HILL PC on all communications to the laboratory. The validated data package will be due within 14 calendar days of data receipt by the validator.
DV CAs	CH2M HILL Data Validator, Program Chemist, and PC	Herb Kelly Anita Dodson Clairette Campbell	(352) 384-7100 (757) 671-6218 (757) 671-6335	The need for CA for DV issues will be determined by the CH2M HILL data validator, Program Chemist and PC, as necessary. These staff members will ensure that QAPP requirements are met by the analytical results. The PC will notify the PM of any needed DV CAs. The PM will have 48 hours to respond to the request for the DV CA. DV CAs will be coordinated by the PC in coordination with the CH2M HILL data validator and Program Chemist.

SAP Worksheet #7—Personnel Responsibilities Table

[\(UFP-QAPP Manual Section 2.4.3\)](#)

Title/Role	Organizational Affiliation	Responsibilities
Bryan Peed/NAVFAC RPM	NAVFAC Mid-Atlantic	Coordinates all environmental restoration program activities at WPNSTA Yorktown
Moshood Oduwole/USEPA RPM	USEPA Region 3	Manages all aspects of the project to confirm federal regulations and requirements are met
Wade Smith/VDEQ RPM	VDEQ	Manages all aspects of the project to confirm state regulations and requirements are met
Bonnie Capito/Librarian	NAVFAC Mid-Atlantic	Responsible for document tracking and filing
Bill Friedmann/AM	CH2M HILL	Responsible for support to Navy to implement CERCLA Environmental Restoration Program (ERP) at WPNSTA Yorktown
Renee Hunt/PM	CH2M HILL	Day-to-day project management to implement SAP. Directs and oversees staff; health, safety, and environment (HS&E). Contractor point of contact (POC) for decision-making. Conducts data usability assessment.
Douglas Bitterman/AQM	CH2M HILL	Provides activity-level quality review and guidance
Laura Cook/STC	CH2M HILL	Provides senior technical oversight
William Kappleman/Ecological Risk Assessor	CH2M HILL	Responsible for Ecological Risk Assessment (ERA) to determine any impacts to ecological receptors
Roni Warren/Human Health Risk Assessor	CH2M HILL	Responsible for Human Health Risk Assessment (HHRA) to determine any impacts to human receptors
Anita Dodson/Program Chemist	CH2M HILL	Provides program level review of the UFP-SAP and program-level support throughout the project duration
Clairette Campbell/PC	CH2M HILL	Performs oversight of laboratory and data validators, and evaluates usability of data. Manages sample tracking.
TBD/FTL	CH2M HILL	Supervises field sampling and coordinates all field activities
Herb Kelly/Data Validator	CH2M HILL	Responsible for the analytical data review and validation
Mark Orman/Health and Safety Officer (HSO)	CH2M HILL	Oversees Health and Safety (H&S) for CLEAN Program
Jennifer Obrin/Laboratory PM	Katahdin Laboratories	Responsible for Katahdin Laboratories analytical services
Kathryn Kelly/Laboratory PM	TestAmerica-Burlington	Responsible for TestAmerica-Burlington analytical services

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SAP Worksheet #8—Special Personnel Training Requirements Table

[\(UFP-QAPP Manual Section 2.4.4\)](#)

Project Function	Specialized Training By Title or Description of Course	Training Provider	Training Date	Personnel/Groups Receiving Training	Personnel Titles/Organizational Affiliation	Location of Training Records/Certificates
Environmental Field Work	Environmental Compliance Assessment, Training, and Tracking System (ECATTS)	NAVFAC - Online	Project-specific	All field crew members	Field Staff, TBD	Document in project files
Environmental Field Work	HERO	NAVFAC – in person	Prior to Field work	All field crew members who will be using radio transmitters or cell phones on site	Field Staff, TBD	Document in project files

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SAP Worksheet #9a—Project Scoping Session Participants Sheet

[\(UFP-QAPP Manual Section 2.5.1\)](#)

Project Name: SI at WPNSTA Yorktown Site 33 Projected Date(s) of Sampling: April 2010 (tentative) PM: Renee Hunt			Site Name: Site 33 Site Location: WPNSTA Yorktown, Virginia		
Date of Session: June 25, 2009 Scoping Session Purpose: To review previous investigation data and present the proposed sampling approach to the Partnering Team for Site 33.					
Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Bill Friedmann	AM	CH2M HILL	(757) 671-6223	William.Friedmann@ch2m.com	Overseeing project delivery, technical support
Renee Hunt	PM	CH2M HILL	(414) 847-0349	Renee.Hunt@ch2m.com	UFP-SAP production, project management
Adam Forshey	Project Engineer	CH2M HILL	(757) 671-6267	Adam.Forshey@ch2m.com	Coordination of field investigation and reporting effort
Wade Smith	RPM	VDEQ	(804) 698-4125	wade.smith@deq.virginia.gov	Lead representative of VDEQ, responsible for review of documents and ensure that appropriate regulations are applied
Rob Thomson	RPM	USEPA	(215) 814-3357	Thomson.Bob@epamail.epa.gov	Lead representative of USEPA, responsible for review of documents and ensure that appropriate regulations are applied
Tom Kowalski	RPM	NAVFAC Mid-Atlantic	(757) 444-3826	Tom.Kowalski@navy.mil	Representative of lead agency responsible for overseeing execution of projects

Comments/Decisions:

The Yorktown Tier I Partnering Team reviewed previous investigations conducted at Site 33 to determine current data objectives and future needs for site investigation. The team discussed that while a soil removal was performed at Site 33 for blast grit and lead-contaminated soils, additional evaluation was necessary for groundwater to determine if site impacts may pose an unacceptable risk to human health or the environment, whether remedial actions are warranted, and if there is no unacceptable risk to complete site closure for all media. Based on available data collected as part of previous investigations, tentative sample locations were identified based on existing analytical results, potential site risks, and transport mechanisms for each medium (surface water bodies and flow, groundwater direction, and site terrain).

The team reviewed the preliminary groundwater COPCs for Site 33 based on the comparison to screening values. VOCs (primarily trichloroethene [TCE]) and total/dissolved metals (primarily aluminum, arsenic, chromium, manganese, and vanadium) were identified as COPCs from the former grinding and sand blasting operations. Because the precise source of VOC impacts at Site 33 is unknown, the team proposed a sampling strategy involving initial sampling of groundwater via direct-push grab samples for VOCs around the perimeter of Former

SAP Worksheet #9a—Project Scoping Session Participants Sheet (continued)

Building 530. Two discrete-depth groundwater samples were tentatively considered for collection at 10 sampling locations – one sample to be collected at the depth of first encountered groundwater and the second sample directly above the confining unit at the base of the shallow aquifer. The team discussed the possibility of holding the deeper sample for analysis pending review of the shallow groundwater sample results. Reconvening the Partnering Team following analysis of the shallow sample was discussed to determine whether analysis of the deeper groundwater sample is warranted. The team also discussed collection of soil cores for characterization of site lithology due to the lack of historical information available for this site and the need to place groundwater samples above the fine-grained units that would restrict downward migration of contaminants with specific gravities greater than water. It was proposed that permanent monitoring well locations could be determined based on the results of the direct-push sampling.

The Partnering Team agreed upon the rationale for the proposed sampling locations. The action item resolutions have been incorporated into the proposed sampling approach.

Action Items:

1. Change the name of Site Screening Area (SSA) 22 to Site 33.

Resolution: SSA 22 has been renamed as Site 33.

2. Follow up on a closeout report for the former underground storage tank (UST) at Site 33.

Resolution: Historical UST information for Former Building 530 at Site 33 has been reviewed by CH2M HILL. Site documentation indicates that the former 10,000-gallon fuel oil UST at Former Building 530 was removed in 1996. At the time of the tank removal, soil confirmation and groundwater sampling was performed within the former UST tank pit and the surrounding area. No evidence of releases from the tank was documented during the tank removal.

Consensus Decisions:

None

SAP Worksheet #9b—Project Scoping Session Participants Sheet

[\(UFP-QAPP Manual Section 2.5.1\)](#)

Project Name: SI at WPNSTA Yorktown Site 33 Projected Date(s) of Sampling: June 2012 (tentative) PM: Renee Hunt			Site Name: Site 33 Site Location: WPNSTA Yorktown, Virginia		
Date of Session: April 7, 2011 Scoping Session Purpose: To discuss the modified sampling approaches for Site 33 as requested by the USEPA (during the February 2011 Partnering Meeting).					
Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Bill Friedmann	AM	CH2M HILL	(757) 671-6223	William.Friedmann@ch2m.com	Overseeing project delivery, technical support
Renee Hunt	PM	CH2M HILL	(414) 847-0349	Renee.Hunt@ch2m.com	UFP-SAP production, project management
Adam Forshey	Project Engineer	CH2M HILL	(757) 671-6267	Adam.Forshey@ch2m.com	Coordination of field investigation and reporting effort
Wade Smith	RPM	VDEQ	(804) 698-4125	wade.smith@deq.virginia.gov	Lead representative of VDEQ, responsible for review of documents and ensure that appropriate regulations are applied
Rob Thomson	RPM	USEPA	(215) 814-3357	Thomson.Bob@epamail.epa.gov	USEPA support, responsible for review of documents and ensure that appropriate regulations are applied
Moshood Oduwole	RPM	USEPA	(215) 814-3362	oduwole.moshood@epamail.epa.gov	Lead representative of USEPA, responsible for review of documents and ensure that appropriate regulations are applied
Tom Kowalski	RPM	NAVFAC Mid-Atlantic	(757) 444-3826	Tom.Kowalski@navy.mil	Representative of lead agency responsible for overseeing execution of projects

SAP Worksheet #9b—Project Scoping Session Participants Sheet (continued)

Comments/Decisions:

Since the previous scoping session, site sampling and finalization of the SAP was delayed while awaiting the decontamination and demolition of buildings located at Site 9 and 19. Following the completion of the demolition activities, a follow-up site visit was performed at Sites 9, 19 and 33 in February 2011 to reassess site conditions and reevaluate the sampling approach.

The team reviewed information related to waste material observed in the northern and western portion of Site 33 during the February 2011 site visit, which included metal slag and other debris. This material was observed in the wooded areas surrounding the Former Building 530 soil removal area. The source of the waste material is not known, but based on the observed characteristics of the waste material, it appears that the material may be attributable to former Site 33 operations. Based on this information, the team determined that investigation of these areas was warranted and could be completed as part of the Site 33 investigation. Consequently, the team determined that the Site 33 SI would consist of evaluation of groundwater in the sand-blasting area where VOCs and metals were previously detected and sampling for groundwater and other media in the debris areas, which was not previously evaluated.

The team proposed sampling of surface soil, subsurface soil, and waste material in the waste disposal areas. Proposed samples would be analyzed for VOCs, SVOCs, pesticides/ PCBs, metals, and cyanide, as this area has not been sampled previously.

The team also revisited the proposed SI sampling strategy for Site 33 groundwater to include potential impacts from the debris areas and to evaluate potential migration to surface water bodies. The team concurred that the investigation should include a DPT soil investigation in the debris areas. The team agreed that the selection of permanent monitoring well locations should be based on the waste area locations. The team also proposed collection of groundwater samples from newly-installed permanent monitoring wells. Should the groundwater results indicate the potential for discharge of contaminated groundwater to surface water and sediment, the SI should also include groundwater seep, surface water, and sediment samples. If there is no concern regarding groundwater discharge related to a Site 33 release to surface water, seep, surface water, and sediment sampling will not be necessary.

Action Items:

None

Consensus Decisions:

None

SAP Worksheet #9c—Project Scoping Session Participants Sheet

[\(UFP-QAPP Manual Section 2.5.1\)](#)

Project Name: SI at WPNSTA Yorktown Site 33 Projected Date(s) of Sampling: August 2013 (tentative) PM: Renee Hunt			Site Name: Site 33 Site Location: WPNSTA Yorktown, Virginia		
Date of Session: August 14, 2012 Scoping Session Purpose: To discuss the modified sampling approach for Site 33 including test pitting during the SI activities.					
Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Bill Friedmann	AM	CH2M HILL	(757) 671-6223	William.Friedmann@ch2m.com	Overseeing project delivery, technical support
Adam Forshey	Project Engineer	CH2M HILL	(757) 671-6267	Adam.Forshey@ch2m.com	Coordination of field investigation and reporting effort
Wade Smith	RPM	VDEQ	(804) 698-4125	wade.smith@deq.virginia.gov	Lead representative of VDEQ, responsible for review of documents and ensure that appropriate regulations are applied
Moshood Oduwole	RPM	USEPA	(215) 814-3362	oduwole.moshood@epamail.epa.gov	Lead representative of USEPA, responsible for review of documents and ensure that appropriate regulations are applied
Jim Gravette	RPM	NAVFAC Mid-Atlantic	(757) 341-0477	James.Gravette@navy.mil	Representative of lead agency responsible for overseeing execution of projects

Comments/Decisions:

The schedule of a separate Site 33 UFP-SAP was discussed with the team. Originally, the UFP-SAP for the Site 33 SI had been combined with that of the Site 9/19 Remedial Investigation (RI). Since the scope of the Site 9/19 RI has continued to expand, it has delayed delivery of a UFP-SAP for Site 33. As a result, the team determined that a separate UFP-SAP for only the Site 33 SI will be developed, instead of the Site 9, 19, and 33 RI UFP-SAP that was originally planned.

Action Items:

None

Consensus Decisions:

None

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SAP Worksheet #9d—Project Scoping Session Participants Sheet

[\(UFP-QAPP Manual Section 2.5.1\)](#)

Project Name: SI at WPNSTA Yorktown Site 33 Projected Date(s) of Sampling: March 2014 (tentative) PM: Renee Hunt			Site Name: Site 33 Site Location: WPNSTA Yorktown, Virginia		
Date of Session: May 21, 2013 Scoping Session Purpose: To discuss the modified sampling approach for Site 33 including the following: (1) addition of soil sampling in the vicinity of Former Building 530, (2) modification to the groundwater sampling approach, (3) change in compounds to be analyzed in site media.					
Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Bill Friedmann	AM	CH2M HILL	(757) 671-6223	William.Friedmann@ch2m.com	Overseeing project delivery, technical support
Wade Smith	RPM	VDEQ	(804) 698-4125	wade.smith@deq.virginia.gov	Lead representative of VDEQ, responsible for review of documents and ensure that appropriate regulations are applied
Moshood Oduwole	RPM	USEPA	(215) 814-3362	oduwole.moshood@epamail.epa.gov	Lead representative of USEPA, responsible for review of documents and ensure that appropriate regulations are applied
Jim Gravette	RPM	NAVFAC Mid-Atlantic	(757) 341-0477	James.Gravette@navy.mil	Representative of lead agency responsible for overseeing execution of projects

Comments/Decisions:

During a review of historical site figures and interviews with previous site workers, NAVFAC identified additional potential contaminant disposal pathways at Site 33. In addition to the disposal of accumulated dust north of the site building, the following potential contaminant pathways were identified: a pit/drain shown in the center of the building in 1940s drawings, a degreaser located in the southeastern portion of the building draining to the building exterior in 1950s drawings, and anecdotal evidence of building workers dumping liquid waste near the railroad tracks east of the Building. A modified sampling plan was proposed to investigate these potential contaminant pathways. The proposed revised SI sampling approach was discussed with the team. The following changes to the SI sampling approach were discussed and agreed to by the team:

- DPT soil logging and groundwater grab samples will no longer be conducted prior to the installation of permanent monitoring wells. The site lithology will be characterized during the installation of permanent groundwater wells on the site.

SAP Worksheet #9d—Project Scoping Session Participants Sheet (continued)

The groundwater monitoring network will no longer be divided into monitoring wells associated with the waste areas and the Former Building 530 monitoring wells. An estimated 16 permanent monitoring wells will be installed throughout Site 33. Of these wells approximately 13 shallow permanent groundwater monitoring wells will be installed and approximately 3 permanent deep groundwater monitoring wells will be installed. Thirteen permanent shallow groundwater monitoring wells and one permanent deep groundwater monitoring well will initially be installed and sampled for VOCs, SVOCs (including polynuclear aromatic hydrocarbons [PAHs]), PCBs, pesticides, cyanide, 1,4-dioxane, and total and dissolved metals. After evaluation of groundwater sampling results from the 14 initially installed wells, an estimate two additional permanent monitoring wells may be installed and sampled for select compounds of concern identified after the first round of groundwater sampling. Monitoring well locations will be selected to monitor and bound groundwater impacts associated with Former Building 530 operations and waste disposal areas, and to evaluate potential contaminant transport to the unnamed stream located west of the site.

- Surface (0-6 inches below ground surface [bgs]) and subsurface soil samples (6-24 inches bgs) will be collected at 15 locations (for a total of 30 samples) in the vicinity of Former Building 530 to assess potential contamination in suspected waste dumping locations and drainage swales within the vicinity of Former Building 530. Soil samples will be analyzed for VOCs, SVOCs (including PAHs), pesticides, PCBs, cyanide, 1,4-dioxane, pH, TOC, and total metals.
- Surface and subsurface soil samples and waste material samples collected from the waste disposal areas will be analyzed for 1,4-dioxane in addition to VOCs, SVOCs (including PAHs), pesticides, PCBs, cyanide, pH, TOC, and total metals.
- The Partnering Team will evaluate the results of the groundwater and soil sampling activities and historical site data, to determine where sediment and surface water samples are needed and which analytical constituents those samples should be analyzed for to evaluate impacts related to historical Site 33 operations. Additionally, samples from groundwater-fed seeps/sediment pore water may be collected at Site 33 should groundwater or soil sample results indicate that these media maybe impacted by site-related constituents. If sediment samples are collected, they will be analyzed for pH, TOC, acid volatile sulfide (AVS)/simultaneously extracted metals (SEM), and grain size in addition to the analytical parameters selected based on groundwater analytical results.

Action Items:

None

Consensus Decisions:

None

Follow-up Action:

In March 2014, the Partnering Team eliminated 1,4-dioxane analysis from Site 33. This determination was made based on new information indicating that 1,4-dioxane is not an indicator parameters for the presence of trichloroethene, which is the primary VOC detected historically at the site.

SAP Worksheet #10—Conceptual Site Model

[\(UFP-QAPP Manual Section 2.5.2\)](#)

WPNSTA Yorktown History and Location

WPNSTA Yorktown is a 10,624-acre installation located on the Virginia Peninsula in York and James City Counties Virginia (**Figure 1**). WPNSTA Yorktown is bounded to the northwest by Cheatham Annex, to the northeast by the York River and the Colonial National Historic Parkway, to the southwest by Route 143 and Interstate 64, and to the southeast by Route 238 and the town of Lackey.

Originally named the United States Mine Depot, WPNSTA Yorktown was established in 1918 to support the laying of mines in the North Sea during World War I. For 20 years after World War I, the depot continued to receive, reclaim, store, and issue mines, depth charges, and related materials. During World War II, the facility was expanded to include three trinitrotoluene (TNT) loading plants and new torpedo overhaul facilities. A research and development laboratory for experimentation with high explosives was established in 1944. In 1947, a quality evaluation laboratory was developed to monitor special tasks assigned to the facility, which included the design and development of depth charges and advanced underwater weapons. On August 7, 1959, the depot was renamed the United States WPNSTA. Today, the primary mission of WPNSTA Yorktown is to provide ordnance, technical support, and related services to sustain the war-fighting capability of the armed forces in support of national military strategy.

Site 33 History and Location

Site 33 is the location of the Former Building 530 Paint Shop and Sand Blasting Operations. This site has also been known as SSA 22 and area of concern (AOC) 4. The site is located to the west of Bollman Road and approximately 300 feet north of Shed 7 Road (**Figures 2 and 3**). The former Site 33 buildings were demolished between 1998 and 2003. The Former Building 530 footprint is clear of heavy vegetation, but the areas to the north, west and south of Site 33 are heavily wooded. The ground surface around the former Building 530 is generally flat, but then slopes to the southwest in the southern portion of the site near the former parking lot. There are drainage swales located along the west and south sides of the site of the former building and parking lot area (**Figures 2 and 3**). The wooded areas that make up the remainder of the site slope downhill with surface water runoff flowing to the north, east and south. An unnamed stream is present along the southern portion of the site. This stream appears to continuously flow and eventually discharges into Lee Pond, approximately 2,500 feet downstream of the site.

Sand blasting operations were conducted at the site from 1945 until the mid-1980s. Bomb fins and wings, inert bomb casings, and various other inert ordnance items were grit blasted in a blasting booth inside Former Building 530 and outside at the northern end of the building. Grit blasting material may have been composed of coal slag or steel grit. The blasting booth within the building used a dust collector. Accumulated dust was disposed of on the ground along the northern side of Former Building 530 (Baker, 2001). The historical configuration of Former Building 530 is illustrated on **Figure 4**. A review of historical building construction plans and interviews of past site workers were performed to identify potential contaminant pathways. In addition to the disposal of accumulated dust north of the site building, the following potential contaminant pathways were identified: a pit/drain shown in the center of the building in 1940s drawings, a degreaser located in the southeastern portion of the building draining to the building exterior in 1950s drawings, and anecdotal evidence of building workers dumping liquid waste near the railroad tracks east of the Building. Detailed information regarding the historical disposal practices at this site is unknown.

During a February 2011 site visit, waste disposal areas were observed in the wooded areas to the north and south of the Former Building 530. The waste material observed at the ground surface during the site visit appeared discontinuous and consisted of metal slag, drum fragments, railroad ties, pipe, and other metal debris. The Partnering Team decided during the April 7, 2011 scoping session to investigate the waste material areas as part of the Site 33 investigation. The Site 33 study area now incorporates the Former Building 530 footprint and the waste disposal areas (**Figure 3**).

The spatial relationship of Site 33 to its surroundings is illustrated in the conceptual site model (CSM) (**Figure 5**).

SAP Worksheet #10—Conceptual Site Model (continued)

Previous Investigations and Remedial Action

In 1995, Site 33 was identified as AOC 4, and soil samples were collected from the grit disposal pile located to the northeast of Former Building 530. These samples were analyzed for metals. Elevated lead concentrations were detected in the sample collected from the grit pile, with a maximum concentration of 3,100 milligrams per kilogram (mg/kg). Based on this sampling, it was recommended that the site be retained as an AOC and that the grit pile be removed (Navy, 1995). The Site Screening Process was initiated at Site 33 in 1997. Site investigation activities included the collection of soil and groundwater samples analyzed for organic compounds and metals. VOCs, SVOCs, PCBs, and metals were detected in surface soil, primarily in the areas of grit disposal. A groundwater sample was collected from the one monitoring well located at the site. TCE was the primary constituent detected in groundwater at a concentration of 220 micrograms per liter ($\mu\text{g/L}$). It was concluded that elevated VOC levels may be due to the use of solvents at Former Building 530. VOCs and metals were identified as COPCs at Site 33 (Baker, 2001).

In July 1998, additional characterization of site impacts was conducted. Excavation of the lead-impacted soil and sandblasting grit began in 1999 and was completed in April 2000. The soil excavation area covered approximately 600 square feet, with excavation depths ranging from 6 inches to 2 feet (Baker, 2001). The groundwater monitoring well was abandoned during the soil excavation efforts. Surface water and sediment were not present within the historical Site 33 boundary and were not sampled during the historical site sampling efforts.

In 2004, the USEPA indicated that no further action was required for site soil following the soil removal effort and post-removal confirmatory sampling (CH2M HILL, 2008).

In 2011, waste material was observed within the woods in the northern and southern portions of Site 33 during a site visit. This material consisted of metal slag, drum fragments, railroad ties, and other metal debris.

A 10,000 gallon fuel oil UST at Former Building 530 was removed under the Virginia UST Program in 1996 (Environmental Safety Consultants Inc., 1996). At the time of the tank removal, soil confirmation and groundwater sampling was performed within the former UST tank pit and the surrounding area. TPH detections in groundwater at the time of the removal were less than the Virginia UST Program's cleanup standards. The Virginia UST Program's established cleanup goal during the 1996 removal for total petroleum hydrocarbons (TPH) was 100ppm. Subsurface soil exceeding the TPH cleanup goal was located between 5 to 10 feet below ground surface. All soil (including surface soil) in the vicinity of the former UST was excavated to below that level, removed for off-site disposal, and replaced with fill (R.E. Wright Environmental, Inc., 1996). The commonwealth of Virginia determined that the UST site did not warrant further corrective action, documented in a letter dated December 5, 1996 (Commonwealth of Virginia Department of Environmental Quality, 1996).

Hydrogeological Setting

WPNSTA Yorktown

WPNSTA Yorktown is situated within the Virginia Coastal Plain Physiographic Province, which is characterized by unconsolidated sediments several thousand feet in thickness (Meng and Harsh, 1988). Deposition and erosion associated with fluctuating sea levels resulted in terraces that decrease in topographic elevation in a stair-step pattern, as well as scarps, oriented north to south, delineating the eroded shoreline along the toe of each terrace. Two terraces (Lackey Plain and Croaker Flat) are divided by one scarp (the Camp Peary Scarp) within the boundaries of WPNSTA Yorktown.

SAP Worksheet #10—Conceptual Site Model (continued)

Site-specific

The shallow aquifer system in the vicinity of Site 33 likely comprises the following three units in descending order: (1) Cornwallis Cave aquifer, (2) Yorktown confining unit, and (3) Yorktown-Eastover aquifer. In the northern portion of WPNSTA Yorktown, north of Site 33, the Camp Peary Scarp truncates the Columbia aquifer, the underlying Cornwallis Cave confining unit, the Cornwallis Cave aquifer, and some to all of the Yorktown confining unit; hence, the upper units are missing and either the Yorktown aquifer or a thin portion of the Yorktown confining unit occurs at the surface. Where present, the Cornwallis cave aquifer may range in thickness from 10 to 30 feet. The Yorktown confining unit is up to 36 feet thick.

The soil boring log from the one monitoring well historically present on the site suggests there is clay present near the surface of the site. In the one former site monitoring well, 8 feet of clay (2-10 feet bgs) were observed underlying 2 feet of fill material (0-2 feet bgs). Underlying the clay, approximately 10 feet of fine sand were present from 10-20 feet bgs followed by approximately 13 feet of silt from 20-33 feet bgs. Clay and silt were observed from 33 feet bgs to the bottom of the boring at 34 feet bgs.

Deeper groundwater flow travels primarily toward the York River, but shallow groundwater is locally controlled by topography with discharge to nearby surface water bodies. The groundwater depth, shallow groundwater flow directions, and depth of the confining unit at Site 33 are unknown since only one monitoring well was historically present on the site. Since the site is near a topographic high, groundwater flow can vary across the site. The majority of the groundwater flow is anticipated to be to the south and west in the direction of an unnamed stream. Additionally, ditches are present to the north and south of the Former Building 530 area. Recharge to the groundwater system is from precipitation.

Potential Exposure and Receptor Pathways

A three-dimensional depiction of the Site 33 CSM is presented on **Figure 5**. Surface site features, groundwater flow characteristics, and potential receptors and exposure routes are presented on the CSM. The potential receptors considered in this CSM include future residents, future construction workers, future industrial workers, current and future trespassers and visitors, and terrestrial and aquatic ecological receptors. Potential exposure pathways for human receptors include ingestion and dermal contact with soil and inhalation of volatile and particulate emissions from soil, and ingestion and dermal contact with groundwater, inhalation of volatile emissions from groundwater, inhalation of volatiles in indoor air, and ingestion and dermal contact with surface water and sediment. Potential exposure pathways for ecological receptors include direct contact, root uptake (plants), and ingestion (both incidental ingestion of site media and exposure via food webs).

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SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements

[\(UFP-QAPP Manual Section 2.6.1\)](#)

Problem Definition/Objective, Environmental Questions, and PQOs

Problem Definition/Objective	Environmental Question	General Investigation Approach	Project Quality Objective (PQO)
Obtain a more complete understanding of soil lithology, groundwater depth and flow directions at Site 33 to assist with contaminant transport assessment	At what depth is the Yorktown confining unit present at the site that may limit vertical transport of site contaminants?	Continuous split spoon samples will be collected and characterized during installation of the permanent groundwater monitoring wells (approximately 13 shallow groundwater monitoring wells and approximately 3 deep groundwater monitoring wells) in the vicinity of Former Building 530 and waste disposal areas to characterize soil lithology and assess the presence and depth of a confining layer (Figure 6).	The soil lithology and groundwater data will be used to update the site CSM and provide a better understanding of potential contamination migration pathways at the site.
	What is the depth to groundwater and directions of groundwater flow at Site 33?	An estimated 16 permanent groundwater monitoring wells (approximately 13 shallow groundwater monitoring wells and approximately 3 deep groundwater monitoring wells) will be installed and sampled in and around Site 33 to define the depths to groundwater and to provide a sufficient number of data points to determine the horizontal and vertical groundwater flow directions at Site 33 (Figure 6).	
Delineate the contaminant concentrations in groundwater and soil at Site 33	What is the nature and extent of contamination in groundwater associated with Site 33 activities?	An estimated 16 permanent groundwater monitoring wells will be installed to evaluate the horizontal and vertical contamination distribution in groundwater at the site (Figure 6). Groundwater monitoring wells will be installed at two depths: (1) within the shallow groundwater (assumed to be the Cornwallis Cave Aquifer) and (2) within the deep groundwater (assumed to be the Yorktown-Eastover aquifer). Thirteen permanent shallow groundwater monitoring wells and one permanent deep groundwater monitoring well will initially be installed and sampled for VOCs, SVOCs (including PAHs), PCBs, pesticides, cyanide, and total and dissolved metals. After evaluating groundwater sampling results from the 14 initially installed wells, additional permanent monitoring wells may be installed and sampled for select compounds identified after the first round of groundwater sampling. Monitoring well locations will be selected to monitor and bound groundwater impacts associated with Former Building 530 operations and waste disposal areas, and to evaluate potential transport and discharge to the unnamed stream located west of the site.	<p>If groundwater analytical results from the initial groundwater well installation indicate that additional contaminant delineation within the shallow Cornwallis Cave or the deeper Yorktown aquifer is needed, additional wells will be installed to further determine the contaminant nature and extent.</p> <p>If the groundwater analytical results from the initial sampling indicate that the contaminant nature and extent have been sufficiently delineated, no additional wells will be installed.</p> <p>If the nature and extent of site contamination have been reliably determined or can be reasonably estimated based on the results of the field investigation and laboratory analysis, the SI report will be completed, risks will be assessed, and evaluation of a path forward for the site will be completed.</p>
	What is the nature and extent of contamination in surface and subsurface soil associated with Former Building 530 activities?	Surface (0-6 inches bgs) and subsurface soil samples (6-24 inches bgs) will be collected at approximately 21 locations in the vicinity of Former Building 530 (Figure 6). Surface and subsurface soil sampling locations were selected to focus in suspected waste dumping locations and drainage swales within the vicinity of Former Building 530. Soil samples will be analyzed for VOCs, SVOCs (including PAHs), pesticides, PCBs, cyanide, pH, TOC, and total metals.	If the nature and extent have not been reliably determined or cannot be reasonably estimated based on the results of the field investigation and laboratory analysis, additional investigation activities will be performed to accomplish this objective with Partnering Team consensus.
	Do contaminant levels in groundwater or soil pose an unacceptable risk to current or future receptors?	A human health risk screening and ecological risk screening will be performed during the SI for site groundwater to assess risks to current and future receptors and identify COPCs. Based on the results of the risk screenings, the Partnering Team will evaluate the need for a quantitative Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (ERA). If needed, the risk assessments will be performed for all identified human health and ecological COPCs. Information gathered during the SI will be evaluated to determine the potential for contaminant transport and discharge to nearby water bodies, or potential contaminant leaching from surface soil to shallow groundwater.	<p>If contaminant levels pose an unacceptable risk to receptors, nature and extent are defined, and risks are determined to be site-related, an RI Report will summarize the investigation findings and propose a path forward to address unacceptable risks.</p> <p>If contaminant levels pose an unacceptable risk to receptors and the risks are determined to be site-related, but nature and extent are not defined, additional investigation to determine the nature extent will be performed.</p> <p>If contaminant levels do not pose an unacceptable risk to receptors, an SI Report will summarize the investigation findings and propose no future action for the portion of the site associated with Former Building 530.</p>

SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements (continued)

Problem Definition/Objective	Environmental Question	General Investigation Approach	Project Quality Objective (PQO)
<p>Determine the types of waste material and the extent of the waste disposal areas and associated potential impacts on site receptors.</p>	<p>What are the horizontal and vertical extents of the waste material observed at Site 33 and what types of waste are present?</p>	<p>Approximately 10 test pits will be excavated to confirm the extent of the waste material. Prior to test pitting, a field survey will be conducted to identify any visual indications of historical dumping operations and activity (e.g., hummocky terrain).</p>	<p>If the extent of the waste disposal areas is defined or can be reasonably estimated based on test pit data collected during the SI, the environmental sampling data collected will be used to select sample locations for the SI and may be used for design purposes for a removal action at the site.</p> <p>If the waste disposal area extent is not defined and/or cannot be reasonably estimated based on test pit data collected during the SI, additional investigation activities will be performed with Partnering Team consensus.</p>
	<p>What is the nature and extent of contamination associated with the Site 33 waste disposal areas?</p>	<p>Co-located surface and subsurface soil samples will be collected at approximately 10 locations in the vicinity of the waste disposal areas. Subsurface soil samples are to be collected at the vertical extent of the waste materials or from intervals of visual or olfactory contamination (sheen, staining, odor, etc.). Approximately five additional subsurface soil samples will be collected at the vertical extent of the waste materials or from intervals of visual or olfactory contamination. Approximately five samples of the waste material itself may also be collected and analyzed based on the observed nature of the waste. Samples collected from the Site 33 waste disposal areas will be analyzed for VOCs, SVOCs (including PAHs), pesticides, PCBs, cyanide, pH, TOC, and total metals.</p>	<p>If the nature and extent of site chemical contamination within the debris areas have been determined or can be reasonably estimated based on data collected during the SI, the collected data will be used to develop potential remedial alternatives for the site.</p> <p>If the nature and extent have not been determined and cannot be estimated from the SI data, additional investigation activities will be proposed to accomplish this objective.</p>
<p>Determine whether surface water, sediment (including pore water), and groundwater seeps are impacted by site contaminants at Site 33.</p>	<p>Are groundwater seeps present at Site 33?</p>	<p>A groundwater seep survey will be performed during the winter months to evaluate whether seeps are present at Site 33 or in the vicinity of the waste disposal areas and nearby surface water bodies.</p>	<p>If groundwater seeps are present and groundwater results indicate that the groundwater seeps may be impacted by site contaminants exceeding ecological screening values for surface water, the groundwater seeps will be sampled for the groundwater constituents of concern (COCs) at that location (pore water will be sampled in the vicinity of previously identified seeps if seeps are absent at the time of sampling).</p> <p>If groundwater seeps are not present or groundwater results do not indicate that existing seeps may be impacted, this contaminant transport pathway will be considered incomplete and no further consideration will be given to groundwater seeps at Site 33.</p>
	<p>Is groundwater contamination (associated with Former Building 530 or the waste disposal areas) at Site 33 migrating to impact surface water, sediment, and groundwater seeps?</p>	<p>Soil and groundwater sampling results will be evaluated to determine whether surface water, sediment, sediment pore water, or groundwater seeps may be potentially impacted by site contaminants. Installation of additional groundwater monitoring wells in the vicinity of surface water bodies may be needed to determine the likelihood of groundwater impacts on site surface water features. Potentially impacted media will be sampled for constituents determined to be of concern plus physical parameters. Upstream background samples will also be selected for surface water and sediment analysis through Partnering Team concurrence. The physical parameters for surface water and groundwater seeps/sediment pore water will include hardness and for sediment will include pH, TOC, AVS/ SEM, and grain size.</p>	<p>If the nature and extent of site contamination have been determined during the SI, the collected data will be used to develop potential remedial alternatives for the site.</p> <p>If the nature and extent have not been determined, additional investigation activities will be performed to accomplish this objective.</p>
	<p>Do contaminant levels in surface water, sediment, and groundwater seeps/sediment pore water pose an unacceptable risk to current or future receptors?</p>	<p>A human health risk screening and ecological risk screening will be performed during the SI to assess risks to current and future receptors and to identify COPCs. Based on the results of the risk screenings, the Partnering Team will evaluate the need for a quantitative Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (ERA). If needed, the risk assessments will be performed for all identified human health and ecological COPCs.</p>	<p>If contaminant levels pose an unacceptable risk to receptors, nature and extent are defined, and risks are determined to be site-related, an RI Report will summarize the investigation findings and propose a path forward to address unacceptable risks.</p> <p>If contaminant levels do not pose an unacceptable risk to receptors, an SI Report will propose no future action for this portion of the site.</p>

SAP Worksheet #11—Project Quality Objectives/ Systematic Planning Process Statements (continued)

Who will use the data?

The data will be used by the Navy (and its contractors) and the regulatory agencies. Once published in the Administrative Record for the site, the data will be available to the public.

What are the Project Action Limits and Project Indicator Levels?

Project action limits (PALs) are media-specific standards and criteria chosen for evaluation to help provide a conservative assessment of site conditions and determine if action is needed to address concentrations of chemicals present at the site, and if so, what remedial alternative(s) are potentially appropriate. The following list presents a summary of the PALs for each medium. **Worksheets #15-1** through **#15-22** provide a list of the PALs for each constituent in each medium. Unless otherwise noted, the screening values used will be the most currently published values available.

- There are those instances where a laboratory's limit of detection (LOD) for a specific constituent will be greater than the corresponding PAL. Any detection of this constituent above the LOD will be considered an exceedance of the associated PAL. In efforts to reach lower limits, the laboratory will report concentrations between the limit of quantitation (LOQ) and detection limit (DL) as estimated. These results will have a J qualifier applied to them.
- Soil data will be screened against the PALs, which are based on the following human health and ecological screening values:
 - Human Health Screening Criteria for Soil – USEPA Residential Regional Screening Levels (RSLs). RSLs based on non-carcinogenic effects will be based on a hazard quotient (HQ) of 0.1 to account for exposure to more than one constituent that affects the same organ. RSLs based on carcinogenic endpoints will be based on a carcinogenic risk of 1×10^{-6} .
 - Ecological Screening Values for Surface and Shallow Subsurface Soil (0 to 24 inches bgs) – Values from the literature compiled for use at WPNSTA Yorktown (only soil data in the specified depth range will be screened against ecological screening values); see **Appendix C**.
 - Sediment data, if collected, will be screened against the PALs, which are based on the following human health and ecological screening values:
 - Human Health Screening Criteria for Sediment – USEPA Residential Soil RSLs x 10. RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ. RSLs based on carcinogenic endpoints will be based on a carcinogenic risk of 1×10^{-6} .
 - Ecological Screening Values for Freshwater Sediment – Values from the literature compiled for use at WPNSTA Yorktown (freshwater); see **Appendix C**.
 - Groundwater data will be screened against the PALs, which are based on the following human health and ecological screening values:
 - Human Health Screening Criteria for Groundwater – USEPA Tap Water RSLs. RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ. RSLs based on carcinogenic endpoints will be based on a carcinogenic risk of 1×10^{-6} .
 - Ecological Screening Values for Groundwater – Ecological Freshwater screening values from the literature compiled for use at WPNSTA Yorktown (see **Appendix D**).

SAP Worksheet #11—Project Quality Objectives/ Systematic Planning Process Statements (continued)

- Groundwater data also will be screened against the federal maximum contaminant levels (MCLs) to assist in the nature and extent of contamination evaluation.
- Surface water, groundwater seep, or sediment pore water data will be screened against the PALs, which are based on the following human health and ecological screening values:
- Human Health Screening Criteria for Surface Water – USEPA Tap Water RSLs x 10. RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ. RSLs based on carcinogenic endpoints will be based on a carcinogenic risk of 1×10^{-6} .
- Ecological Screening Values for Surface Water – Ecological Freshwater screening values from the literature compiled for use at WPNSTA Yorktown (see **Appendix C**).
- Soil and groundwater data also will be screened against the 2011 Yorktown background dataset (CH2M HILL, 2011) and surface water and sediment data will be screened against upstream background data to help distinguish site-related contaminants from background constituent concentrations. Further, the determination of presence of contamination (versus background) will take into consideration professional judgment evaluations such as nature of the constituents versus those likely released, presence of other constituents in the dataset, and magnitude and frequency of exceedances.
- Project indicator levels (PILs) are media-specific standards and were developed to evaluate the fate and transport of contaminants with regard to ecological receptors. These physical parameters will be collected to evaluate the fate and transport of contaminants with regard to ecological receptors as detailed in Table 1. See **Worksheets #15-1** through **#15-22** for a detailed list of the PALs and PILs for each constituent by medium.

TABLE 1
 Project Indicator Levels

Parameter	PIL	Justification
AVS/SEM	Not available	The ratio of SEM to AVS will be used to evaluate the potential bioavailability of certain metals in sediment.
Grain size	Not available	Grain size data will be used to characterize sediment conditions in terms of habitat for certain invertebrates.
Hardness	0-75 milligrams per liter (mg/L), 75-150 mg/L, 150-300 mg/L, and 300 and up	Hardness data will be used to adjust the freshwater ecological screening values (ESVs) for certain metals to reflect site-specific conditions. Additionally, classification of water hardness content is based on the values presented from soft to very hard.
pH	6 - 8.5	A pH value ranging from 6 to 8.5 is ideal for supporting microbial populations needed for natural attenuation. Data for pH in soil will be used to determine the ESV for certain metals (aluminum and iron). Data for pH in sediment will be used to evaluate habitat conditions.
TOC	> 20 mg/L	TOC is an indicator of the total amount of organic matter available to microbial communities to use as a carbon source in the degradation of VOCs. TOC data in sediment will be used to adjust equilibrium partitioning-based ESVs and to evaluate habitat conditions. TOC data in soil will be used to help evaluate fate, transport, and bioavailability.

SAP Worksheet #11—Project Quality Objectives/ Systematic Planning Process Statements (continued)

What will the data be used for?

The data will be used to determine the nature and extent of contamination and associated risks attributable to historical CERCLA-related releases at Site 33. A human health risk screening and an ecological risk screening will be performed to identify human health and ecological COPCs, respectively. The ecological risk screening will be a streamlined version of a standard step 3A Ecological Risk Assessment (ERA) and will evaluate all relevant complete exposure pathways. Based on the results of the risk screenings, the Partnering Team will evaluate the need for a quantitative Human Health Risk Assessment (HHRA) and an ERA. If needed, the risk assessments will be performed for all identified human health and ecological COPCs. The determination as to whether the site warrants further investigation, a removal action, or remediation will be based on the risk screenings and/or assessments and where applicable, base background and MCL exceedances.

What types of data are needed?

The data collected will be representative of historical waste disposal activities at Site 33 and will include:

Continuous split spoon samples will be collected and logged during installation of approximately 16 permanent, 2-inch diameter, groundwater monitoring wells (approximately 13 shallow groundwater monitoring wells and approximately 3 deep groundwater monitoring wells) in the vicinity of Former Building 530 and waste disposal areas, to characterize soil lithology and assess the presence and depth of a confining layer. Groundwater wells installed on the site will be used to monitoring groundwater conditions and determine groundwater depth. Fourteen groundwater wells will initially be installed on the site (13 shallow groundwater monitoring wells and 1 deep groundwater monitoring well). These 14 wells will be sampled for VOCs, SVOCs (including PAHs), PCBs, pesticides, cyanide, and total and dissolved metals. After evaluation of groundwater sampling results from the 14 initially installed wells, additional permanent monitoring wells may be installed and sampled for select compounds identified after the first round of groundwater sampling to better define contaminant nature and extent.

Surface (0-6 inches bgs) and subsurface soil (6-24 ft bgs) samples will be collected in the vicinity of Former Building 530. Surface and subsurface soil sampling locations were selected to focus in suspected waste dumping locations and drainage swales within the vicinity of Former Building 530. These samples will be analyzed for VOCs, SVOCs (including PAHs), pesticides, PCBs, cyanide, pH, TOC, and total metals.

In the vicinity of the waste disposal areas, test pits will be excavated and samples of surface and subsurface soil and waste materials will be collected and analyzed for VOCs, SVOCs (including PAHs), pesticides, PCBs, cyanide, pH, TOC, and total metals. An estimated 30 total soil and/or waste samples will be collected within the waste disposal areas. It is anticipated that the soil/waste samples will be distributed as follows, although the sample distribution may be modified in the field based on observed site conditions: 10 co-located surface and subsurface soil samples collected in the vicinity of the waste disposal areas, 5 additional subsurface soil samples collected at vertical extent of waste material or from intervals of visual or olfactory contamination (sheen, staining, odor, etc.), and 5 samples of the waste material itself. .

Analytes for surface water, surface sediment, and groundwater seep (or sediment pore water) samples will be determined based on the groundwater and soil sampling results, groundwater flow directions, and contaminant extent. Both total and dissolved metals data will be included in the ERA screening tables if metals are analytes for these media. However, the dissolved metals data will be used preferentially during COPC selection because the dissolved metal fraction in water (filtered samples) is more representative of the bioavailable fraction to aquatic receptors than the total metal fraction (unfiltered samples). This is reflected in how the most recent Ambient Water Quality Criteria have been developed for many metals; that is, they are based upon the dissolved fraction.

SAP Worksheet #11—Project Quality Objectives/ Systematic Planning Process Statements (continued)

The physical parameters for surface water and groundwater seeps/sediment pore water will include hardness and for sediment will include pH, TOC, AVS/SEM, and grain size. These physical parameters will be collected to evaluate the fate and transport of contaminants with regard to ecological receptors as follows:

- Hardness data will be used to adjust the ecological screening values for certain metals in water.
- Grain size data will be used to characterize sediment conditions in terms of habitat for certain invertebrates.
- The ratio of SEM to AVS will be used to evaluate the potential bioavailability of certain metals in sediment.
- TOC data in sediment will be used to adjust equilibrium partitioning-based ecological screening values and to evaluate habitat conditions.
- Data for pH in sediment will be used to evaluate habitat conditions.
- Data for pH in soil will be used as the ecological screening value for certain metals (aluminum and iron).
- TOC data in soil will be used to help evaluate fate, transport, and bioavailability.
- Photoionization detector (PID) organic vapor data will be collected during split spoon sampling, monitoring well installation, and sampling of groundwater monitoring wells at Site 33. In addition, geologic data will be collected during the monitoring well installation at Site 33 to characterize site lithology and identify the location of the shallow aquifer confining layer.
- Prior to groundwater sampling from permanent monitoring wells, depth to groundwater will be measured. A groundwater elevation contour map will be included as a product of the investigation.
- Adherence to the standard operating procedures (SOPs) for laboratory and sampling techniques referenced in this UFP-SAP, **Worksheets #21 and #23**.

Are there any special data quality needs, field or laboratory, in order to support environmental decisions?

The off-site laboratory analytical data will be of the quantity and quality necessary to provide technically sound and defensible assessments with respect to the aforementioned project objectives. QC sample requirements are detailed in **Worksheet #20**. For action decisions, the laboratory will follow the Measurement Performance Criteria (MPC) in **Worksheet #12** for field QC samples and **Worksheets #24 and #28** for laboratory QC samples.

These MPC are consistent with the DoD Quality Systems Manual (QSM) as applicable and laboratory in-house limits where the QSM does not apply.

In the instance that the laboratory LOD for a specific constituent is greater than the corresponding PAL, any detection of this constituent above a corresponding 95 percent background upper tolerance limit (UTL) will be considered potentially site-related. In those cases where this specific constituent is not detected above the LOD, the analyte will be considered not present.

Data will be validated by CH2M HILL using the procedures listed in **Worksheet #36**. A full level IV equivalent data package and QC sampling are required for these data. A Level IV equivalent data package includes a case narrative, all field sample results, QC forms, and raw data.

SAP Worksheet #11—Project Quality Objectives/ Systematic Planning Process Statements (continued)

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

An estimated 16 permanent groundwater monitoring wells (approximately 13 shallow groundwater monitoring wells and approximately 3 deep groundwater monitoring wells) will be installed in the vicinity of Former Building 530 and waste disposal areas (**Figure 6**). Thirteen permanent shallow groundwater monitoring wells and one deep groundwater monitoring well will initially be installed and sampled for VOCs, SVOCs (including PAHs), PCBs, pesticides, cyanide, and total and dissolved metals. Following assessment of the groundwater sampling results from the 14 initially installed wells, an estimated two additional permanent monitoring wells may be installed and sampled for select compounds identified after the first round of groundwater sampling. Monitoring well locations will be selected to monitor and bound groundwater impacts associated with Former Building 530 operations and waste disposal areas, and to evaluate potential transport to the unnamed stream located west of the site.

Surface (0-6 inches bgs) and subsurface soil (6-24 inches bgs) samples will be collected at approximately 21 locations in the vicinity of Former Building 530 (**Figure 6**). These samples will be analyzed for VOCs, SVOCs (including PAHs), pesticides, PCBs, cyanide, pH, TOC, and total metals. Surface and subsurface soil sampling locations were selected to focus in suspected waste dumping locations and drainage swales within the vicinity of Former Building 530 and will be used to evaluate the nature and extent of soil contamination associated with Former Building 530 activities.

The Partnering Team will evaluate the results of the groundwater and soil sampling activities and historical site data, to determine where sediment and surface water samples are needed and which analytical constituents those samples should be analyzed for to evaluate impacts related to historical Site 33 operations. Additionally, samples from groundwater seeps/sediment pore water may be collected at Site 33 should groundwater or soil sample results indicate that these media maybe impacted by site-related constituents. A decision tree outlining the process for sampling and evaluation of surface water, sediment, and groundwater seep/sediment pore water samples is presented on **Figure 7**. While the exact number of samples for each of these media will be determined following the evaluation of the site soil and groundwater data, for the purposes of this SAP, it is estimated that approximately 5 groundwater seep, 5 sediment pore water samples, 5 surface water, and 5 sediment samples will be collected, if warranted.

Prior to test pitting, a field survey will be conducted to identify any visual indications of historical waste disposal operations and activity (such as hummocky terrain). Test pit locations will be selected in areas of historical waste disposal operations. It is assumed for the purposes of the SAP that approximately 10 test pit locations will be investigated. A decision tree outlining the process for test pitting is presented on **Figure 8**. An estimated 30 total soil and/or waste samples will be collected within the waste disposal areas. It is anticipated that the soil/waste samples will be distributed as follows, although the sample distribution may be modified in the field based on observed site conditions: 10 co-located surface and subsurface soil samples collected in the vicinity of the waste disposal areas, 5 additional subsurface soil samples collected at vertical extent of waste material or from intervals of visual or olfactory contamination (sheen, staining, odor, etc.), and 5 samples of the waste material itself. Soil and waste samples will be analyzed for VOCs, SVOCs (including PAHs), pesticides, PCBs, cyanide, pH, TOC, and total metals). Sample locations are intended to assess the nature and extent of contamination and potential risks. Target analytical concentrations (that is, quantitation limits [QLs]) are listed in **Worksheet #15**.

SAP Worksheet #11—Project Quality Objectives/ Systematic Planning Process Statements (continued)

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

The data will be collected and generated in accordance with the SOPs contained in this SAP. Fieldwork is tentatively scheduled to begin in April 2015. The fieldwork will be conducted in more than one mobilization as detailed in the project schedule (**Worksheet #16**). Multiple mobilizations are necessary to allow for evaluation of groundwater data to determine if the two deep groundwater monitoring wells should be installed and sampled for select site analytes, and also to evaluate groundwater results to determine the scope of sediment, surface water, and groundwater-fed seep/sediment pore water sampling at the site. Validated data would be received approximately 7 weeks after the lab receives each set of samples.

How will the data be reported?

An SI Report will be prepared that presents the data, evaluation of results, including HHRAs and ERAs, and recommendations for no further action, further investigation, removal action, or remediation. In general, CERCLA guidance will be followed. More detail is provided in the Yorktown and Cheatham Annex Master QAPP.

SAP Worksheet #12-1—Measurement Performance Criteria Table for Field QC Samples

Matrix: Groundwater, Surface Water, Seeps

Analytical Group: VOCs

Concentration Level: Medium

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	MPC
Field Duplicate ¹	VOCs	1 per 10 field samples of similar matrix	Precision	Relative Percent Difference (RPD) ≤ 30%
Equipment Blank		1 per day of sampling for decontaminated equipment, 1 per lot for disposable equipment	Bias/Contamination	No target analytes detected > 1/2 LOQ
Trip Blank		1 per cooler to the laboratory containing VOC samples	Bias/Contamination	No target analytes detected > 1/2 LOQ
Cooler Temperature Indicator		1 per cooler to the laboratory	Representativeness	Temperature ≤ 6 degrees Celsius (°C), not frozen

Notes:

¹ Field QA/QC will be collected separately for each media.

SAP Worksheet #12-2—Measurement Performance Criteria Table for Field QC Samples

Matrix: Groundwater, Surface Water, Seeps

Analytical Group: SVOCs, Pesticides, PCBs

Concentration Level: Medium/Low

QC Sample	Analytical Group ¹	Frequency	DQIs	MPC
Field Duplicate ²	SVOCs, Pesticides, PCBs	1 per 10 field samples of similar matrix	Precision	RPD ≤ 30%
Equipment Blank		1 per day of sampling for decontaminated equipment, 1 per lot for disposable equipment	Bias/Contamination	No target analytes detected > 1/2 LOQ
Cooler Temperature Indicator		1 per cooler to the laboratory	Representativeness	Temperature ≤ 6°C, not frozen

Notes:

¹ Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed.

² Field QA/QC will be collected separately for each media.

SAP Worksheet #12-3—Measurement Performance Criteria Table for Field QC Samples

Matrix: Groundwater, Surface Water, Seeps

Analytical Group: Total and/or Dissolved Metals and Mercury, Cyanide

Concentration Level: Medium/Low

QC Sample	Analytical Group ¹	Frequency	DQIs	MPC
Field Duplicate ²	Total and/or Dissolved Metals and Mercury, Cyanide	1 per 10 field samples of similar matrix	Precision	RPD ≤ 20%
Equipment Blank		1 per day of sampling for decontaminated equipment 1 per lot for disposable equipment	Bias/Contamination	No target analytes detected > 1/2 LOQ
Cooler Temperature Indicator		1 per cooler to the laboratory	Representativeness	Temperature ≤ 6°C, not frozen

Notes:

¹ Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed.

² Field QA/QC will be collected separately for each media.

SAP Worksheet #12-4—Measurement Performance Criteria Table for Field QC Samples

Matrix: Surface Soil, Subsurface Soil, Sediment

Analytical Group: VOCs

Concentration Level: Medium/Low

QC Sample	Analytical Group	Frequency	DQIs	MPC
Field Duplicate ¹	VOCs	1 per 10 field samples of similar matrix	Precision	RPD ≤ 30%
Equipment Blank ¹		1 per day of sampling for decontaminated equipment, 1 per lot for disposable equipment	Bias/Contamination	No target analytes detected > 1/2 LOQ
Trip Blank		1 per cooler to the laboratory containing VOC samples	Bias/Contamination	No target analytes detected > 1/2 LOQ
Cooler Temperature Indicator		1 per cooler to the laboratory	Representativeness	Temperature ≤ 6°C, not frozen

Notes:

¹ Field QA/QC will be collected separately for each media.

SAP Worksheet #12-5—Measurement Performance Criteria Table for Field QC Samples

Matrix: Surface Soil, Subsurface Soil, Sediment

Analytical Group: SVOCs, Pesticides, PCBs

Concentration Level: Medium/Low

QC Sample	Analytical Group ¹	Frequency	DQIs	MPC
Field Duplicate ²	SVOCs, Pesticides, PCBs	1 per 10 field samples of similar matrix	Precision	RPD ≤ 30%
Equipment Blank ²		1 per day of sampling for decontaminated equipment, 1 per lot for disposable equipment	Bias/Contamination	No target analytes detected > 1/2 LOQ
Cooler Temperature Indicator		1 per cooler to the laboratory	Representativeness	Temperature ≤ 6°C, not frozen

Notes:

¹ Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed.

² Field QA/QC will be collected separately for each media.

SAP Worksheet #12-6—Measurement Performance Criteria Table for Field QC Samples

Matrix: Sediment, Surface Soil, Subsurface Soil

Analytical Group: Metals, Mercury, and Cyanide

Concentration Level: Medium

QC Sample	Analytical Group ¹	Frequency	DQIs	MPC
Field Duplicate ²	Metals, Mercury, and Cyanide	1 per 10 field samples of similar matrix	Precision	RPD ≤ 30%
Equipment Blank ²		1 per day of sampling for decontaminated equipment, 1 per lot for disposable equipment	Bias/Contamination	No target analytes detected > 1/2 LOQ
Cooler Temperature Indicator		1 per cooler to the laboratory	Representativeness	Temperature ≤ 6°C, not frozen

Notes:

¹ Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed.

² Field QA/QC will be collected separately for each media.

SAP Worksheet #12-7—Measurement Performance Criteria Table for Field QC Samples

Matrix: Surface Soil, Subsurface Soil, Sediment

Analytical Group: WCHEM (TOC and pH)

Concentration Level: Low

QC Sample	Analytical Group 1	Frequency	DQI	MPC
Cooler Temperature Indicator	WCHEM (TOC and PH)	1 per cooler to the laboratory	Representativeness	Temperature ≤ 6 °C, not frozen

Notes:

¹ Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed.

SAP Worksheet #12-8—Measurement Performance Criteria Table for Field QC Samples

Matrix: Surface Water, Seeps

Analytical Group: Hardness

Concentration Level: Low

QC Sample	Analytical Group ¹	Frequency	DQI	MPC
Cooler Temperature Indicator	Hardness	1 per cooler to the laboratory	Representativeness	Temperature ≤ 6 °C, not frozen

Notes:

¹ Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed.

SAP Worksheet #13—Secondary Data Criteria and Limitations Table

[\(UFP-QAPP Manual Section 2.7\)](#)

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
Site 33 Historical Data	Baker Environmental, Inc., 2001. <i>Site Screening Process Report for Site Screening Areas 3, 4, 5, 9, 10, 20, 21, 22, 23, and 24, Naval Weapons Station, Yorktown, Virginia.</i> October.	Baker Environmental, Inc.	Data used to determine the COCs and proposed sample locations for the SI.	None known
Yorktown Background Dataset	CH2M HILL, 2011. <i>Background Study Report, Naval Weapons Station Yorktown, Yorktown, Virginia and Cheatham Annex, Williamsburg, Virginia.</i> May.	CH2M HILL	Soil and groundwater datasets will be used to determine if contaminant levels exceed Station background concentrations.	None Known

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SAP Worksheet #14—Summary of Project Tasks

[\(UFP-QAPP Manual Section 2.8.1\)](#)

Project Logistics

- In general, work will be performed in Level D personal protective equipment (PPE), which includes hardhat, safety glasses, safety toed boots, and hearing protection. Optional PPE includes the use of Tyvek coveralls as necessary. Upgrades to higher levels of PPE are discussed in the Health and Safety Plan (HSP), which will be provided as a separate document from this UFP-SAP.
- Field investigation activities will be performed over separate mobilizations, as follows:
- Mobilization #1: Surface delineation of waste, test pitting, soil sampling, installation and sampling of 14 permanent groundwater monitoring wells (13 shallow monitoring wells, 1 deep monitoring well) and completion of a groundwater seep survey.
- Mobilization #2: If warranted, installation and sampling of additional permanent groundwater monitoring wells for select compounds identified after the first round of groundwater sampling, surface water, sediment, and groundwater-fed seep/sediment pore water sampling.
- Well installation, development, and sampling will take place during normal working hours.
- Following the investigational activities, the site will be restored to its original condition.

Project Tasks

- Applicable SOPs for project tasks outlined in this section are listed on **Worksheet #21** and provided in **Appendix A**.

Utility Clearance

- Utilities will be cleared before beginning intrusive activities. CH2M HILL will coordinate utility clearance with Miss Utility of Virginia and the base's approving authority. Additionally, a separate utilities subcontractor will be procured to ensure the accuracy of the utility markings. Any proposed soil sampling and monitoring well locations interfering with utility locations will be relocated to avoid impact to utilities while continuing to meet the intent of the sampling rationale.

Investigation Activities

Monitoring Well Installation and Groundwater Sampling (Former Building 530 and Waste Disposal Areas)— Permanent groundwater monitoring wells will be installed at an estimated 16 locations in the vicinity of the Former Building 530 and waste disposal areas (**Figure 6**). Approximately 13 monitoring wells will be installed within the shallow (Cornwallis Cave) aquifer to an approximate depth of up to 40 feet bgs using hollow stem auger and split spoon drilling methods. The Cornwallis Cave wells will be installed immediately above the Yorktown-Eastover Confining Unit. An estimated 3 monitoring wells will be installed beneath the (Yorktown) confining unit and within the deep (Yorktown-Eastover) aquifer to an approximate depth of 60 feet bgs. The Yorktown-Eastover wells will be installed just below the Yorktown-Eastover Confining Unit.

Thirteen permanent shallow groundwater monitoring wells and one permanent deep groundwater monitoring well will initially be installed on site. These 14 wells will be sampled using a peristaltic pump for VOCs, SVOCs (including PAHs), PCBs, pesticides, and total and dissolved metals. Groundwater quality parameters (pH, specific conductance, turbidity, dissolved oxygen [DO], temperature, salinity, and oxidation-reduction potential [ORP]) should be recorded at the time of sample collection. After evaluation of groundwater sampling results from the 14 initially installed wells, additional permanent monitoring wells may be installed and sampled with a peristaltic pump for field parameters and for select compounds identified after the first round of groundwater sampling.

SAP Worksheet #14—Summary of Project Tasks (continued)

New monitoring well screen intervals will be determined through the use of historical site information and observed field conditions. Each new monitoring well will be constructed with 2-inch inside-diameter Schedule 40 polyvinyl chloride (PVC) screen and riser. The monitoring well screen will be machine-slotted, 0.010-inch, and 10 feet long. A silica sand filter pack will be placed around the annular space of the well screen from the bottom of the boring extending to 2 feet above the top of the screen. A 2-foot-thick bentonite layer will be placed above the sand pack. After the bentonite has been hydrated, a cement-bentonite grout will be placed in the remaining annular space to the ground surface. The monitoring wells will be completed with stickup casing with a watertight steel cover. A locking watertight cap will be placed on the PVC pipe and the wells will be clearly marked with a well ID. Wells will be surrounded with protective bollards and locked.

Continuous split spoon samples will be collected and characterized by a geologist during drilling at the permanent monitoring well locations to provide a better understanding of site lithology.

- **Surface and Subsurface Soil Sampling (Former Building 530)**—Surface and subsurface soil samples will be collected using a hand auger at approximately 21 locations to evaluate the nature and extent of soil contamination associated with Former Building 530 activities (**Figure 6**). Surface soil samples will be collected at a depth interval of 0 to 6 inches bgs and subsurface soil samples will be collected from 6 to 24 inches bgs (for a total of 2 sampling intervals at each sampling location). Surface and subsurface soil samples will be analyzed for VOCs, SVOCs (including PAHs), pesticides, PCBs, pH, TOC, and total metals. Soil samples collected for VOC and SVOC analysis will be collected using TerraCore samplers.
- **Testing Pitting and Soil/Waste Sampling (Waste Disposal Areas)**—Approximately 10 test pits will be used to delineate the lateral and vertical extent of the Site 33 waste disposal areas. An estimated 30 total soil and/or waste samples will be collected within the waste disposal areas. It is anticipated that the soil/waste samples will be distributed as follows, although the sample distribution may be modified in the field based on observed site conditions: 10 co-located surface and subsurface soil samples collected in the vicinity of the waste disposal areas, 5 additional subsurface soil samples collected at vertical extent of waste material or from intervals of visual or olfactory contamination (sheen, staining, odor, etc.), and 5 samples of the waste material itself.
- Soil samples collected for VOC and SVOC analysis will be collected using TerraCore samplers. All sample locations will be identified based on observed site conditions. Soil/waste samples will be analyzed for VOCs, SVOCs (including PAHs), pesticides, PCBs, pH, TOC, and total metals. During test pitting, excavated waste will be segregated from soil to the extent practicable. Following completion of each test pit, the soil and waste will be returned to the test pit.
- **Monitoring Well Development**--Each new monitoring well will be developed using a submersible pump. At least three well volumes of water will be removed, in addition to the volume of any water added during the well installation process. Development will continue until the water is clear and free of sediment or until 6 hours of development have passed, whichever comes first. Development information, including readings of turbidity, pH, specific conductivity, temperature, and gallons removed, will be recorded in the field logbook.
- **Land Surveying**--Test pitting; soil, surface water, sediment, groundwater seep sampling locations, and newly-installed monitoring wells will be horizontally (± 0.1 feet) and vertically (± 0.01 feet) located by a Virginia-licensed surveyor.
- **Water-Level Survey**--A complete round of water level depth measurements will be recorded from the monitoring wells. Depth to water and time measured will be recorded in the field logbook.

SAP Worksheet #14—Summary of Project Tasks (continued)

- **Monitoring Well Groundwater Sampling**—Permanent groundwater monitoring wells will be purged using a peristaltic pump following low-flow sampling protocol prior to sampling. Groundwater quality parameters (pH, specific conductance, turbidity, DO, temperature, salinity, and ORP) should be collected using a Horiba U-22 water quality meter, recorded, and allowed to stabilize before a sample is collected. The 14 initially installed permanent groundwater monitoring wells (13 shallow groundwater monitoring wells and 1 deep groundwater monitoring well) will be sampled using a peristaltic pump for VOCs, SVOCs (including PAHs), PCBs, pesticides, cyanide, and total and dissolved metals. After evaluation of groundwater sampling results from the 14 initially installed groundwater monitoring wells, additional permanent monitoring wells may be installed and sampled for field parameters and for select compounds identified after the first round of groundwater sampling.
- **Surface Water Sampling** – The number and location of surface water samples will be determined based on soil and groundwater analytical results and the presence of surface water at the site. Background surface water sample locations will also be selected in order to determine what surface water impacts are site-related. All sample locations should be approached from downstream to avoid disturbance of bottom sediments as much as possible. Prior to sample collection, water quality data will be measured from the top, middle, and bottom of the water column (where applicable) using a Horiba U-22 water quality meter (pH, conductivity, turbidity, DO, temperature, salinity, and ORP). To facilitate sample collection, a clean, unpreserved sample container will be gently submerged within the surface water with the mouth pointed upstream and the bottle tilted slightly downstream. Bubbles and floating materials should be prevented from entering the bottle. When the bottle is full, it will be gently removed from the water and the surface water sample transferred to the laboratory-supplied bottleware. Surface water analytes will be selected based on soil and groundwater analytical results and historical site data, and will include hardness (if metals are analytes).
- **Sediment Sampling** – The number and location of sediment samples will be determined based on soil and groundwater analytical results. Background sediment sample locations will also be selected in order to determine what sediment impacts are site-related. Sediment samples will be collected from 0 to 4 inches bgs and will be co-located with surface water samples. With the exception of samples for VOCs and AVS/SEM analyses, collected sediment will be homogenized in stainless steel bowls prior to placement in laboratory-prepared sample containers. Samples collected for VOCs and AVS/SEM analyses will be placed directly into sample containers. Sediment analytes will be selected based on soil and groundwater analytical results, and will include TOC, pH, sieve grain size, and AVS/SEM (AVS/SEM will only be collected if metals are analytes).
- **Groundwater Seep Sampling** – The number and location of groundwater seep samples will be determined based on the presence of groundwater seeps and soil and groundwater analytical results. If collected, groundwater seep samples will be collected directly from the seep into a clean, laboratory-prepared sample container and transferred to preserved containers as necessary. Groundwater seep analytes will be selected based on groundwater analytical results, and will include hardness.
- **Sediment Pore Water Sampling** – The number and location of sediment pore water samples will be determined based on the presence or absence of groundwater seeps and soil and groundwater analytical results indicating that sediment pore water may be impacted by site contamination. Sediment pore water analytes will be selected based on groundwater analytical results, and will include hardness. If pore water sampling is necessary, the sampling methodology will be selected after evaluating the site conditions at the proposed pore water sampling locations to ensure that the most appropriate sample method is used.

SAP Worksheet #14—Summary of Project Tasks (continued)

Equipment Decontamination

- All non-disposable sampling equipment will be decontaminated before use and immediately after each use in accordance with applicable SOPs (**Appendix A**). The water-level indicator will be rinsed with distilled water between each measurement. Heavy equipment such as drill rig (augers, rods or split spoons) will be steam-cleaned before use at each new monitoring well location. Monitoring well risers and screens will also be steam-cleaned using the same procedure, unless they are certified by the manufacturer as clean and the plastic seals are intact. Heavy equipment used for test pitting will also be decontaminated before use, when transitioning to different waste areas, and before being removed from the site. A decontamination pad will be set up to prevent runoff of the decontamination water and to allow easy collection of decontamination fluids.

Investigation-derived Waste Handling

- Investigation-derived waste (IDW) generated during investigation activities at Site 33 will include disposable PPE and sampling supplies, soil cuttings, well purge water, and solutions used to decontaminate drill and hand auger equipment. Aqueous IDW and soil cuttings will be containerized in approved 55-gallon drums and will be managed using the procedure described below. Approximately 97 soil and 30 aqueous drums for IDW are estimated to be generated during the field effort. Used PPE and sampling supplies will be placed in opaque contractor's bags and disposed of in an on-Base dumpster.

IDW Management Procedure

The process for coordinating the location of an IDW storage area includes:

- Informing the Navy RPM of the number of IDW drums to be generated during the investigation.
- Coordinating with the Navy RPM, the Base Environmental Director, and Base IDW Coordinator to identify a location for IDW (including providing the number of drums and a figure with proposed IDW storage area).
- Site visit with the Base Environmental Director and/or the Base IDW Coordinator to field verify the location.
- The following considerations will be given to the IDW Storage Area:
 - Size (number of drums) requirement, levelness, and firmness of ground if not stored on asphalt or concrete
 - Accessibility to vehicles (height, width, turning radius), including semi-trailer
 - Protectiveness - sheltering, away from heavy traffic areas, limited accessibility to base employees if possible

The process for preparing an IDW storage area includes:

- Construction of a secondary containment area that requires:
 - Able to contain 10% of total volume of material to be stored
 - Minimum 6 mil poly sheeting flooring wrapped over minimum 4" side wall
 - Pallets will be required to keep all drums directly off the poly sheeting
 - Poly or other weather proof tarp capable preventing infiltration into the secondary containment
 - Metal or fabric strapping capable of securing drums to each other and securing a tarp over the containment area
- A sign will be placed in plain view stating the purpose of the area and contact information
- IDW Spill Control Kit to be kept on site at all times that will include:

SAP Worksheet #14—Summary of Project Tasks (continued)

- A fire extinguisher
- Spill pads
- Nitrile gloves
- Trash bags and paper towels
- Forms - additional drum labels and inspection forms, pens, markers

The process for filling and storing IDW drums will include:

- All drums used for IDW must be new or recondition 55-gallon DOT approved drums with open top
- Drums may only be filled to approximately $\frac{3}{4}$ full to meet weight requirements for transport
- Any excess material will be cleaned from the side of the drum
- The cover of the drum will be secured to prevent any leakage from the drum should it be placed on its side
- The filled drum will be placed on a pallet within the secondary storage container
- Labels will be affixed to the drum in accordance to the SOP included in **Appendix A**. The label will be affixed to the drum so that it is facing outward where it may be read by an inspector.
- Once the IDW operations have been completed for the day, a tarp will be placed over the drums and secured. The tarp will be placed in a way that prevents any precipitation from collecting in the secondary containment

The process for inspecting the IDW storage area will include:

- On a weekly basis, all aspects of the IDW storage area will be inspected
- The condition of the tarp, sidewalls, poly sheeting will be inspected for any holes or breaks. Any deficiencies will be corrected at the time of the inspection
- The drums will be inspected to ensure that no leaks or breaching of the drum has occurred or is imminent. All labels will be inspected to ensure that they are still properly affixed to the drum and that the information on them are current.
- The pallets will be inspected to ensure that there is no rotting or breakage on the wood.
- The inspection sheet provided by the base will be completed and kept with the IDW Spill Control Kit
- Any deficiencies that cannot be corrected at the time of the inspection will be communicated to the Navy RPM, the Base Environmental Director and/or the Base IDW Coordinator

The process for characterizing, profiling, and removal of the IDW from the base includes:

- Sampling of the IDW drums will be conducted by CH2MHILL and the parameters for disposal will be determined based on the contracted receiving facilities requirements
- Sampling results received by CH2M HILL will be forwarded on the IDW receiving facility and a waste profile will be generated to make the determination regarding the material being considered hazardous or non-hazardous.
- Sampling results and the waste profile will be forwarded to the Navy RPM for review
- Once the Navy approves of the profile, CH2M HILL will schedule a pick up date and time. This will be coordinated with the Navy RPM to ensure that a Navy representative is present to sign the appropriate disposal forms

SAP Worksheet #14—Summary of Project Tasks (continued)

Quality Control

- Implement SOPs for field activities (**Appendix A**) being performed.
- Summary of daily field activities will be documented in a field log book; this log book will also detail sampling activities and information regarding soil sampling, testing pitting, boring logs, well construction, well development and groundwater sampling.
- QC samples to be collected are outlined on **Worksheet #20**.

Analytical Tasks

- The laboratory will maintain, test, inspect, and calibrate analytical instruments (**Worksheets #24 and #25**).
- The laboratory will process and prepare samples for analysis.

Data Management

- Procedures for data tracking, storage, archiving, retrieval and security for both electronic and hardcopy data:
- The PC (Clairette Campbell) is responsible for data tracking and storage
- Monica Marrow of Critigen will coordinate archiving and retrieval of data

Project Assessment/Audit

- **Worksheets #31 and #32**

Data Review

- DV (**Worksheets #35 and #36**)

SAP Worksheet #15-1—Reference Limits and Evaluation Table – VOCs in Groundwater

Matrix: Groundwater
 Analytical Group: VOCs

Analyte	Columbia Analytical Services (CAS) Number	PALs ¹ (µg/L)			Project QL Goal ² (µg/L)	Laboratory-specific (µg/L)			LCS and MS/MSD Control Limits ³ (%)		
		MCLs	Tap Water RSLs	Eco PAL		LOQs	LODs	DLs	Lower Control Limit (LCL)	Upper Control Limit (UCL)	RPD
Dichlorodifluoromethane (Freon-12)	75-71-8	NC	19	NC	9.5	2	1	0.24	30	155	30
Chloromethane	74-87-3	NC	19	5,500	9.5	2	1	0.36	40	125	
Vinyl chloride (VC)	75-01-4	2	0.015	930	0.0075	2	1	0.25	50	145	
Bromomethane	74-83-9	NC	0.7	110	0.35	2	1	0.49	30	145	
Chloroethane	75-00-3	NC	2,100	NC	1,050	2	1	0.55	60	135	
Trichlorofluoromethane (Freon-11)	75-69-4	NC	110	NC	55	2	1	0.24	60	145	
1,1- DCE	75-35-4	7	26	25	3.5	1	0.5	0.35	70	130	
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon-113)	76-13-1	NC	5,300	NC	2,650	1	0.5	0.31	73	126	
Acetone	67-64-1	NC	1,200	1,500	600	5	2.5	2.21	40	140	
Carbon disulfide	75-15-0	NC	72	0.92	0.46	1	0.5	0.25	35	160	
Methyl acetate	79-20-9	NC	1,600	NC	800	1	0.75	0.53	70	132	
Methylene chloride	75-09-2	5	8.4	2,200	2.5	5	2.5	1.13	55	140	
trans-1,2-DCE	156-60-5	100	8.6	590	4.3	1	0.5	0.25	60	140	
Methyl-tert-butyl ether (MTBE)	1634-04-4	NC	12	11,070	6	1	0.5	0.36	65	125	
1,1-DCA	75-34-3	NC	2.4	47	1.2	1	0.5	0.21	70	135	
cis-1,2-DCE	156-59-2	70	2.8	590	1.4	1	0.5	0.21	70	125	
2-Butanone (MEK)	78-93-3	NC	490	14,000	245	5	2.5	1.31	30	150	
Bromochloromethane	74-97-5	NC	8.3	NC	4.15	1	0.5	0.21	65	130	
Chloroform	67-66-3	80	0.19	28	0.095	1	0.5	0.32	65	135	
1,1,1-TCA	71-55-6	200	750	11	5.5	1	0.5	0.2	65	130	
Cyclohexane	110-82-7	NC	1,300	NC	650	1	0.5	0.31	71	133	
Carbon tetrachloride	56-23-5	5	0.39	240	0.195	1	0.5	0.22	65	140	
Benzene	71-43-2	5	0.39	130	0.195	1	0.5	0.26	80	120	
1,2-DCA	107-06-2	5	0.15	910	0.075	1	0.5	0.2	70	130	
TCE	79-01-6	5	0.26	47	0.13	1	0.5	0.28	70	125	
Methylcyclohexane	108-87-2	NC	NC	NC	0.5	1	0.5	0.3	73	125	
1,2-Dichloropropane	78-87-5	5	0.38	525	0.19	1	0.5	0.25	75	125	
Bromodichloromethane	75-27-4	80	0.12	NC	0.06	1	0.5	0.33	75	120	
cis-1,3-Dichloropropene	10061-01-5	NC	0.41	24.4	0.205	1	0.5	0.21	70	130	
4-Methyl-2-pentanone	108-10-1	NC	100	170	50	5	2.5	1.32	60	135	

SAP Worksheet #15-1—Reference Limits and Evaluation Table – VOCs in Groundwater (continued)

Analyte	CAS Number	PALs ¹ (µg/L)			Project QL Goal ² (µg/L)	Laboratory-specific (µg/L)			LCS and MS/MSD Control Limits ⁴ (%)		
		MCLs	Tap Water RSLs	Eco PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Toluene	108-88-3	1,000	86	9.8	4.9	1	0.5	0.27	75	120	30
trans-1,3-Dichloropropene	10061-02-6	NC	0.41	24.4	0.205	1	0.5	0.2	55	140	
1,1,2-TCA	79-00-5	5	0.041	1,200	0.0205	1	0.5	0.33	75	125	
Tetrachloroethene	127-18-4	5	3.5	98	1.75	1	0.5	0.4	45	150	
2-Hexanone	591-78-6	NC	3.4	99	1.7	5	2.5	1.7	55	130	
Dibromochloromethane	124-48-1	80	0.15	NC	0.075	1	0.5	0.3	60	135	
1,2-Dibromoethane (EDB)	106-93-4	0.05	0.0065	NC	0.00325	1	0.5	0.22	80	120	
Chlorobenzene	108-90-7	100	7.2	64	3.6	1	0.5	0.22	80	120	
Ethylbenzene	100-41-4	700	1.3	290	0.65	1	0.5	0.21	75	125	
o-Xylene	95-47-6	NC	19	13	6.5	1	0.5	0.25	80	120	
m- and p-Xylene	m&pXYLENE	NC	19	13	6.5	2	1	0.59	80	120	
Styrene	100-42-5	100	110	72	36	1	0.5	0.23	65	135	
Bromoform	75-25-2	80	7.9	320	3.95	1	0.5	0.23	70	130	
Isopropylbenzene	98-82-8	NC	39	2.6	1.3	1	0.5	0.23	75	125	
1,1,2,2-Tetrachloroethane	79-34-5	NC	0.066	610	0.033	1	0.5	0.38	65	130	
1,3-Dichlorobenzene	541-73-1	NC	NC	71	35.5	1	0.5	0.26	75	125	
1,4-Dichlorobenzene	106-46-7	75	0.42	15	0.21	1	0.5	0.24	75	125	
1,2-Dichlorobenzene	95-50-1	600	28	14	7	1	0.5	0.15	70	120	
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	0.2	0.00032	NC	0.00016	1	0.5	0.5	50	130	
1,2,4-Trichlorobenzene	120-82-1	70	0.39	110	0.195	1	0.5	0.37	65	135	
1,2,3-Trichlorobenzene	87-61-6	NC	0.52	8	0.26	1	0.5	0.27	55	140	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013, Ecological Screening Values are for freshwater.

² Project QL Goals are half of the lowest PAL. When no PAL exists, the laboratory LOD is shown.

³ Criteria are as per DoD QSM 4.2. Where limits are not specified in the QSM, in-house laboratory limits will be used. These limits are bolded.

NC indicates that there is no criterion for an analyte.

Shading represents cases where the PAL is lower than the laboratory LOD. Non-detects will not be treated as exceedances, though they will be reported as a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on HQ of 0.1 to account for exposure to more than one constituent that affects the same organ. RSLs

SAP Worksheet #15-2—Reference Limits and Evaluation Table – VOCs in Surface Water or Seeps/Pore Water

Matrix: Surface Water, Seeps/Pore Water
 Analytical Group: VOCs

Analyte	CAS Number	PALs ¹ (µg/L)		Project QL Goal ² (µg/L)	Laboratory-specific (micrograms per kilogram [µg/kg])			LCS and MS/MSD Control Limits ³ (%)		
		Eco PAL	Tap Water RSLs x 10 for SW		LOQs	LODs	DLs	LCL	UCL	RPD
Dichlorodifluoromethane (Freon-12)	75-71-8	NC	190	95	2	1	0.24	30	155	30
Chloromethane	74-87-3	5,500	190	95	2	1	0.36	40	125	
VC	75-01-4	930	0.15	0.075	2	1	0.25	50	145	
Bromomethane	74-83-9	110	7	3.5	2	1	0.49	30	145	
Chloroethane	75-00-3	NC	21,000	10,500	2	1	0.55	60	135	
Trichlorofluoromethane(Freon-11)	75-69-4	NC	1,100	550	2	1	0.24	60	145	
1,1-DCE	75-35-4	25	260	12.5	1	0.5	0.35	70	130	
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	76-13-1	NC	53,000	26,500	1	0.5	0.31	73	126	
Acetone	67-64-1	1,500	12,000	750	5	2.5	2.21	40	140	
Carbon disulfide	75-15-0	0.92	720	0.46	1	0.5	0.25	35	160	
Methyl acetate	79-20-9	NC	16,000	8,000	1	0.75	0.53	70	132	
Methylene chloride	75-09-2	2,200	84	42	5	2.5	1.13	55	140	
trans-1,2-DCE	156-60-5	590	86	43	1	0.5	0.25	60	140	
MTBE	1634-04-4	11,070	120	60	1	0.5	0.36	65	125	
1,1-DCA	75-34-3	47	24	12	1	0.5	0.21	70	135	
cis-1,2-DCE	156-59-2	590	28	14	1	0.5	0.21	70	125	
MEK	78-93-3	14,000	4,900	2,450	5	2.5	1.31	30	150	
Bromochloromethane	74-97-5	NC	83	41.5	1	0.5	0.21	65	130	
Chloroform	67-66-3	28	1.9	0.95	1	0.5	0.32	65	135	
1,1,1-TCA	71-55-6	11	7,500	5.5	1	0.5	0.2	65	130	
Cyclohexane	110-82-7	NC	13,000	6,500	1	0.5	0.31	71	133	
Carbon tetrachloride	56-23-5	240	3.9	1.95	1	0.5	0.22	65	140	
Benzene	71-43-2	130	3.9	1.95	1	0.5	0.26	80	120	
1,2-DCA	107-06-2	910	1.5	0.75	1	0.5	0.2	70	130	
TCE	79-01-6	47	2.6	1.3	1	0.5	0.28	70	125	
Methylcyclohexane	108-87-2	NC	NC	0.5	1	0.5	0.3	73	125	
1,2-Dichloropropane	78-87-5	525	3.8	1.9	1	0.5	0.25	75	125	
Bromodichloromethane	75-27-4	NC	1.2	0.6	1	0.5	0.33	75	120	
cis-1,3-Dichloropropene	10061-01-5	24.4	4.1	2.05	1	0.5	0.21	70	130	
4-Methyl-2-pentanone	108-10-1	170	1,000	85	5	2.5	1.32	60	135	
Toluene	108-88-3	9.8	860	4.9	1	0.5	0.27	75	120	

SAP Worksheet #15-2—Reference Limits and Evaluation Table – VOCs in Surface Water or Seeps/Pore Water

Analyte	CAS Number	PALs ¹ (µg/L)		Project QL Goal ² (µg/L)	Laboratory-specific (micrograms per kilogram [µg/kg])			LCS and MS/MSD Control Limits ³ (%)		
		Eco PAL	Tap Water RSLs x 10 for SW		LOQs	LODs	DLs	LCL	UCL	RPD
trans-1,3-Dichloropropene	10061-02-6	24.4	4.1	2.05	1	0.5	0.2	55	140	
1,1,2-TCA	79-00-5	1,200	0.41	0.205	1	0.5	0.33	75	125	
Tetrachloroethene	127-18-4	98	35	17.5	1	0.5	0.4	45	150	
2-Hexanone	591-78-6	99	34	17	5	2.5	1.7	55	130	
Dibromochloromethane	124-48-1	NC	1.5	0.75	1	0.5	0.3	60	135	
EDB	106-93-4	NC	0.065	0.0325	1	0.5	0.22	80	120	
Chlorobenzene	108-90-7	64	72	32	1	0.5	0.22	80	120	
Ethylbenzene	100-41-4	290	13	6.5	1	0.5	0.21	75	125	
o-Xylene	95-47-6	13	190	6.5	1	0.5	0.25	80	120	
m- and p-Xylene	m&pXYLENE	13	190	6.5	2	1	0.59	80	120	
Styrene	100-42-5	72	1,100	36	1	0.5	0.23	65	135	
Bromoform	75-25-2	320	79	39.5	1	0.5	0.23	70	130	
Isopropylbenzene	98-82-8	2.6	390	1.3	1	0.5	0.23	75	125	
1,1,2,2-Tetrachloroethane	79-34-5	610	0.66	0.33	1	0.5	0.38	65	130	
1,3-Dichlorobenzene	541-73-1	71	NC	35.5	1	0.5	0.26	75	125	
1,4-Dichlorobenzene	106-46-7	15	4.2	2.1	1	0.5	0.24	75	125	
1,2-Dichlorobenzene	95-50-1	14	280	7	1	0.5	0.15	70	120	
DBCP	96-12-8	NC	0.0032	0.0016	1	0.5	0.5	50	130	
1,2,4-Trichlorobenzene	120-82-1	110	3.9	1.95	1	0.5	0.37	65	135	
1,2,3-Trichlorobenzene	87-61-6	8	5.2	2.6	1	0.5	0.27	55	140	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater.

² Project QL Goals are half of the lowest PAL. When no PAL exists, the laboratory LOD is shown.

³ Criteria are as per DoD QSM 4.2. Where limits are not specified in the QSM, in-house laboratory limits will be used. These limits are bolded.

NC indicates that there is no criterion for an analyte.

Shading represents cases where the PAL is lower than the laboratory LOD. Non-detects will not be treated as exceedances, though they will be reported as a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-3—Reference Limits and Evaluation Table – SVOCs in Groundwater

Matrix: Groundwater
 Analytical Group: SVOCs

Analyte	CAS Number	Full Scan or Selected Ion Monitoring (SIM)	PALs ¹ (µg/L)			Project QL Goal ² (µg/L)	Laboratory-Specific (µg/L)			LCS and MS/MSD Control Limits ³ (%)		
			MCLs	Tap Water RSLs	Eco PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Benzaldehyde	100-52-7	Full Scan	NC	150	NC	75	10	7.5	0.96	10	189	30
Phenol	108-95-2	Full Scan	NC	450	110	55	10	7.5	1.8	0	115	
bis(2-Chloroethyl)ether	111-44-4	Full Scan	NC	0.012	1,900	0.006	10	7.5	2	35	110	
2-Chlorophenol	95-57-8	Full Scan	NC	7.1	24	3.55	10	7.5	3	35	105	
2-Methylphenol	95-48-7	Full Scan	NC	72	13	6.5	10	7.5	3.8	40	110	
2,2'-Oxybis(1-chloropropane)	108-60-1	Full Scan	NC	0.31	NC	0.155	10	7.5	2.1	25	130	
Acetophenone	98-86-2	Full Scan	NC	150	NC	75	10	7.5	3.9	49	102	
4-Methylphenol	106-44-5	Full Scan	NC	140	543	70	10	7.5	5.6	30	110	
n-Nitroso-di-n-propylamine	621-64-7	Full Scan	NC	0.0093	NC	0.00465	10	7.5	1.9	35	130	
Hexachloroethane	67-72-1	Full Scan	NC	0.51	12	0.255	10	7.5	2.3	30	100	
Nitrobenzene (NB)	98-95-3	Full Scan	NC	0.12	270	0.06	10	7.5	3.1	45	110	
Isophorone	78-59-1	Full Scan	NC	67	1,170	33.5	10	7.5	1.7	50	110	
2-Nitrophenol	88-75-5	Full Scan	NC	7.1	1,920	3.55	10	7.5	2.7	40	115	
2,4-Dimethylphenol	105-67-9	Full Scan	NC	27	100	13.5	10	7.5	4.4	30	110	
bis(2-Chloroethoxy)methane	111-91-1	Full Scan	NC	4.6	NC	2.3	10	7.5	2.1	45	105	
2,4-Dichlorophenol	120-83-2	Full Scan	NC	3.5	11	1.75	10	7.5	3	50	105	
Naphthalene	91-20-3	SIM	NC	0.14	12	0.07	0.2	0.1	0.064	40	100	
4-Chloroaniline	106-47-8	Full Scan	NC	0.32	232	0.16	10	7.5	1.9	15	110	
Hexachlorobutadiene	87-68-3	Full Scan	NC	0.26	1.3	0.13	10	7.5	1.8	25	105	
Caprolactam	105-60-2	Full Scan	NC	770	NC	385	10	7.5	0.4	10	86	
4-Chloro-3-methylphenol	59-50-7	Full Scan	NC	110	0.3	0.15	10	7.5	3.6	45	110	
2-Methylnaphthalene	91-57-6	SIM	NC	2.7	330	1.35	0.2	0.1	0.077	45	105	
Hexachlorocyclopentadiene	77-47-4	Full Scan	50	2.2	1.04	0.52	10	7.5	1.2	23	70	
2,4,6-Trichlorophenol	88-06-2	Full Scan	NC	0.9	4.9	0.45	10	7.5	2.7	50	115	
2,4,5-Trichlorophenol	95-95-4	Full Scan	NC	89	63	31.5	25	18.75	3.6	50	110	
1,1-Biphenyl	92-52-4	Full Scan	NC	0.083	14	0.0415	10	7.5	2.7	51	105	
2-Chloronaphthalene	91-58-7	Full Scan	NC	55	0.4	0.2	10	7.5	2.9	50	105	
2-Nitroaniline	88-74-4	Full Scan	NC	15	NC	7.5	25	18.75	1.8	50	115	
Dimethyl phthalate	131-11-3	Full Scan	NC	NC	330	165	10	7.5	2	25	125	
2,6-Dinitrotoluene (DNT)	606-20-2	Full Scan	NC	0.042	81	0.02	10	7.5	2	50	115	

SAP Worksheet #15-3—Reference Limits and Evaluation Table – SVOCs in Groundwater (continued)

Analyte	CAS Number	Full Scan or SIM	PALs ¹ (µg/L)			Project QL Goal ² (µg/L)	Laboratory-Specific (µg/L)			LCS and MS/MSD Control Limits ³ (%)		
			MCLs	Tap Water RSLs	Eco PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Acenaphthylene	208-96-8	SIM	NC	40	4,840	20	0.2	0.1	0.054	50	105	30
3-Nitroaniline	99-09-2	Full Scan	NC	NC	NC	18.75	25	18.75	1.5	20	125	
Acenaphthene	83-32-9	SIM	NC	40	23	11.5	0.2	0.1	0.064	45	110	
2,4-Dinitrophenol	51-28-5	Full Scan	NC	3	19	1.5	25	18.75	1	15	140	
4-Nitrophenol	100-02-7	Full Scan	NC	0.12	300	0.06	25	18.75	1.8	0	125	
Dibenzofuran	132-64-9	Full Scan	NC	0.58	3.7	0.29	10	7.5	1.6	55	105	
2,4-DNT	121-14-2	Full Scan	NC	0.2	44	0.1	10	7.5	2.2	50	120	
Diethylphthalate	84-66-2	Full Scan	NC	1,100	270	135	10	7.5	2	40	120	
Fluorene	86-73-7	SIM	NC	22	3.9	1.95	0.2	0.1	0.061	50	110	
4-Chlorophenyl-phenylether	7005-72-3	Full Scan	NC	2.7	NC	1.35	10	7.5	2.2	50	110	
4-Nitroaniline	100-01-6	Full Scan	NC	3.3	NC	1.65	25	18.75	1.6	35	120	
4,6-Dinitro-2-methylphenol	534-52-1	Full Scan	NC	0.12	2.3	0.06	25	18.75	2	40	130	
n-Nitrosodiphenylamine	86-30-6	Full Scan	NC	10	210	5	10	7.5	3.7	50	110	
4-Bromophenyl-phenylether	101-55-3	Full Scan	NC	NC	1.5	0.75	10	7.5	2.2	50	115	
Hexachlorobenzene	118-74-1	Full Scan	1	0.042	3.68	0.021	10	7.5	2.1	50	110	
Atrazine	1912-24-9	Full Scan	3	0.26	1.8	0.13	10	7.5	3.3	83	153	
Pentachlorophenol	87-86-5	Full Scan	1	0.035	15	0.017	25	18.75	2.3	40	115	
Phenanthrene	85-01-8	SIM	NC	130	6.3	3.15	0.2	0.1	0.051	50	115	
Anthracene	120-12-7	SIM	NC	130	0.73	0.365	0.2	0.1	0.044	55	110	
Carbazole	86-74-8	Full Scan	NC	NC	NC	7.5	10	7.5	2.1	50	115	
Di-n-butylphthalate	84-74-2	Full Scan	NC	67	35	17.5	10	7.5	2.5	55	115	
Fluoranthene	206-44-0	SIM	NC	63	8.1	4.05	0.2	0.1	0.073	55	115	
Pyrene	129-00-0	SIM	NC	8.7	0.025	0.0125	0.2	0.1	0.059	50	130	
Butylbenzylphthalate	85-68-7	Full Scan	NC	14	19	7	10	7.5	1.9	45	115	
3,3'-Dichlorobenzidine	91-94-1	Full Scan	NC	0.11	4.5	0.055	10	7.5	1.1	20	110	
Benzo(a)anthracene	56-55-3	SIM	NC	0.029	0.027	0.0135	0.2	0.1	0.046	55	110	
Chrysene	218-01-9	SIM	NC	2.9	NC	1.45	0.2	0.1	0.036	55	110	
bis(2-Ethylhexyl)phthalate	117-81-7	Full Scan	6	4.8	32	2.4	10	7.5	1.8	40	125	
Di-n-octylphthalate	117-84-0	Full Scan	NC	16	22	8	10	7.5	1.8	35	135	
Benzo(b)fluoranthene	205-99-2	SIM	NC	0.029	9.07	0.0145	0.2	0.1	0.089	45	120	
Benzo(k)fluoranthene	207-08-9	SIM	NC	0.29	9.07	0.145	0.2	0.1	0.049	45	125	
Benzo(a)pyrene	50-32-8	SIM	0.2	0.0029	0.014	0.00145	0.2	0.1	0.066	55	110	
Indeno(1,2,3-cd)pyrene	193-39-5	SIM	NC	0.029	4.31	0.0145	0.2	0.1	0.052	45	125	

SAP Worksheet #15-3—Reference Limits and Evaluation Table – SVOCs in Groundwater (continued)

Analyte	CAS Number	Full Scan or SIM	PALs ¹ (µg/L)			Project QL Goal ² (µg/L)	Laboratory-Specific (µg/L)			LCS and MS/MSD Control Limits ³ (%)		
			MCLs	Tap Water RSLs	Eco PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Dibenz(a,h)anthracene	53-70-3	SIM	NC	0.0029	NC	0.00145	0.2	0.1	0.07	40	125	30
Benzo(g,h,i)perylene	191-24-2	SIM	NC	8.7	7.64	3.82	0.2	0.1	0.065	40	125	
1,2,4,5-Tetrachlorobenzene	95-94-3	Full Scan	NC	0.12	3	0.06	10	7.5	1.8	30	150	
2,3,4,6-Tetrachlorophenol	58-90-2	Full Scan	NC	17	1.2	0.6	10	7.5	2.7	49	119	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater.

² Project QL Goals are half of the lowest PAL. When no PAL exists, the laboratory LOD is shown.

³ Criteria are as per DoD QSM 4.2. Where limits are not specified in the QSM, in-house laboratory limits will be used. These limits are bolded.

NC indicates that there is no criterion for an analyte.

Shading represents cases where the PAL is lower than the laboratory LOD. Non-detects will not be treated as exceedances, though they will be reported as a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

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SAP Worksheet #15-4—Reference Limits and Evaluation Table – SVOCs in Surface Water or Seeps/Pore Water

Matrix: Surface Water, Seeps/Pore Water
 Analytical Group: SVOCs

Analyte	CAS Number	PALs ¹ (µg/L)		Project QL Goal ² (µg/L)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ³ (%)		
		Eco PAL	Tap Water RSLs x 10 for SW		LOQs	LODs	DLs	LCL	UCL	RPD
Benzaldehyde	100-52-7	NC	1,500	750	10	7.5	0.96	10	189	30
Phenol	108-95-2	110	4,500	55	10	7.5	1.8	0	115	
bis(2-Chloroethyl)ether	111-44-4	1,900	0.12	0.06	10	7.5	2	35	110	
2-Chlorophenol	95-57-8	24	71	12	10	7.5	3	35	105	
2-Methylphenol	95-48-7	13	720	6.5	10	7.5	3.8	40	110	
2,2'-Oxybis(1-chloropropane)	108-60-1	NC	3.1	1.55	10	7.5	2.1	25	130	
Acetophenone	98-86-2	NC	1,500	750	10	7.5	3.9	49	102	
4-Methylphenol	106-44-5	543	1,400	271.5	10	7.5	5.6	30	110	
n-Nitroso-di-n-propylamine	621-64-7	NC	0.093	0.0465	10	7.5	1.9	35	130	
Hexachloroethane	67-72-1	12	5.1	2.55	10	7.5	2.3	30	100	
NB	98-95-3	270	1.2	0.6	10	7.5	3.1	45	110	
Isophorone	78-59-1	1,170	670	335	10	7.5	1.7	50	110	
2-Nitrophenol	88-75-5	1,920	71	35.5	10	7.5	2.7	40	115	
2,4-Dimethylphenol	105-67-9	100	270	50	10	7.5	4.4	30	110	
bis(2-Chloroethoxy)methane	111-91-1	NC	46	23	10	7.5	2.1	45	105	
2,4-Dichlorophenol	120-83-2	11	35	5.5	10	7.5	3	50	105	
Naphthalene	91-20-3	12	1.4	0.7	0.2	0.1	0.064	40	100	
4-Chloroaniline	106-47-8	232	3.2	1.6	10	7.5	1.9	15	110	
Hexachlorobutadiene	87-68-3	1.3	2.6	0.65	10	7.5	1.8	25	105	
Caprolactam	105-60-2	NC	7,700	3,850	10	7.5	0.4	10	86	

SAP Worksheet #15-4—Reference Limits and Evaluation Table – SVOCs in Surface Water or Seeps/Pore Water (continued)

Analyte	CAS Number	PALs ¹ (µg/L)		Project QL Goal ² (µg/L)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ³ (%)		
		Eco PAL	Tap Water RSLs x 10 for SW		LOQs	LODs	DLs	LCL	UCL	RPD
4-Chloro-3-methylphenol	59-50-7	0.3	1,100	0.15	10	7.5	3.6	45	110	30
2-Methylnaphthalene	91-57-6	330	27	13.5	0.2	0.1	0.077	45	105	
Hexachlorocyclopentadiene	77-47-4	1.04	22	0.52	10	7.5	1.2	23	70	
2,4,6-Trichlorophenol	88-06-2	4.9	9	2.45	10	7.5	2.7	50	115	
2,4,5-Trichlorophenol	95-95-4	63	890	31.5	25	18.75	3.6	50	110	
1,1-Biphenyl	92-52-4	14	0.83	0.415	10	7.5	2.7	51	105	
2-Chloronaphthalene	91-58-7	0.4	550	0.2	10	7.5	2.9	50	105	
2-Nitroaniline	88-74-4	NC	150	75	25	18.75	1.8	50	115	
Dimethyl phthalate	131-11-3	330	NC	165	10	7.5	2	25	125	
2,6-DNT	606-20-2	81	0.42	0.2	10	7.5	2	50	115	
Acenaphthylene	208-96-8	4,840	400	200	0.2	0.1	0.054	50	105	
3-Nitroaniline	99-09-2	NC	NC		25	18.75	1.5	20	125	
Acenaphthene	83-32-9	23	400	11.5	0.2	0.1	0.064	45	110	
2,4-Dinitrophenol	51-28-5	19	30	9.5	25	18.75	1	15	140	
4-Nitrophenol	100-02-7	300	1.2	0.6	25	18.75	1.8	0	125	
Dibenzofuran	132-64-9	3.7	5.8	1.85	10	7.5	1.6	55	105	
2,4-DNT	121-14-2	44	2	1	10	7.5	2.2	50	120	
Diethylphthalate	84-66-2	270	11,000	135	10	7.5	2	40	120	
Fluorene	86-73-7	3.9	220	1.9	0.2	0.1	0.061	50	110	
4-Chlorophenyl-phenylether	7005-72-3	NC	27	13.5	10	7.5	2.2	50	110	
4-Nitroaniline	100-01-6	NC	33	16.5	25	18.75	1.6	35	120	

**SAP Worksheet #15-4—Reference Limits and Evaluation Table –
 SVOCs in Surface Water or Seeps/Pore Water (continued)**

Analyte	CAS Number	PALs ¹ (µg/L)		Project QL Goal ² (µg/L)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ³ (%)		
		Eco PAL	Tap Water RSLs x 10 for SW		LOQs	LODs	DLs	LCL	UCL	RPD
4,6-Dinitro-2-methylphenol	534-52-1	2.3	1.2	0.6	25	18.75	2	40	130	30
n-Nitrosodiphenylamine	86-30-6	210	100	50	10	7.5	3.7	50	110	
4-Bromophenyl-phenylether	101-55-3	1.5	NC	0.75	10	7.5	2.2	50	115	
Hexachlorobenzene	118-74-1	3.68	0.42	0.21	10	7.5	2.1	50	110	
Atrazine	1912-24-9	1.8	2.6	0.9	10	7.5	3.3	83	153	
Pentachlorophenol	87-86-5	15	0.35	0.17	25	18.75	2.3	40	115	
Phenanthrene	85-01-8	6.3	1,300	3.15	0.2	0.1	0.051	50	115	
Anthracene	120-12-7	0.73	1,300	0.365	0.2	0.1	0.044	55	110	
Carbazole	86-74-8	NC	NC	7.5	10	7.5	2.1	50	115	
Di-n-butylphthalate	84-74-2	35	670	17.5	10	7.5	2.5	55	115	
Fluoranthene	206-44-0	8.1	630	4.05	0.2	0.1	0.073	55	115	
Pyrene	129-00-0	0.025	87	0.012	0.2	0.1	0.059	50	130	
Butylbenzylphthalate	85-68-7	19	140	9.5	10	7.5	1.9	45	115	
3,3'-Dichlorobenzidine	91-94-1	4.5	1.1	0.55	10	7.5	1.1	20	110	
Benzo(a)anthracene	56-55-3	0.027	0.29	0.0135	0.2	0.1	0.046	55	110	
Chrysene	218-01-9	NC	29	14.5	0.2	0.1	0.036	55	110	
bis(2-Ethylhexyl)phthalate	117-81-7	32	48	16	10	7.5	1.8	40	125	
Di-n-octylphthalate	117-84-0	22	160	11	10	7.5	1.8	35	135	
Benzo(b)fluoranthene	205-99-2	9.07	0.29	0.145	0.2	0.1	0.089	45	120	
Benzo(k)fluoranthene	207-08-9	9.07	2.9	1.45	0.2	0.1	0.049	45	125	
Benzo(a)pyrene	50-32-8	0.014	0.029	0.007	0.2	0.1	0.066	55	110	

SAP Worksheet #15-4—Reference Limits and Evaluation Table – SVOCs in Surface Water or Seeps/Pore Water (continued)

Analyte	CAS Number	PALs ¹ (µg/L)		Project QL Goal ² (µg/L)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ³ (%)		
		Eco PAL	Tap Water RSLs x 10 for SW		LOQs	LODs	DLs	LCL	UCL	RPD
Indeno(1,2,3-cd)pyrene	193-39-5	4.31	0.29	0.145	0.2	0.1	0.052	45	125	30
Dibenz(a,h)anthracene	53-70-3	NC	0.029	0.0145	0.2	0.1	0.07	40	125	
Benzo(g,h,i)perylene	191-24-2	7.64	87	3.82	0.2	0.1	0.065	40	125	
1,2,4,5-Tetrachlorobenzene	95-94-3	3	1.2	0.6	10	7.5	1.8	30	150	
2,3,4,6-Tetrachlorophenol	58-90-2	1.2	170	0.6	10	7.5	2.7	49	119	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater.

² Project QL Goals are half of the lowest PAL. When no PAL exists, the laboratory LOD is shown.

³ Criteria are as per DoD QSM 4.2. Where limits are not specified in the QSM, in-house laboratory limits will be used. These limits are bolded.

NC indicates that there is no criterion for an analyte.

Shading represents cases where the PAL is lower than the laboratory LOD. Non-detects will not be treated as exceedances, though they will be reported as a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-5—Reference Limits and Evaluation Table – Pesticides in Groundwater

Matrix: Groundwater Analytical Group: Pesticides

Analyte	CAS Number	PALs ¹ (µg/L)			Project QL Goal ² (µg/L)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ³ (%)		
		Tap Water RSLs	MCLs	Eco PAL		LOQ	LOD	DL	LCL	UCL	%RPD
alpha-benzene hexachloride (BHC)	319-84-6	0.0062	NC	2.2	0.0031	0.01	0.005	0.00138	60	130	30
beta-BHC	319-85-7	0.022	NC	2.2	0.011	0.01	0.005	0.00126	65	125	
delta-BHC	319-86-8	0.022	NC	2.2	0.011	0.01	0.005	0.0026	45	135	
gamma-BHC (Lindane)	58-89-9	0.036	0.2	0.08	0.018	0.01	0.005	0.00144	25	135	
Heptachlor	76-44-8	0.0018	0.4	0.0069	0.0009	0.01	0.005	0.0016	40	130	
Aldrin	309-00-2	0.004	NC	0.3	0.002	0.01	0.005	0.00148	25	140	
Heptachlor epoxide	1024-57-3	0.0033	0.2	0.0069	0.00165	0.01	0.005	0.00148	60	130	
Endosulfan I	959-98-8	7.8	NC	0.056	0.028	0.01	0.005	0.00128	50	110	
Dieldrin	60-57-1	0.0015	NC	0.056	0.00075	0.02	0.01	0.0013	60	130	
4,4'-dichlorodiphenyldichloroethylene (DDE)	72-55-9	0.2	NC	0.013	0.0065	0.02	0.01	0.00098	35	140	
Endrin	72-20-8	0.17	2	0.036	0.018	0.02	0.01	0.00168	55	135	
Endosulfan II	33213-65-9	7.8	NC	0.056	0.028	0.02	0.01	0.00114	30	130	
4,4'-dichlorodiphenyldichloroethane (DDD)	72-54-8	0.027	NC	0.011	0.0055	0.02	0.01	0.0018	25	150	
Endosulfan sulfate	1031-07-8	7.8	NC	0.056	0.028	0.02	0.01	0.00134	55	135	
4,4'-dichlorodiphenyltrichloroethane (DDT)	50-29-3	0.2	NC	0.013	0.0065	0.02	0.01	0.00178	45	140	
Methoxychlor	72-43-5	2.7	40	0.03	0.015	0.1	0.05	0.00168	55	150	
Endrin ketone	53494-70-5	0.17	2	0.15	0.075	0.02	0.01	0.00156	75	125	
Endrin aldehyde	7421-93-4	0.17	2	0.15	0.075	0.02	0.01	0.00124	55	135	
alpha-Chlordane	5103-71-9	0.19	NC	0.17	0.095	0.01	0.005	0.00152	65	125	

SAP Worksheet #15-5—Reference Limits and Evaluation Table – Pesticides in Groundwater (continued)

Analyte	CAS Number	PALs ¹ (µg/L)			Project QL Goal ² (µg/L)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ³ (%)		
		Tap Water RSLs	MCLs	Eco PAL		LOQ	LOD	DL	LCL	UCL	%RPD
gamma-Chlordane	5103-74-2	0.19	NC	0.17	0.095	0.01	0.005	0.0012	60	125	30
Toxaphene	8001-35-2	0.013	3	0.011	0.0055	0.2	0.1	0.034	32	110	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater.

² Project QL Goals are half of the lowest PAL. When no PAL exists, the laboratory LOD is shown.

³ Criteria are as per DoD QSM 4.2. Where limits are not specified in the QSM, in-house laboratory limits will be used. These limits are bolded.

NC indicates that there is no criterion for an analyte.

Shading represents cases where the PAL is lower than the laboratory LOD. Non-detects will not be treated as exceedances, though they will be reported as a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-6—Reference Limits and Evaluation Table – Pesticides in Surface Water or Seeps/Pore Water

Matrix: Surface Water, Seeps/Pore Water
 Analytical Group: Pesticides

Analyte	CAS Number	PALs ¹ (µg/L)		Project QL Goal ² (µg/L)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ³ (%)		
		Tap Water RSLs X 10 for SW	Eco PAL		LOQ	LOD	DL	LCL	UCL	%RPD
alpha-BHC	319-84-6	0.062	2.2	0.031	0.01	0.005	0.00138	60	130	30
beta-BHC	319-85-7	0.22	2.2	0.11	0.01	0.005	0.00126	65	125	
delta-BHC	319-86-8	0.22	2.2	0.11	0.01	0.005	0.0026	45	135	
gamma-BHC (Lindane)	58-89-9	0.36	0.08	0.04	0.01	0.005	0.00144	25	135	
Heptachlor	76-44-8	0.018	0.0069	0.0035	0.01	0.005	0.0016	40	130	
Aldrin	309-00-2	0.04	0.3	0.02	0.01	0.005	0.00148	25	140	
Heptachlor epoxide	1024-57-3	0.033	0.0069	0.0035	0.01	0.005	0.00148	60	130	
Endosulfan I	959-98-8	78	0.056	0.028	0.01	0.005	0.00128	50	110	
Dieldrin	60-57-1	0.015	0.056	0.0075	0.02	0.01	0.0013	60	130	
4,4'-DDE	72-55-9	2	0.013	0.0065	0.02	0.01	0.00098	35	140	
Endrin	72-20-8	1.7	0.036	0.018	0.02	0.01	0.00168	55	135	
Endosulfan II	33213-65-9	78	0.056	0.028	0.02	0.01	0.00114	30	130	
4,4'-DDD	72-54-8	0.27	0.011	0.0055	0.02	0.01	0.0018	25	150	
Endosulfan sulfate	1031-07-8	78	0.056	0.028	0.02	0.01	0.00134	55	135	
4,4'-DDT	50-29-3	2	0.013	0.0065	0.02	0.01	0.00178	45	140	
Methoxychlor	72-43-5	27	0.03	0.015	0.1	0.05	0.00168	55	150	
Endrin ketone	53494-70-5	1.7	0.15	0.075	0.02	0.01	0.00156	75	125	
Endrin aldehyde	7421-93-4	1.7	0.15	0.075	0.02	0.01	0.00124	55	135	
alpha-Chlordane	5103-71-9	1.9	0.17	0.085	0.01	0.005	0.00152	65	125	

SAP Worksheet #15-6—Reference Limits and Evaluation Table – Pesticides in Surface Water or Seeps/Pore Water (continued)

Analyte	CAS Number	PALs ¹ (µg/L)		Project QL Goal ² (µg/L)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
		Tap Water RSLs X 10 for SW	Eco PAL		LOQ	LOD	DL	LCL	UCL	%RPD
gamma-Chlordane	5103-74-2	1.9	0.17	0.085	0.01	0.005	0.0012	60	125	30
Toxaphene	8001-35-2	0.13	0.011	0.0055	0.2	0.1	0.034	32	110	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater.

² Project QL Goals are half of the lowest PAL. When no PAL exists, the laboratory LOD is shown.

³ Criteria are as per DoD QSM 4.2. Where limits are not specified in the QSM, in-house laboratory limits will be used. These limits are bolded.

NC indicates that there is no criterion for an analyte.

Shading represents cases where the PAL is lower than the laboratory LOD. Non-detects will not be treated as exceedances, though they will be reported as a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-7—Reference Limits and Evaluation Table – PCBs in Groundwater

Matrix: Groundwater
 Analytical Group: PCBs

Analyte	CAS Number	PALs ¹ (µg/L)			Project QL Goal ² (µg/L)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ³ (%)		
		Tap Water RSLs	MCLs	Eco PAL		LOQ	LOD	DL	LCL	UCL	%RPD
Aroclor-1016	12674-11-2	0.11	0.5	0.14	0.055	0.1	0.05	0.03	25	145	30
Aroclor-1221	11104-28-2	0.004	0.5	0.28	0.002	0.1	0.05	0.04	Not applicable (N/A)	N/A	
Aroclor-1232	11141-16-5	0.004	0.5	0.58	0.002	0.1	0.05	0.0178	N/A	N/A	
Aroclor-1242	53469-21-9	0.034	0.5	0.053	0.017	0.1	0.05	0.036	N/A	N/A	
Aroclor-1248	12672-29-6	0.034	0.5	0.081	0.017	0.1	0.05	0.04	N/A	N/A	
Aroclor-1254	11097-69-1	0.031	0.5	0.033	0.0155	0.1	0.05	0.0164	N/A	N/A	
Aroclor-1260	11096-82-5	0.034	0.5	0.14	0.017	0.1	0.05	0.034	30	145	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater.

² Project QL Goals are half of the lowest PAL. When no PAL exists, the laboratory LOD is shown.

³ Criteria are as per DoD QSM 4.2. Where limits are not specified in the QSM, in-house laboratory limits will be used. These limits are bolded.

NC indicates that there is no criterion for an analyte.

Shading represents cases where the PAL is lower than the laboratory LOD. Non-detects will not be treated as exceedances, though they will be reported as a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-8—Reference Limits and Evaluation Table – PCBs in Surface Water or Seeps/Pore Water

Matrix: Surface Water, Seeps/Pore Water

Analytical Group: PCBs

Analyte	CAS Number	PALs ¹ (µg/L)		Project QL Goal ² (µg/L)	Laboratory-Specific (µg/L)			LCS and MS/MSD Control Limits ³ (%)		
		Tap Water RSLs X 10 for SW	Eco PAL		LOQ	LOD	DL	LCL	UCL	%RPD
Aroclor-1016	12674-11-2	1.1	0.14	0.07	0.1	0.05	0.03	25	145	30
Aroclor-1221	11104-28-2	0.04	0.28	0.02	0.1	0.05	0.04	N/A	N/A	
Aroclor-1232	11141-16-5	0.04	0.58	0.02	0.1	0.05	0.0178	N/A	N/A	
Aroclor-1242	53469-21-9	0.34	0.053	0.0265	0.1	0.05	0.036	N/A	N/A	
Aroclor-1248	12672-29-6	0.34	0.081	0.0405	0.1	0.05	0.04	N/A	N/A	
Aroclor-1254	11097-69-1	0.31	0.033	0.0165	0.1	0.05	0.0164	N/A	N/A	
Aroclor-1260	11096-82-5	0.34	0.14	0.07	0.1	0.05	0.034	30	145	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater.

² Project QL Goals are half of the lowest PAL. When no PAL exists, the laboratory LOD is shown.

³ Criteria are as per DoD QSM 4.2. Where limits are not specified in the QSM, in-house laboratory limits will be used. These limits are bolded.

NC indicates that there is no criterion for an analyte.

Shading represents cases where the PAL is lower than the laboratory LOD. Non-detects will not be treated as exceedances, though they will be reported as a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-9—Reference Limits and Evaluation Table – Total Metals in Groundwater

Matrix: Groundwater

Analytical Group: Total Metals including Cyanide⁴

Analyte	CAS Number	PALs ¹ (µg/L)				Project QL Goal ² (µg/L)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ³ (%)		
		Background	MCLs	Tap Water RSLs	Eco PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Aluminum	7429-90-5	2,230	NC	1600	87	43.5	300	100	15	80	120	20
Antimony	7440-36-0	18.8	6	0.6	30	0.3	8	5	1.3	80	120	
Arsenic	7440-38-2	2.28	10	0.045	150	0.0225	8	5	1.4	80	120	
Barium	7440-39-3	118	2,000	290	4	2	5	3	0.23	80	120	
Beryllium	7440-41-7	2.45	4	1.6	0.66	0.33	5	0.5	0.1	80	120	
Cadmium	7440-43-9	0.605	5	0.69	0.27	0.135	10	3	0.049	80	120	
Calcium	7440-70-2	158,000	NC	NC	NC	79,000	100	80	11	80	120	
Chromium	7440-47-3	15.1	100	0.031	11.4	0.0155	15	4	0.36	80	120	
Cobalt	7440-48-4	20.6	NC	0.47	23	0.235	30	4	0.24	80	120	
Copper	7440-50-8	12.2	1,300	62	9.33	4.665	25	10	0.63	80	120	
Iron	7439-89-6	3,590	NC	1,100	1,000	500	100	80	5.4	80	120	
Lead	7439-92-1	21.3	15	15	3.18	1.59	5	4	1.1	80	120	
Magnesium	7439-95-4	3,600	NC	NC	NC	1,800	100	80	7.8	80	120	
Manganese	7439-96-5	57.9	NC	32	120	16	5	4	1.1	80	120	
Mercury	7439-97-6	0.081	2	0.43	0.91	0.0405	0.2	0.1	0.013	80	120	
Nickel	7440-02-0	11.4	NC	30	52.16	5.7	40	4	0.28	80	120	
Potassium	9/7/7440	3,490	NC	NC	NC	1,745	1,000	500	41	80	120	
Selenium	7782-49-2	NC	50	7.8	5	2.5	10	7	2.4	80	120	
Silver	7440-22-4	NC	NC	7.1	0.36	0.18	15	4	0.27	80	120	
Sodium	7440-23-5	9,920	NC	NC	NC	4,960	1,000	500	24	80	120	

SAP Worksheet #15-9—Reference Limits and Evaluation Table – Total Metals in Groundwater (continued)

Analyte	CAS Number	PALs ¹ (µg/L)				Project QL Goal ² (µg/L)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
		Background	MCLs	Tap Water RSLs	Eco PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Thallium	7440-28-0	NC	NC	0.016	12	0.008	15	5	1.1	80	120	20
Vanadium	7440-62-2	26.2	NC	6.3	20	3.1	25	4	0.23	80	120	
Zinc	7440-66-6	4.52	NC	470	119.82	2.26	25	10	0.73	80	120	
Cyanide ⁴	57-12-5	NC	200	0.14	5.2	0.07	10	5	4	85	115	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater. Background values are Cornwallis Cave Aquifer 95 percent Upper Tolerance Limits (UTLs), if no 95 percent UTL exists, the max background value is shown.

² Project QL Goals are half of the lowest PAL. When no PAL exists, the laboratory LOD is shown.

³ Criteria are as per DoD QSM 4.2. Where limits are not specified in the QSM, in-house laboratory limits will be used. These limits are bolded.

⁴ Cyanide will only be sampled from specific wells; refer to Worksheet #18.

NC indicates that there is no criterion for an analyte.

Shading represents cases where the PAL is lower than the laboratory LOD. Non-detects will not be treated as exceedances, though they will be reported as a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-10—Reference Limits and Evaluation Table – Dissolved Metals in Groundwater

Matrix: Groundwater

Analytical Group: Dissolved Metals

Analyte	CAS Number	PALs ¹ (µg/L)				Project QL Goal ² (µg/L)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ³ (%)		
		Background	MCLs	Tap Water RSLs	Eco PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Aluminum	7429-90-5	100	NC	1,600	87	43.5	300	100	15	80	120	20
Antimony	7440-36-0	9.7	6	0.6	30	0.3	8	5	1.3	80	120	
Arsenic	7440-38-2	1.37	10	0.045	150	0.0225	8	5	1.4	80	120	
Barium	7440-39-3	127	2,000	290	4	2	5	3	0.23	80	120	
Beryllium	7440-41-7	NC	4	1.6	0.66	0.33	5	0.5	0.1	80	120	
Cadmium	7440-43-9	0.177	5	0.69	0.25	0.0885	10	3	0.049	80	120	
Calcium	7440-70-2	148,000	NC	NC	NC	74000	100	80	11	80	120	
Chromium	7440-47-3	6.04	100	0.031	11	0.0155	15	4	0.36	80	120	
Cobalt	7440-48-4	0.7	NC	0.47	23	0.235	30	4	0.24	80	120	
Copper	7440-50-8	3	1,300	62	8.96	1.5	25	10	0.63	80	120	
Iron	7439-89-6	631	NC	1,100	1,000	315.5	100	80	5.4	80	120	
Lead	7439-92-1	1.7	15	15	2.52	0.85	5	4	1.1	80	120	
Magnesium	7439-95-4	3,880	NC	NC	NC	1,940	100	80	7.8	80	120	
Manganese	7439-96-5	49.5	NC	32	120	16	5	4	1.1	80	120	
Mercury	7439-97-6	0.1	2	0.43	0.77	0.05	0.2	0.1	0.013	80	120	
Nickel	7440-02-0	12.2	NC	30	52	6.1	40	4	0.28	80	120	
Potassium	7440-09-7	1,710	NC	NC	NC	855	1,000	500	41	80	120	
Selenium	7782-49-2	9.1	50	7.8	4.61	2.3	10	7	2.4	80	120	
Silver	7440-22-4	NC	NC	7.1	0.36	0.18	15	4	0.27	80	120	
Sodium	7440-23-5	10,000	NC	NC	NC	5,000	1,000	500	24	80	120	

SAP Worksheet #15-10—Reference Limits and Evaluation Table – Dissolved Metals in Groundwater (continued)

Analyte	CAS Number	PALs ¹ (µg/L)				Project QL Goal ² (µg/L)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
		Background	MCLs	Tap Water RSLs	Eco PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Thallium	7440-28-0	NC	NC	0.016	12	0.008	15	5	1.1	80	120	20
Vanadium	7440-62-2	4.3	NC	6.3	20	2.15	25	4	0.23	80	120	
Zinc	7440-66-6	NC	NC	470	118	59	25	10	0.73	80	120	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater. Background values are Cornwallis Cave Aquifer 95 percent UTLs, if no 95 percent UTL exists, the max background value is shown.

² Project QL Goals are half of the lowest PAL. When no PAL exists, the laboratory LOD is shown.

³ Criteria are as per DoD QSM 4.2. Where limits are not specified in the QSM, in-house laboratory limits will be used. These limits are bolded.

NC indicates that there is no criterion for an analyte.

Shading represents cases where the PAL is lower than the laboratory LOD. Non-detects will not be treated as exceedances, though they will be reported as a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-11—Reference Limits and Evaluation Table – Total Metals in Surface Water or Seeps/ Pore Water

Matrix: Surface Water, Seeps/Pore Water
 Analytical Group: Total Metals including Cyanide

Analyte	CAS Number	PALs ¹ (µg/L)		Project QL Goal ² (µg/L)	Laboratory-specific (µg/L)			LCS and MS/MSD Control Limits ³ (%)		
		Eco PAL	Tap Water RSLs x 10 for SW		LOQs	LODs	DLs	LCL	UCL	RPD
Aluminum	7429-90-5	87	16,000	43.5	300	100	15	80	120	20
Antimony	7440-36-0	30	6	3	8	5	1.3	80	120	
Arsenic	7440-38-2	150	0.45	0.225	8	5	1.4	80	120	
Barium	7440-39-3	4	2,900	2	5	3	0.2	80	120	
Beryllium	7440-41-7	0.66	16	0.33	5	0.5	0.1	80	120	
Cadmium	7440-43-9	0.27	6.9	0.135	10	3	0.049	80	120	
Calcium	7440-70-2	NC	NC	80	100	80	11	80	120	
Chromium	7440-47-3	11.4	0.31	0.155	15	4	0.36	80	120	
Cobalt	7440-48-4	23	4.7	2.35	30	4	0.2	80	120	
Copper	7440-50-8	9.33	620	4.665	25	10	0.63	80	120	
Iron	7439-89-6	1000	11,000	500	100	80	5.4	80	120	
Lead	7439-92-1	3.18	15	1.59	5	4	1.1	80	120	
Magnesium	7439-95-4	NC	NC	80	100	80	7.8	80	120	
Manganese	7439-96-5	120	320	60	5	4	1.1	80	120	
Mercury	7439-97-6	0.91	4.3	0.455	0.2	0.1	0.013	80	120	
Nickel	7440-02-0	52.16	300	26.08	40	4	0.28	80	120	
Potassium	7440-09-7	NC	NC	500	1,000	500	41	80	120	
Selenium	7782-49-2	5	78	2.5	10	7	2.4	80	120	
Silver	7440-22-4	0.36	71	0.18	15	4	0.27	80	120	
Sodium	7440-23-5	NC	NC	500	1,000	500	24	80	120	

SAP Worksheet #15-11—Reference Limits and Evaluation Table – Total Metals in Surface Water or Seeps/Pore Water (continued)

Analyte	CAS Number	PALs ¹ (µg/L)		Project QL Goal ² (µg/L)	Laboratory-specific (µg/L)			LCS and MS/MSD Control Limits ³ (%)		
		Eco PAL	Tap Water RSLs x 10 for SW		LOQs	LODs	DLs	LCL	UCL	RPD
Thallium	7440-28-0	12	0.16	0.08	15	5	1.1	80	120	20
Vanadium	7440-62-2	20	63	10	25	4	0.23	80	120	
Zinc	7440-66-6	119.82	4,700	59.91	25	10	0.73	80	120	
Cyanide	57-12-5	5.2	1.4	0.7	10	5	3.96	85	115	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater.

² Project QL Goals are half of the lowest PAL. When no PAL exists, the laboratory LOD is shown.

³ Criteria are as per DoD QSM 4.2. Where limits are not specified in the QSM, in-house laboratory limits will be used. These limits are bolded.

NC indicates that there is no criterion for an analyte.

Shading represents cases where the PAL is lower than the laboratory LOD. Non-detects will not be treated as exceedances, though they will be reported as a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ. RSLs based on carcinogenic endpoints will not be adjusted.

SAP Worksheet #15-12—Reference Limits and Evaluation Table – Dissolved Metals in Surface Water or Seeps/Pore Water

Matrix: Surface Water, Seeps/Pore Water
 Analytical Group: Dissolved Metals

Analyte	CAS Number	PALs ¹ (µg/L)		Project QL Goal ² (µg/L)	Laboratory-specific (µg/L)			LCS and MS/MSD Control Limits ³ (%)		
		Eco PAL	Tap Water RSLs x 10 for SW		LOQs	LODs	DLs	LCL	UCL	RPD
Aluminum	7429-90-5	87	16,000	43.5	300	100	15	80	120	20
Antimony	7440-36-0	30	6	3	8	5	1.3	80	120	
Arsenic	7440-38-2	150	0.45	0.225	8	5	1.4	80	120	
Barium	7440-39-3	4	2,900	2	5	3	0.23	80	120	
Beryllium	7440-41-7	0.66	16	0.33	5	0.5	0.1	80	120	
Cadmium	7440-43-9	0.25	6.9	0.125	10	3	0.049	80	120	
Calcium	7440-70-2	NC	NC	80	100	80	11	80	120	
Chromium	7440-47-3	11	0.31	0.155	15	4	0.36	80	120	
Cobalt	7440-48-4	23	4.7	2.35	30	4	0.24	80	120	
Copper	7440-50-8	8.96	620	4.48	25	10	0.63	80	120	
Iron	7439-89-6	1,000	11,000	500	100	80	5.4	80	120	
Lead	7439-92-1	2.52	15	1.26	5	4	1.1	80	120	
Magnesium	7439-95-4	NC	NC	80	100	80	7.8	80	120	
Manganese	7439-96-5	120	320	60	5	4	1.1	80	120	
Mercury	7439-97-6	0.77	4.3	0.385	0.2	0.1	0.013	80	120	
Nickel	7440-02-0	52	300	26	40	4	0.28	80	120	
Potassium	7440-09-7	NC	NC	500	1,000	500	41	80	120	
Selenium	7782-49-2	4.61	78	2.305	10	7	2.4	80	120	
Silver	7440-22-4	0.36	71	0.18	15	4	0.27	80	120	

SAP Worksheet #15-12—Reference Limits and Evaluation Table – Dissolved Metals in Surface Water or Seeps/Pore Water (continued)

Analyte	CAS Number	PALs ¹ (µg/L)		Project QL Goal ² (µg/L)	Laboratory-specific (µg/L)			LCS and MS/MSD Control Limits ³ (%)		
		Eco PAL	Tap Water RSLs x 10 for SW		LOQs	LODs	DLs	LCL	UCL	RPD
Sodium	7440-23-5	NC	NC	500	1,000	500	24	80	120	20
Thallium	7440-28-0	12	0.16	0.08	15	5	1.1	80	120	
Vanadium	7440-62-2	20	63	10	25	4	0.23	80	120	
Zinc	7440-66-6	118	4,700	59	25	10	0.73	80	120	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater.

² Project QL Goals are half of the lowest PAL. When no PAL exists, the laboratory LOD is shown.

³ Criteria are as per DoD QSM 4.2. Where limits are not specified in the QSM, in-house laboratory limits will be used. These limits are bolded.

NC indicates that there is no criterion for an analyte.

Shading represents cases where the PAL is lower than the laboratory LOD. Non-detects will not be treated as exceedances, though they will be reported as a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-13—Reference Limits and Evaluation Table – VOCs in Soils and Waste Material

Matrix: Surface Soil, Subsurface Soil, Waste Material

Analytical Group: VOCs

Analyte	CAS Number	PALs ¹ (µg/kg)			Project QL Goal ^{3,4} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
		Industrial Soil RSLs	Residential Soil RSLs	Eco PAL ²		LOQs	LODs	DLs	LCL	UCL	RPD
Dichlorodifluoromethane (Freon-12)	75-71-8	40,000	9,400	NC	4,700	10	5	0.92	35	135	30
Chloromethane	74-87-3	50,000	12,000	5,000	2,500	10	5	1.4	50	130	
VC	75-01-4	1,700	60	412	30	10	5	0.87	60	125	
Bromomethane	74-83-9	3,200	730	NC	365	10	5	1.1	30	160	
Chloroethane	75-00-3	2,100,000	1,500,000	5,000	2,500	10	5	1.3	40	155	
Trichlorofluoromethane(Freon-11)	75-69-4	340,000	79,000	NC	39,500	10	5	0.91	25	185	
1,1-DCE	75-35-4	110,000	24,000	173	86.5	5	2.5	0.93	65	135	
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	76-13-1	910,000	910,000	NC	455,000	5	2.5	0.9	67	135	
Acetone	67-64-1	63,000,000	6,100,000	NC	3,050,000	25	12.5	5.1	20	160	
Carbon disulfide	75-15-0	370,000	82,000	NC	41,000	5	2.5	0.78	45	160	
Methyl acetate	79-20-9	29,000,000	7,800,000	NC	3,900,000	5	3	2.7	72	133	
Methylene chloride	75-09-2	310,000	36,000	1,250	625	25	12.5	7.9	55	140	
trans-1,2-DCE	156-60-5	69,000	15,000	447	223.5	5	2.5	0.71	65	135	
MTBE	1634-04-4	220,000	43,000	NC	21,500	5	2.5	1.1	81	125	
1,1-DCA	75-34-3	17,000	3,300	548	274	5	2.5	1.7	75	125	
cis-1,2-DCE	156-59-2	200,000	16,000	447	223.5	5	2.5	0.91	65	125	
MEK	78-93-3	20,000,000	2,800,000	NC	1,400,000	25	12.5	5.9	30	160	
Bromochloromethane	74-97-5	68,000	16,000	NC	8000	5	2.5	0.91	70	125	
Chloroform	67-66-3	1,500	290	1,844	145	5	2.5	0.35	70	125	
1,1,1-TCA	71-55-6	640,000	640,000	1,025	512.5	5	2.5	0.42	70	135	

SAP Worksheet #15-13—Reference Limits and Evaluation Table – VOCs in Soils and Waste Material (continued)

Analyte	CAS Number	PALs ¹ (µg/kg)			Project QL Goal ^{3,4} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁵ (%)		
		Industrial Soil RSLs	Residential Soil RSLs	Eco PAL ²		LOQs	LODs	DLs	LCL	UCL	RPD
Cyclohexane	110-82-7	120,000	120,000	6,000	3,000	5	2.5	1.4	75	128	30
Carbon tetrachloride	56-23-5	3,000	610	3,400	305	5	2.5	1.3	65	135	
Benzene	71-43-2	5,400	1,100	1,140	550	5	2.5	0.92	75	125	
1,2-DCA	107-06-2	2,200	430	2,190	215	5	2.5	1	70	135	
TCE	79-01-6	2,000	440	500	220	5	2.5	0.59	75	125	
Methylcyclohexane	108-87-2	NC	NC	NC	2.5	5	2.5	0.96	71	127	
1,2-Dichloropropane	78-87-5	4,700	940	38,800	470	5	2.5	1.4	70	120	
Bromodichloromethane	75-27-4	1,400	270	NC	135	5	2.5	0.6	70	130	
cis-1,3-Dichloropropene	10061-01-5	8,300	1,700	5000	850	5	2.5	0.72	70	125	
4-Methyl-2-pentanone	108-10-1	3,400,000	530,000	NC	265,000	25	12.5	5.9	45	145	
Toluene	108-88-3	820,000	500,000	40,000	20,000	5	2.5	1.4	70	125	
trans-1,3-Dichloropropene	10061-02-6	8,300	1,700	5,000	850	5	2.5	0.86	65	125	
1,1,2-TCA	79-00-5	680	160	2,000	80	5	2.5	0.97	60	125	
Tetrachloroethene	127-18-4	41,000	8,600	179	89.5	5	2.5	1.2	65	140	
2-Hexanone	591-78-6	140,000	21,000	NC	10,500	25	12.5	4.8	45	145	
Dibromochloromethane	124-48-1	3,300	680	NC	340	5	2.5	1	65	130	
EDB	106-93-4	170	34	300	17	5	2.5	1.2	70	125	
Chlorobenzene	108-90-7	140,000	29,000	2,400	1,200	5	2.5	0.51	75	125	
Ethylbenzene	100-41-4	27,000	5,400	1,815	907.5	5	2.5	0.65	75	125	
o-Xylene	95-47-6	300,000	69,000	1,300	650	5	2.5	1.3	75	125	
m- and p-Xylene	m&pXYLENE	250,000	59,000	1,300	650	10	5	1.7	80	125	

SAP Worksheet #15-13—Reference Limits and Evaluation Table – VOCs in Soils and Waste Material (continued)

Analyte	CAS Number	PALs ¹ (µg/kg)			Project QL Goal ^{3,4} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁵ (%)		
		Industrial Soil RSLs	Residential Soil RSLs	Eco PAL ²		LOQs	LODs	DLs	LCL	UCL	RPD
Styrene	100-42-5	870,000	630,000	64,000	32,000	5	2.5	0.51	75	125	30
Bromoform	75-25-2	220,000	62,000	300	150	5	2.5	0.7	55	135	
Isopropylbenzene	98-82-8	270,000	210,000	NC	105,000	5	2.5	0.92	75	130	
1,1,2,2-Tetrachloroethane	79-34-5	2,800	560	5,000	280	5	2.5	0.84	55	130	
1,3-Dichlorobenzene	541-73-1	NC	NC	1,000	500	5	2.5	0.62	70	125	
1,4-Dichlorobenzene	106-46-7	12,000	2,400	1,280	640	5	2.5	0.44	70	125	
1,2-Dichlorobenzene	95-50-1	380,000	190,000	1,000	500	5	2.5	0.78	75	120	
DBCP	96-12-8	69	5.4	NC	2.7	5	2.5	1.5	40	135	
1,2,4-Trichlorobenzene	120-82-1	27,000	6,200	1,270	635	5	2.5	0.79	65	130	
1,2,3-Trichlorobenzene	87-61-6	49,000	4,900	1,150	575	5	2.5	0.76	60	135	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013.

² ECO values are only applicable to subsurface samples collected at depths less than 24 inches bgs; Waste material will only be evaluated against RSLs, and will not be evaluated against ECO values

³ PALs and Project QL Goals assume dry weight basis.

⁴ Project QL goals are equal to half of the minimum applicable PAL.

⁵ DoD QSM v.4.2 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where in-house limits are used.

NC indicates that there is no criterion for an analyte.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL. RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

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SAP Worksheet #15-14—Reference Limits and Evaluation Table – VOCs in Sediment

Matrix: Sediment
 Analytical Group: VOCs

Analyte	CAS Number	PALs ¹ (µg/kg)		Project QL Goal ^{2,3} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
		Residential Soil RSLs x 10 for Sediment	Eco Sediment PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Dichlorodifluoromethane (Freon-12)	75-71-8	94,000	NC	47,000	10	5	0.92	35	135	30
Chloromethane	74-87-3	120,000	NC	60,000	10	5	1.4	50	130	
VC	75-01-4	600	NC	300	10	5	0.87	60	125	
Bromomethane	74-83-9	7,300	NC	3,650	10	5	1.1	30	160	
Chloroethane	75-00-3	2,100,000	NC	1,050,000	10	5	1.3	40	155	
Trichlorofluoromethane(Freon-11)	75-69-4	790,000	NC	395,000	10	5	0.91	25	185	
1,1-DCE	75-35-4	240,000	31	15.5	5	2.5	0.93	65	135	
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	76-13-1	910,000	NC	455,000	5	2.5	0.9	67	135	
Acetone	67-64-1	61,000,000	NC	30,500,000	25	12.5	5.1	20	160	
Carbon disulfide	75-15-0	740,000	0.85	0.425	5	2.5	0.78	45	160	
Methyl acetate	79-20-9	29,000,000	NC	14,500,000	5	3	2.7	72	133	
Methylene chloride	75-09-2	360,000	370	185	25	12.5	7.9	55	140	
trans-1,2-DCE	156-60-5	150,000	400	200	5	2.5	0.71	65	135	
MTBE	1634-04-4	430,000	NC	215,000	5	2.5	1.1	81	125	
1,1-DCA	75-34-3	33,000	27	13.5	5	2.5	1.7	75	125	
cis-1,2-DCE	156-59-2	160,000	400	200	5	2.5	0.91	65	125	
MEK	78-93-3	28,000,000	NC	14,000,000	25	12.5	5.9	30	160	
Bromochloromethane	74-97-5	160,000	NC	80,000	5	2.5	0.91	70	125	

SAP Worksheet #15-14—Reference Limits and Evaluation Table - VOCs in Sediment (continued)

Analyte	CAS Number	PALs ¹ (µg/kg)		Project QL Goal ^{2,3} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
		Residential Soil RSLs x 10 for Sediment	Eco Sediment PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Chloroform	67-66-3	2,900	22	11	5	2.5	0.35	70	125	30
1,1,1-TCA	71-55-6	640,000	170	85	5	2.5	0.42	70	135	
Cyclohexane	110-82-7	120,000	NC	60,000	5	2.5	1.4	75	128	
Carbon tetrachloride	56-23-5	6,100	1,200	600	5	2.5	1.3	65	135	
Benzene	71-43-2	11,000	57	28.5	5	2.5	0.92	75	125	
1,2-DCA	107-06-2	4,300	250	125	5	2.5	1	70	135	
TCE	79-01-6	4,400	1,600	800	5	2.5	0.59	75	125	
Methylcyclohexane	108-87-2	NC	NC	2.5	5	2.5	0.96	71	127	
1,2-Dichloropropane	78-87-5	9,400	NC	4,700	5	2.5	1.4	70	120	
Bromodichloromethane	75-27-4	2,700	NC	1,350	5	2.5	0.6	70	130	
cis-1,3-Dichloropropene	10061-01-5	17,000	0.051	0.0255	5	2.5	0.72	70	125	
4-Methyl-2-pentanone	108-10-1	3,400,000	NC	1,700,000	25	12.5	5.9	45	145	
Toluene	108-88-3	820,000	670	335	5	2.5	1.4	70	125	
trans-1,3-Dichloropropene	10061-02-6	17,000	0.051	0.0255	5	2.5	0.86	65	125	
1,1,2-TCA	79-00-5	1,600	1,200	600	5	2.5	0.97	60	125	
Tetrachloroethene	127-18-4	86,000	530	265	5	2.5	1.2	65	140	
2-Hexanone	591-78-6	210,000	NC	105,000	25	12.5	4.8	45	145	
Dibromochloromethane	124-48-1	6,800	NC	3,400	5	2.5	1	65	130	
EDB	106-93-4	340	NC	170	5	2.5	1.2	70	125	
Chlorobenzene	108-90-7	290,000	820	410	5	2.5	0.51	75	125	

SAP Worksheet #15-14—Reference Limits and Evaluation Table – VOCs in Sediment (continued)

Analyte	CAS Number	PALs ¹ (µg/kg)		Project QL Goal ^{2,3} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
		Residential Soil RSLs x 10 for Sediment	Eco Sediment PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Ethylbenzene	100-41-4	54,000	3,600	1,800	5	2.5	0.65	75	125	30
o-Xylene	95-47-6	430,000	160	80	5	2.5	1.3	75	125	
m- and p-Xylene	m&pXYLENE	390,000	160	80	10	5	1.7	80	125	
Styrene	100-42-5	870,000	559	279.5	5	2.5	0.51	75	125	
Bromoform	75-25-2	620,000	650	325	5	2.5	0.7	55	135	
Isopropylbenzene	98-82-8	270,000	86	43	5	2.5	0.92	75	130	
1,1,2,2-Tetrachloroethane	79-34-5	5,600	940	470	5	2.5	0.84	55	130	
1,3-Dichlorobenzene	541-73-1	NC	1,700	850	5	2.5	0.62	70	125	
1,4-Dichlorobenzene	106-46-7	24,000	350	175	5	2.5	0.44	70	125	
1,2-Dichlorobenzene	95-50-1	380,000	340	170	5	2.5	0.78	75	120	
DBCP	96-12-8	54	NC	27	5	2.5	1.5	40	135	
1,2,4-Trichlorobenzene	120-82-1	62,000	9,200	4,600	5	2.5	0.79	65	130	
1,2,3-Trichlorobenzene	87-61-6	49,000	858	429	5	2.5	0.76	60	135	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater sediment.

² PALs and Project QL Goals assume dry weight basis.

³ Project QL goals are equal to half of the minimum applicable PAL.

⁴ DoD QSM v.4.2 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where in-house limits are used.

NC indicates that there is no criterion for an analyte.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

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SAP Worksheet #15-15—Reference Limits and Evaluation Table – SVOCs in Soils and Waste Material

Matrix: Surface Soil, Subsurface Soil, Waste Material

Analytical Group: SVOCs

Analyte	CAS Number	Full Scan or SIM	PALs ¹ (µg/kg)			Project QL Goa ^{3,4} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁵ (%)		
			Industrial Soil RSLs	Residential Soil RSLs	Eco PAL ²		LOQs	LODs	DLs	LCL	UCL	RPD
Benzaldehyde	100-52-7	Full Scan	1,200,000	780,000	NC	390,000	330	250	120	10	134	30
Phenol	108-95-2	Full Scan	18,000,000	1,800,000	1,880	940	330	250	156	40	100	
bis(2-Chloroethyl)ether	111-44-4	Full Scan	1,000	210	NC	105	330	250	81	40	105	
2-Chlorophenol	95-57-8	Full Scan	510,000	39,000	500	250	330	250	164	45	105	
2-Methylphenol	95-48-7	Full Scan	3,100,000	310,000	1,000	500	330	250	200	40	105	
2,2'-Oxybis(1-chloropropane)	108-60-1	Full Scan	22,000	4,600	NC	2,300	330	250	89	20	115	
Acetophenone	98-86-2	Full Scan	2,500,000	780,000	NC	390,000	330	250	178	35	95	
4-Methylphenol	106-44-5	Full Scan	6,200,000	610,000	1,000	500	330	250	187	40	105	
n-Nitroso-di-n-propylamine	621-64-7	Full Scan	250	69	NC	34.5	330	250	83	40	115	
Hexachloroethane	67-72-1	Full Scan	43,000	4,300	NC	2,150	330	250	96	35	110	
NB	98-95-3	Full Scan	24,000	4,800	2,260	1,130	330	250	91	40	115	
Isophorone	78-59-1	Full Scan	1,800,000	510,000	NC	255,000	330	250	75	45	110	
2-Nitrophenol	88-75-5	Full Scan	510,000	39,000	1,000	500	330	250	167	40	110	
2,4-Dimethylphenol	105-67-9	Full Scan	1,200,000	120,000	1,000	500	330	250	165	30	105	
bis(2-Chloroethoxy)methane	111-91-1	Full Scan	180,000	18,000	NC	9,000	330	250	96	45	110	
2,4-Dichlorophenol	120-83-2	Full Scan	180,000	18,000	500	250	330	250	150	45	110	
Naphthalene	91-20-3	SIM	18,000	3,600	LMW-PAH	1,800	20	10	2.6	40	105	
4-Chloroaniline	106-47-8	Full Scan	8,600	2,400	500	250	330	250	119	10	100	
Hexachlorobutadiene	87-68-3	Full Scan	22,000	6,100	NC	3,050	330	250	83	40	115	
Caprolactam	105-60-2	Full Scan	31,000,000	3,100,000	NC	1,550,000	330	250	144	10	81	

SAP Worksheet #15-15—Reference Limits and Evaluation Table – SVOCs in Soils and Waste Material (continued)

Analyte	CAS Number	Full Scan or SIM	PALs ¹ (µg/kg)			Project QL Goal ^{3,4} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁵ (%)		
			Industrial Soil RSLs	Residential Soil RSLs	Eco PAL ²		LOQs	LODs	DLs	LCL	UCL	RPD
4-Chloro-3-methylphenol	59-50-7	Full Scan	6,200,000	610,000	500	250	330	250	166	45	115	30
2-Methylnaphthalene	91-57-6	SIM	220,000	23,000	PAH	11,500	20	10	2.2	45	105	
Hexachlorocyclopentadiene	77-47-4	Full Scan	370,000	37,000	2,000	1,000	330	250	82	10	70	
2,4,6-Trichlorophenol	88-06-2	Full Scan	62,000	6,100	580	290	330	250	155	45	110	
2,4,5-Trichlorophenol	95-95-4	Full Scan	6,200,000	610,000	1,350	675	820	615	155	50	110	
1,1-Biphenyl	92-52-4	Full Scan	21,000	5,100	13,600	2,550	330	250	73	31	99	
2-Chloronaphthalene	91-58-7	Full Scan	8,200,000	630,000	LMW-PAH	315,000	330	250	128	45	105	
2-Nitroaniline	88-74-4	Full Scan	600,000	61,000	NC	30,500	820	615	75	45	120	
Dimethyl phthalate	131-11-3	Full Scan	NC	NC	10,640	5,320	330	250	78	50	110	
2,6-DNT	606-20-2	Full Scan	1,200	330	8,500	165	330	250	79	50	110	
Acenaphthylene	208-96-8	SIM	3,300,000	340,000	LMW-PAH	170,000	20	10	1.2	45	105	
3-Nitroaniline	99-09-2	Full Scan	NC	NC	NC	615	820	615	94	25	110	
Acenaphthene	83-32-9	SIM	3,300,000	340,000	LMW-PAH	170,000	20	10	1.5	45	110	
2,4-Dinitrophenol	51-28-5	Full Scan	120,000	12,000	20,000	6,000	820	615	377	15	130	
4-Nitrophenol	100-02-7	Full Scan	24,000	4,800	380	190	820	615	309	15	140	
Dibenzofuran	132-64-9	Full Scan	100,000	7,800	NC	3,900	330	250	79	50	105	
2,4-DNT	121-14-2	Full Scan	5,500	1,600	11,000	800	330	250	85	50	110	
Diethylphthalate	84-66-2	Full Scan	49,000,000	4,900,000	26,800	13,400	330	250	80	50	115	
Fluorene	86-73-7	SIM	2,200,000	230,000	LMW-PAH	115,000	20	10	3.2	50	110	
4-Chlorophenyl-phenylether	7005-72-3	Full Scan	310,000	31,000	NC	15,500	330	250	78	45	110	
4-Nitroaniline	100-01-6	Full Scan	86,000	24,000	NC	12,000	820	615	134	35	115	
4,6-Dinitro-2-methylphenol	534-52-1	Full Scan	4,900	490	1,000	245	820	615	337	30	135	

SAP Worksheet #15-15—Reference Limits and Evaluation Table – SVOCs in Soils and Waste Material (continued)

Analyte	CAS Number	Full Scan or SIM	PALs ¹ (µg/kg)			Project QL Goal ^{3,4} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁵ (%)		
			Industrial Soil RSLs	Residential Soil RSLs	Eco PAL ²		LOQs	LODs	DLs	LCL	UCL	RPD
n-Nitrosodiphenylamine	86-30-6	Full Scan	350,000	99,000	1,090	545	330	250	219	50	115	30
4-Bromophenyl-phenylether	101-55-3	Full Scan	NC	NC	NC	250	330	250	85	46	106	
Hexachlorobenzene	118-74-1	Full Scan	1,100	300	1,000	150	330	250	82	45	120	
Atrazine	1912-24-9	Full Scan	7,500	2,100	11.9	5.95	330	250	91	73	133	
Pentachlorophenol	87-86-5	Full Scan	2,700	890	5,000	445	820	615	237	25	120	
Phenanthrene	85-01-8	SIM	17,000,000	1,700,000	LWM-PAH	1812.5	20	10	1.8	50	110	
Anthracene	120-12-7	SIM	17,000,000	1,700,000	LWM-PAH	1812.5	20	10	1.2	55	105	
Carbazole	86-74-8	Full Scan	NC	NC	NC	250	330	250	111	45	115	
Di-n-butylphthalate	84-74-2	Full Scan	6,200,000	610,000	40,000	20,000	330	250	101	55	110	
Fluoranthene	206-44-0	SIM	2,200,000	230,000	LMW-PAH	115,000	20	10	1.8	55	115	
Pyrene	129-00-0	SIM	1,700,000	170,000	HMW-PAH	85,000	20	10	2.1	45	125	
Butylbenzylphthalate	85-68-7	Full Scan	910,000	260,000	30,000	15,000	330	250	93	50	125	
3,3'-Dichlorobenzidine	91-94-1	Full Scan	3,800	1,100	NC	550	330	250	114	10	130	
Benzo(a)anthracene	56-55-3	SIM	2,100	150	HMW-PAH	75	20	10	1.9	50	110	
Chrysene	218-01-9	SIM	210,000	15,000	HMW-PAH	7,500	20	10	1.7	55	110	
bis(2-Ethylhexyl)phthalate	117-81-7	Full Scan	120,000	35,000	30,000	15,000	330	250	98	45	125	
Di-n-octylphthalate	117-84-0	Full Scan	620,000	61,000	30,500	15,000	330	250	211	40	130	
Benzo(b)fluoranthene	205-99-2	SIM	2,100	150	HMW-PAH	75	20	10	2.4	45	115	
Benzo(k)fluoranthene	207-08-9	SIM	21,000	1,500	HMW-PAH	750	20	10	3.1	15	125	
Benzo(a)pyrene	50-32-8	SIM	210	15	HMW-PAH	7.5	20	10	3.3	50	110	
Indeno(1,2,3-cd)pyrene	193-39-5	SIM	2,100	150	HMW-PAH	75	20	10	1.9	40	120	

SAP Worksheet #15-15—Reference Limits and Evaluation Table – SVOCs in Soils and Waste Material (continued)

Analyte	CAS Number	Full Scan or SIM	PALs ¹ (µg/kg)			Project QL Goal ^{3,4} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁵ (%)		
			Industrial Soil RSLs	Residential Soil RSLs	Eco PAL ²		LOQs	LODs	DLs	LCL	UCL	RPD
Dibenz(a,h)anthracene	53-70-3	SIM	210	15	HMW-PAH	7.5	20	10	1.8	40	125	30
Benzo(g,h,i)perylene	191-24-2	SIM	1,700,000	170,000	HMW-PAH	85,000	20	10	2	40	125	
1,2,4,5-Tetrachlorobenzene	95-94-3	Full Scan	18,000	1,800	1,000	500	330	250	135	37	97	
2,3,4,6-Tetrachlorophenol	58-90-2	Full Scan	1,800,000	180,000	500	250	330	250	140	44	104	

Notes:

- ¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013.
- ² ECO values are only applicable to subsurface samples collected at depths less than 24 inches bgs; Waste material will only be evaluated against RSLs, and will not be evaluated against ECO values. ECO values for PAHs are cumulative, the total PAL for the sum of all low-molecular weight PAHs is 29,000 µg/kg, and the ECO value for the sum of all high-molecular weight PAHs is 18,000 µg/kg.
- ³ PALs and Project QL Goals assume dry weight basis.
- ⁴ Project QL goals are equal to half of the minimum applicable PAL.
- ⁵ DoD QSM v.4.2 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where in-house limits are used.

NC indicates that there is no criterion for an analyte.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL. RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-16—Reference Limits and Evaluation Table – SVOCs in Sediment

Matrix: Sediment

Analytical Group: SVOCs

Analyte	CAS Number	Full Scan or SIM	PALs ¹ (µg/kg)		Project QL Goal ^{2,3} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
			Residential Soil RSLs x 10 for Sediment	Eco Sediment PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Benzaldehyde	100-52-7	Full Scan	1,200,000	NC	600,000	330	250	120	10	134	30
Phenol	108-95-2	Full Scan	18,000,000	48	24	330	250	156	40	100	
bis(2-Chloroethyl)ether	111-44-4	Full Scan	2,100	NC	1,050	330	250	81	40	105	
2-Chlorophenol	95-57-8	Full Scan	390,000	31.2	15.6	330	250	164	45	105	
2-Methylphenol	95-48-7	Full Scan	3,100,000	NC	1,550,000	330	250	200	40	105	
2,2'-Oxybis(1-chloropropane)	108-60-1	Full Scan	46,000	NC	23,000	330	250	89	20	115	
Acetophenone	98-86-2	Full Scan	2,500,000	NC	1,250,000	330	250	178	35	95	
4-Methylphenol	106-44-5	Full Scan	6,100,000	670	335	330	250	187	40	105	
n-Nitroso-di-n-propylamine	621-64-7	Full Scan	690	NC	345	330	250	83	40	115	
Hexachloroethane	67-72-1	Full Scan	43,000	1,000	500	330	250	96	35	110	
NB	98-95-3	Full Scan	48,000	1,779	889.5	330	250	91	40	115	
Isophorone	78-59-1	Full Scan	5,100,000	NC	2,550,000	330	250	75	45	110	
2-Nitrophenol	88-75-5	Full Scan	390,000	NC	195,000	330	250	167	40	110	
2,4-Dimethylphenol	105-67-9	Full Scan	1,200,000	29	14.5	330	250	165	30	105	
bis(2-Chloroethoxy)methane	111-91-1	Full Scan	180,000	NC	90,000	330	250	96	45	110	
2,4-Dichlorophenol	120-83-2	Full Scan	180,000	117	58.5	330	250	150	45	110	
Naphthalene	91-20-3	SIM	36,000	176	88	20	10	2.6	40	105	
4-Chloroaniline	106-47-8	Full Scan	24,000	NC	12,000	330	250	119	10	100	
Hexachlorobutadiene	87-68-3	Full Scan	61,000	550	275	330	250	83	40	115	

SAP Worksheet #15-16—Reference Limits and Evaluation Table - SVOCs in Sediment (continued)

Analyte	CAS Number	Full Scan or SIM	PALs ¹ (µg/kg)		Project QL Goal ^{2,3} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
			Residential Soil RSLs x 10 for Sediment	Eco Sediment PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Caprolactam	105-60-2	Full Scan	31,000,000	NC	15,500,000	330	250	144	10	81	30
4-Chloro-3-methylphenol	59-50-7	Full Scan	6,100,000	NC	3,050,000	330	250	166	45	115	
2-Methylnaphthalene	91-57-6	SIM	230,000	NC	115,000	20	10	2.2	45	105	
Hexachlorocyclopentadiene	77-47-4	Full Scan	370,000	NC	185,000	330	250	82	10	70	
2,4,6-Trichlorophenol	88-06-2	Full Scan	61,000	213	106.5	330	250	155	45	110	
2,4,5-Trichlorophenol	95-95-4	Full Scan	6,100,000	NC	3,050,000	820	615	155	50	110	
1,1-Biphenyl	92-52-4	Full Scan	51,000	1,100	550	330	250	73	31	99	
2-Chloronaphthalene	91-58-7	Full Scan	6,300,000	NC	3,150,000	330	250	128	45	105	
2-Nitroaniline	88-74-4	Full Scan	610,000	NC	305,000	820	615	75	45	120	
Dimethyl phthalate	131-11-3	Full Scan	NC	NC	250	330	250	78	50	110	
2,6-DNT	606-20-2	Full Scan	3,300	NC	1,650	330	250	79	50	110	
Acenaphthylene	208-96-8	SIM	3,400,000	160	80	20	10	1.2	45	105	
3-Nitroaniline	99-09-2	Full Scan	NC	NC	615	820	615	94	25	110	
Acenaphthene	83-32-9	SIM	3,400,000	290	145	20	10	1.5	45	110	
2,4-Dinitrophenol	51-28-5	Full Scan	120,000	NC	60,000	820	615	377	15	130	
4-Nitrophenol	100-02-7	Full Scan	48,000	NC	24,000	820	615	309	15	140	
Dibenzofuran	132-64-9	Full Scan	78,000	5,100	2,550	330	250	79	50	105	
2,4-DNT	121-14-2	Full Scan	16,000	41.6	20.8	330	250	85	50	110	
Diethylphthalate	84-66-2	Full Scan	49,000,000	630	315	330	250	80	50	115	
Fluorene	86-73-7	SIM	2,300,000	77.4	38.7	20	10	3.2	50	110	
4-Chlorophenyl-phenylether	7005-72-3	Full Scan	310,000	NC	155,000	330	250	78	45	110	

SAP Worksheet #15-16—Reference Limits and Evaluation Table - SVOCs in Sediment (continued)

Analyte	CAS Number	Full Scan or SIM	PALs ¹ (µg/kg)		Project QL Goal ^{2,3} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
			Residential Soil RSLs x 10 for Sediment	Eco Sediment PAL		LOQs	LODs	DLs	LCL	UCL	RPD
4-Nitroaniline	100-01-6	Full Scan	240,000	NC	120,000	820	615	134	35	115	30
4,6-Dinitro-2-methylphenol	534-52-1	Full Scan	4,900	NC	2,450	820	615	337	30	135	
n-Nitrosodiphenylamine	86-30-6	Full Scan	990,000	2,684	1,342	330	250	219	50	115	
4-Bromophenyl-phenylether	101-55-3	Full Scan	NC	1,300	650	330	250	85	46	106	
Hexachlorobenzene	118-74-1	Full Scan	3,000	20	10	330	250	82	45	120	
Atrazine	1912-24-9	Full Scan	21,000	6.62	3.31	330	250	91	73	133	
Pentachlorophenol	87-86-5	Full Scan	8,900	504	252	820	615	237	25	120	
Phenanthrene	85-01-8	SIM	17,000,000	204	102	20	10	1.8	50	110	
Anthracene	120-12-7	SIM	17,000,000	57.2	28.6	20	10	1.2	55	105	
Carbazole	86-74-8	Full Scan	NC	NC	250	330	250	111	45	115	
Di-n-butylphthalate	84-74-2	Full Scan	6,100,000	110	55	330	250	101	55	110	
Fluoranthene	206-44-0	SIM	2,300,000	423	211.5	20	10	1.8	55	115	
Pyrene	129-00-0	SIM	1,700,000	195	97.5	20	10	2.1	45	125	
Butylbenzylphthalate	85-68-7	Full Scan	2,600,000	11,000	5,500	330	250	93	50	125	
3,3'-Dichlorobenzidine	91-94-1	Full Scan	11,000	127	63.5	330	250	114	10	130	
Benzo(a)anthracene	56-55-3	SIM	1,500	108	54	20	10	1.9	50	110	
Chrysene	218-01-9	SIM	150,000	166	83	20	10	1.7	55	110	
bis(2-Ethylhexyl)phthalate	117-81-7	Full Scan	350,000	750	375	330	250	98	45	125	
Di-n-octylphthalate	117-84-0	Full Scan	610,000	305,000	365,000	330	250	211	40	130	
Benzo(b)fluoranthene	205-99-2	SIM	1,500	240	120	20	10	2.4	45	115	

SAP Worksheet #15-16—Reference Limits and Evaluation Table – SVOCs in Sediment (continued)

Analyte	CAS Number	Full Scan or SIM	PALs ¹ (µg/kg)		Project QL Goal ^{2,3} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
			Residential Soil RSLs x 10 for Sediment	Eco Sediment PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Benzo(k)fluoranthene	207-08-9	SIM	15,000	240	120	20	10	3.1	15	125	30
Benzo(a)pyrene	50-32-8	SIM	150	150	75	20	10	3.3	50	110	
Indeno(1,2,3-cd)pyrene	193-39-5	SIM	1,500	200	100	20	10	1.9	40	120	
Dibenz(a,h)anthracene	53-70-3	SIM	150	33	16.5	20	10	1.8	40	125	
Benzo(g,h,i)perylene	191-24-2	SIM	1,700,000	170	85	20	10	2	40	125	
1,2,4,5-Tetrachlorobenzene	95-94-3	Full Scan	18,000	1,093	546.5	330	250	135	37	97	
2,3,4,6-Tetrachlorophenol	58-90-2	Full Scan	1,800,000	284	142	330	250	140	44	104	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater sediment.

² PALs and Project QL Goals assume dry weight basis.

³ Project QL goals are equal to half of the minimum applicable PAL.

⁴ DoD QSM v.4.2 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where in-house limits are used.

NC indicates that there is no criterion for an analyte.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL. RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-17—Reference Limits and Evaluation Table – Pesticides in Soil or Waste Material

Matrix: Surface Soil, Subsurface Soil, and Waste Material
 Analytical Group: Pesticides

Analyte	CAS Number	PALs ¹ (µg/kg)			Project QL Goal ^{3,4} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁵ (%)		
		Industrial Soil RSLs	Residential Soil RSLs	Eco PAL ²		LOQs	LODs	DLs	LCL	UCL	RPD
alpha-BHC	319-84-6	270	77	226	38.5	1.7	0.85	0.34	60	125	30
beta-BHC	319-85-7	960	270	342	135	1.7	0.85	0.33	60	125	
delta-BHC	319-86-8	960	270	226	113	1.7	0.85	0.32	55	130	
gamma-BHC (Lindane)	58-89-9	2,100	520	7.75	3.875	1.7	0.85	0.27	60	125	
Heptachlor	76-44-8	380	110	52.9	26.45	1.7	0.85	0.29	50	140	
Aldrin	309-00-2	100	29	3.63	1.815	1.7	0.85	0.28	45	140	
Heptachlor epoxide	1024-57-3	190	53	52.9	26.45	1.7	0.85	0.22	65	130	
Endosulfan I	959-98-8	370,000	37,000	6.32	3.16	1.7	0.85	0.24	15	135	
Dieldrin	60-57-1	110	30	10.5	5.25	3.3	1.65	0.22	65	125	
4,4'-DDE	72-55-9	5,100	1,400	114	57	3.3	1.65	0.19	70	125	
Endrin	72-20-8	18,000	1,800	1.95	0.975	3.3	1.65	0.85	60	135	
Endosulfan II	33213-65-9	370,000	37,000	6.32	3.16	3.3	1.65	0.34	35	140	
4,4'-DDD	72-54-8	7,200	2,000	583	291.5	3.3	1.65	0.2	30	135	
Endosulfan sulfate	1031-07-8	370,000	37,000	6.32	3.16	3.3	1.65	0.58	60	135	
4,4'-DDT	50-29-3	7,000	1,700	100	50	3.3	1.65	0.31	45	140	
Methoxychlor	72-43-5	310,000	31,000	500	250	17	8.5	0.5	55	145	
Endrin ketone	53494-70-5	18,000	1,800	1.95	0.975	3.3	1.65	0.4	65	135	
Endrin aldehyde	7421-93-4	18,000	1,800	1.95	0.975	3.3	1.65	0.49	35	145	
alpha-Chlordane	5103-71-9	6,500	1,600	11	5.5	1.7	0.85	0.21	65	120	

SAP Worksheet #15-17—Reference Limits and Evaluation Table – Pesticides in Soil or Waste Material (continued)

Analyte	CAS Number	PALs ¹ (µg/kg)			Project QL Goal ^{3,4} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁵ (%)		
		Industrial Soil RSLs	Residential Soil RSLs	Eco PAL ²		LOQs	LODs	DLs	LCL	UCL	RPD
gamma-Chlordane	5103-74-2	6,500	1,600	11	5.5	1.7	0.85	0.23	65	125	30
Toxaphene	8001-35-2	1,600	440	500	220	33	16	7	30	122	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013.

² ECO values are only applicable to subsurface samples collected at depths less than 24 inches bgs; Waste material will only be evaluated against RSLs, and will not be evaluated against ECO values

³ PALs and Project QL Goals assume dry weight basis.

⁴ Project QL goals are equal to half of the minimum applicable PAL.

⁵ DoD QSM v.4.2 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where in-house limits are used.

NC indicates that there is no criterion for an analyte.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-18—Reference Limits and Evaluation Table – Pesticides in Sediment

Matrix: Sediment

Analytical Group: Pesticides

Analyte	CAS Number	PALs ¹ (µg/kg)		Project QL Goal ^{2,3} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
		Residential Soil RSLs x 10 for Sediment	Eco Sediment PAL		LOQs	LODs	DLs	LCL	UCL	RPD
alpha-BHC	319-84-6	770	6	3	1.7	0.85	0.34	60	125	30
beta-BHC	319-85-7	2,700	5	2.5	1.7	0.85	0.33	60	125	
delta-BHC	319-86-8	2,700	3	1.5	1.7	0.85	0.32	55	130	
gamma-BHC (Lindane)	58-89-9	5,200	2.37	1.185	1.7	0.85	0.27	60	125	
Heptachlor	76-44-8	1,100	68	34	1.7	0.85	0.29	50	140	
Aldrin	309-00-2	290	2	1	1.7	0.85	0.28	45	140	
Heptachlor epoxide	1024-57-3	530	2.47	1.235	1.7	0.85	0.22	65	130	
Endosulfan I	959-98-8	370,000	2.9	1.45	1.7	0.85	0.24	15	135	
Dieldrin	60-57-1	300	1.9	0.95	3.3	1.65	0.22	65	125	
4,4'-DDE	72-55-9	14,000	3.16	1.58	3.3	1.65	0.19	70	125	
Endrin	72-20-8	18,000	2.22	1.11	3.3	1.65	0.85	60	135	
Endosulfan II	33213-65-9	370,000	14	7	3.3	1.65	0.34	35	140	
4,4'-DDD	72-54-8	20,000	4.88	2.44	3.3	1.65	0.2	30	135	
Endosulfan sulfate	1031-07-8	370,000	5.4	2.7	3.3	1.65	0.58	60	135	
4,4'-DDT	50-29-3	17,000	4.16	2.08	3.3	1.65	0.31	45	140	
Methoxychlor	72-43-5	310,000	19	9.5	17	8.5	0.5	55	145	
Endrin ketone	53494-70-5	18,000	2.22	1.11	3.3	1.65	0.4	65	135	
Endrin aldehyde	7421-93-4	18,000	2.22	1.11	3.3	1.65	0.49	35	145	
alpha-Chlordane	5103-71-9	16,000	3.24	1.62	1.7	0.85	0.21	65	120	

SAP Worksheet #15-18—Reference Limits and Evaluation Table – Pesticides in Sediment (continued)

Analyte	CAS Number	PALs ¹ (µg/kg)		Project QL Goal ^{2,3} (µg/kg)	Laboratory-specific (µg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
		Residential Soil RSLs x 10 for Sediment	Eco Sediment PAL		LOQs	LODs	DLs	LCL	UCL	RPD
gamma-Chlordane	5103-74-2	16,000	3.24	1.62	1.7	0.85	0.23	65	125	30
Toxaphene	8001-35-2	4,400	28	14	33	16	7	30	122	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater sediment.

² PALs and Project QL Goals assume dry weight basis.

³ Project QL goals are equal to half of the minimum applicable PAL.

⁴ DoD QSM v.4.2 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where in-house limits are used.

NC indicates that there is no criterion for an analyte.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-19—Reference Limits and Evaluation Table - PCBs in Soils and Waste Material

Matrix: Surface Soil, Subsurface Soil, and Waste Material
 Analytical Group: PCBs

Analyte	CAS Number	PALs ¹ (µg/kg)			Project QL Goal ^{3,4} (µg/kg)	Laboratory-Specific (µg/kg)			LCS and MS/MSD Recovery Limits ⁵ (%)		
		Industrial Soil RSLs	Residential Soil RSLs	Eco PAL ²		LOQ	LOD	DL	LCL	UCL	%RPD
Aroclor-1016	12674-11-2	3700	390	8,000	195	17	8.5	6	40	140	30
Aroclor-1221	11104-28-2	540	140	8,000	70	17	8.5	7.9	N/A	N/A	
Aroclor-1232	11141-16-5	540	140	8,000	70	17	10	9.3	N/A	N/A	
Aroclor-1242	53469-21-9	740	220	8,000	110	17	8.5	5.8	N/A	N/A	
Aroclor-1248	12672-29-6	740	220	8,000	110	17	8.5	6.1	N/A	N/A	
Aroclor-1254	11097-69-1	740	110	8,000	55	17	8.5	4.7	N/A	N/A	
Aroclor-1260	11096-82-5	740	220	8,000	110	17	8.5	6	60	130	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013.

² ECO values are only applicable to subsurface samples collected at depths less than 24 inches bgs; Waste material will only be evaluated against RSLs, and will not be evaluated against ECO values

³ PALs and Project QL Goals assume dry weight basis.

⁴ Project QL goals are equal to half of the minimum applicable PAL.

⁵ DoD QSM v.4.2 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where in-house limits are used.

NC indicates that there is no criterion for an analyte.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL.

RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-20—Reference Limits and Evaluation Table - PCBs in Sediment

Matrix: Sediment
 Analytical Group: PCBs

Analyte	CAS Number	PALs ¹ (µg/kg)		Project QL Goal ^{2,3} (µg/kg)	Laboratory-Specific (µg/kg)			LCS and MS/MSD Recovery Limits ⁴ (%)		
		Residential Soil RSLs x 10 for Sediment	Eco Sediment PAL		LOQ	LOD	DL	LCL	UCL	%RPD
Aroclor-1016	12674-11-2	3,900	59.8	29.9	17	8.5	6	40	140	30
Aroclor-1221	11104-28-2	1,400	59.8	29.9	17	8.5	7.9	N/A	N/A	
Aroclor-1232	11141-16-5	1,400	59.8	29.9	17	10	9.3	N/A	N/A	
Aroclor-1242	53469-21-9	2,200	59.8	29.9	17	8.5	5.8	N/A	N/A	
Aroclor-1248	12672-29-6	2,200	59.8	29.9	17	8.5	6.1	N/A	N/A	
Aroclor-1254	11097-69-1	1,100	59.8	29.9	17	8.5	4.7	N/A	N/A	
Aroclor-1260	11096-82-5	2,200	59.8	29.9	17	8.5	6	60	130	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater sediment.

² PALs and Project QL Goals assume dry weight basis.

³ Project QL goals are equal to half of the minimum applicable PAL.

⁴ DoD QSM v.4.2 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where in-house limits are used.

NC indicates that there is no criterion for an analyte.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL. RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-21—Reference Limits and Evaluation Table – Metals in Soils and Waste Material

Matrix: Surface Soil, Subsurface Soil, and Waste Material
 Analytical Group: Metals including Cyanide

Analyte	CAS Number	PALs ¹ (milligrams per kilogram [mg/kg])					Project QL Goal ^{3,4} (mg/kg)	Laboratory-specific (mg/kg)			LCS and MS/MSD Control Limits ⁵ (%)		
		Surface Soil Background	Subsurface Soil Background	Industrial Soil RSLs	Residential Soil RSLs	Eco PALs ²		LOQs	LODs	DLs	LCL	UCL	RPD
Aluminum	7429-90-5	12200	13,000	99,000	7,700	pH <5.5	3850	30	10	0.71	80	120	20
Antimony	7440-36-0	11	NC	41	3.1	78	1.55	0.8	0.5	0.07			
Arsenic	7440-38-2	6.36	5.54	2.4	0.61	18	0.3	0.8	0.5	0.068			
Barium	7440-39-3	52.9	84.5	19,000	1,500	330	26.45	0.5	0.4	0.026			
Beryllium	7440-41-7	0.587	0.52	200	16	40	0.26	0.5	0.05	0.0068			
Cadmium	7440-43-9	1.5	NC	80	7	32	0.75	1	0.3	0.0079			
Calcium	7440-70-2	2290	2,380	NC	NC	NC	1145	10	8	1.8			
Chromium	7440-47-3	18.2	33.7	5.6	0.29	64	0.145	1.5	0.4	0.026			
Cobalt	7440-48-4	9.93	5.18	30	2.3	13	1.15	3	0.2	0.029			
Copper	7440-50-8	4.25	3.17	4,100	310	70	1.585	2.5	1	0.16			
Iron	7439-89-6	19900	32,000	72,000	5,500	5 < pH > 8	2750	10	8	1.4			
Lead	7439-92-1	17.4	8.79	800	400	120	4.395	0.5	0.4	0.087			
Magnesium	7439-95-4	1070	1120	NC	NC	NC	535	10	8	0.68			
Manganese	7439-96-5	324	176	2,300	180	220	88	0.5	0.4	0.16			
Mercury	7439-97-6	0.111	0.14	31	2.3	0.1	0.05	0.033	0.017	0.0052			
Nickel	7440-02-0	9.52	17.6	2,000	150	38	4.76	4	0.4	0.044			
Potassium	9/7/7440	708	901	NC	NC	NC	354	100	50	2.9			
Selenium	7782-49-2	0.51	0.64	510	39	0.52	0.255	1	0.7	0.17			
Silver	7440-22-4	2.1	1.1	510	39	560	0.55	1.5	0.4	0.027			

SAP Worksheet #15-21—Reference Limits and Evaluation Table – Metals in Soils and Waste Material (continued)

Analyte	CAS Number	PALs ¹ (milligrams per kilogram [mg/kg])					Project QL Goal ^{3,4} (mg/kg)	Laboratory-specific (mg/kg)			LCS and MS/MSD Control Limits ⁵ (%)		
		Surface Soil Background	Subsurface Soil Background	Industrial Soil RSLs	Residential Soil RSLs	Eco PALs ²		LOQs	LODs	DLs	LCL	UCL	RPD
Sodium	7440-23-5	521	811	NC	NC	NC	260.5	100	50	1.5	80	120	20
Thallium	7440-28-0	NC	NC	1	0.078	1	0.039	1.5	0.5	0.087			
Vanadium	7440-62-2	27.9	48.3	510	39	130	13.95	2.5	0.4	0.037			
Zinc	7440-66-6	26.5	28	31,000	2,300	120	13.25	2.5	1	0.17			
Cyanide	57-12-5	NC	2.7	14	2.2	15.8	1.1	0.5	0.25	0.22	85	115	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013.

² ECO values are only applicable to subsurface samples collected at depths less than 24 inches bgs; Waste material will only be evaluated against RSLs, and will not be evaluated against ECO values

³ PALs and Project QL Goals assume dry weight basis.

⁴ Project QL goals are equal to half of the minimum applicable PAL.

⁵ DoD QSM v.4.2 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where in-house limits are used.

NC indicates that there is no criterion for an analyte.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL. RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-22—Reference Limits and Evaluation Table – Metals in Sediment

Matrix: Sediment

Analytical Group: Metals including Cyanide

Analyte	CAS Number	PALs ¹ (mg/kg)		Project QL Goal ^{2,3} (mg/kg)	Laboratory-specific (mg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
		Residential Soil RSLs x 10 for Sediment	Eco Sediment PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Aluminum	7429-90-5	77,000	25,500	12,750	30	10	0.71	80	120	20
Antimony	7440-36-0	31	3	1.5	0.8	0.5	0.07			
Arsenic	7440-38-2	6.1	9.79	3.0	0.8	0.5	0.068			
Barium	7440-39-3	15,000	20	10	0.5	0.4	0.026			
Beryllium	7440-41-7	160	NC	80	0.5	0.05	0.0068			
Cadmium	7440-43-9	70	0.99	0.495	1	0.3	0.0079			
Calcium	7440-70-2	NC	NC	8	10	8	1.8			
Chromium	7440-47-3	2.9	43.4	1.45	1.5	0.4	0.026			
Cobalt	7440-48-4	23	50	11.5	3	0.2	0.029			
Copper	7440-50-8	3,100	31.6	15.8	2.5	1	0.16			
Iron	7439-89-6	55,000	20,000	10,000	10	8	1.4			
Lead	7439-92-1	4,000	35.8	17.9	0.5	0.4	0.087			
Magnesium	7439-95-4	NC	NC	8	10	8	0.68			
Manganese	7439-96-5	1,800	460	230	0.5	0.4	0.16			
Mercury	7439-97-6	23	0.18	0.9	0.033	0.017	0.0052			
Nickel	7440-02-0	1,500	22.7	11.35	4	0.4	0.044			
Potassium	9/7/7440	NC	NC	50	100	50	2.9			
Selenium	7782-49-2	390	2	1	1	0.7	0.17			
Silver	7440-22-4	390	1	0.5	1.5	0.4	0.027			
Sodium	7440-23-5	NC	NC	50	100	50	1.5			

SAP Worksheet #15-22—Reference Limits and Evaluation Table – Metals in Sediment (continued)

Analyte	CAS Number	PALs ¹ (mg/kg)		Project QL Goal ^{2,3} (mg/kg)	Laboratory-specific (mg/kg)			LCS and MS/MSD Control Limits ⁴ (%)		
		Residential Soil RSLs x 10 for Sediment	Eco Sediment PAL		LOQs	LODs	DLs	LCL	UCL	RPD
Thallium	7440-28-0	0.78	NC	0.39	1.5	0.5	0.087	80	120	20
Vanadium	7440-62-2	390	NC	195	2.5	0.4	0.037			
Zinc	7440-66-6	23,000	121	60.5	2.5	1	0.17			
Cyanide	57-12-5	22	NC	11	0.5	0.25	0.22	85	115	

Notes:

¹ PALs were developed to be protective of human health and the environment. Refer to Worksheets #10 and #11 for a detailed discussion on development of PALs. RSLs are from May 2013 and Ecological Screening Values are for freshwater sediment.

² PALs and Project QL Goals assume dry weight basis.

³ Project QL goals are equal to half of the minimum applicable PAL.

⁴ DoD QSM v.4.2 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where in-house limits are used.

NC indicates that there is no criterion for an analyte.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL. RSLs based on non-carcinogenic effects will be based on a HQ of 0.1 to account for exposure to more than one constituent that affects the same organ.

SAP Worksheet #15-23—Reference Limits and Evaluation Table

Matrix: Surface Soil, Subsurface Soil, Sediment
 Analytical Group: WCHEM

Analyte	CAS Number ⁵	Units	Project Indicator Limits(PILs) ¹	Laboratory-Specific (µg/kg)			LCS Control Limits			MS/MSD Control Limits		
				LOQ	LOD	DL	LCL	UCL	%RPD	LCL	UCL	%RPD
Total organic carbon (TOC) ³	TOC	MG_KG	2,000	400	300	85	80	120	30	75	125	30
pH ²	PH	pH	5<pH>8	N/A	N/A	N/A	90	110	20	N/A	N/A	N/A

Notes:

¹ Project indicator Limits (PILs) were developed to assist in determining site conditions.

² pH results will be used to determine the bioavailability of certain metals.

³ TOC results will be used to determine the bioavailability of organic chemicals.

⁴ DoD QSM v.4.2 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where in-house limits are used.

⁵ Contractor-specific identifies are shown.

SAP Worksheet #15-24—Reference Limits and Evaluation Table

Matrix: Surface Water/Groundwater Seeps

Analytical Group: WCHEM

Analyte	CAS Number ²	Project Indicator Limits(PILs) ¹	Laboratory-Specific (µg/kg)			LCS Control Limits			MS/MSD Control Limits		
			LOQ	LOD	DL	LCL	UCL	%RPD	LCL	UCL	%RPD
Hardness	Hardness	25 - 400 mg/L	5	4	1.63	80	120	20	75	125	20

Notes:

¹ Surface water ecological screening values for some target analytes are dependent on the hardness of the media. Hardness data will be used to support the ERA.

² The CAS Number for hardness is a contractor-specific identification (ID) number.

SAP Worksheet #15-25—Reference Limits and Evaluation Table

Matrix: Sediment

Analytical Group: AVS/SEM

Analyte ¹	CAS Number ²	PILs (AVS/SEM ratio) ³	Laboratory-Specific (umol/gram [g])			LCS Control Limits			MS/MSD Control Limits		
			LOQ	LOD	DL	LCL	UCL	%RPD	LCL	UCL	%RPD
Acid volatile sulfide	ACIDSO2	>1	0.1	0.076	0.038	80	120	20	75	125	20
Cadmium	7440-43-9	>1	0.00089	0.00053	0.000014	80	120	20	75	125	20
Copper	7440-50-8	>1	0.007868	0.003147	0.00073	80	120	20	75	125	20
Lead	7439-92-1	>1	0.000483	0.000386	0.0003	80	120	20	75	125	20
Mercury	7439-97-6	>1	0.00002	0.000018	0.000016	80	120	20	75	125	20
Nickel	7440-02-0	>1	0.00341	0.001363	0.00022	80	120	20	75	125	20
Silver	7440-22-4	>1	0.00185	0.000742	0.0001	80	120	20	75	125	20
Zinc	7440-66-6	>1	0.00612	0.00306	0.0011	80	120	20	75	125	20

Notes:

¹ There are no applicable PALs for these analytes.

² The CAS Number for AVS is a contractor-specific ID number.

³ AVS/SEM results are provided as a ratio. SEM/AVS ratios >1 are interpreted to indicate that the metals evaluated are potentially bioavailable.

SAP Worksheet #15-26—Reference Limits and Evaluation Table

Matrix: Sediment

Analytical Group: Grain-size

Units are specified below

Analyte ^{1,2}	CAS # ³	Units
GS05 Sieve 2" (50 mm)	SIEVE50.0	PCT_P
GS05 Sieve 3" (75 mm)	SIEVE75.0	PCT_P
GS06 Sieve 1.5" (37.5 mm)	SIEVE37.5	PCT_P
GS07 Sieve 1" (25.0 mm)	SIEVE25.0	PCT_P
GS08 Sieve 0.75" (19.0 mm)	SIEVE19.0	PCT_P
GS10 Sieve 0.375" (9.5 mm)	SIEVE9.5	PCT_P
Sieve No. 004 (4.75 mm)	SIEVE4.75	PCT_P
Sieve No. 010 (2.00 mm)	SIEVE2.0	PCT_P
Sieve No. 020 (850 µm)	SIEVE850	PCT_P
Sieve No. 040 (425 µm)	SIEVE425	PCT_P
Sieve No. 060 (250 µm)	SIEVE250	PCT_P
Sieve No. 080 (180 µm)	SIEVE180	PCT_P
Sieve No. 100 (150 µm)	SIEVE150	PCT_P
Sieve No. 200 (75 µm)	SIEVE75	PCT_P
Gravel (%)	GRAVEL	PCT
Sand (%)	14808-60-7	PCT
Coarse Sand (%)	COARSE SAND	PCT
Medium Sand (%)	MEDIUM SAND	PCT
Fine Sand (%)	FINE SAND	PCT
Fines (%)	FINES	PCT

Notes:

¹ Grain-size data will be used to determine the nature of the substrate and how suitable it is as habitat for particular species; the distribution of particle sizes will also influence the bioavailability of some constituents.

² This is a typical sieve set. A similar sieve set is also acceptable.

³ Contractor-specific identifiers are shown.

Mm = millimeter

µm = micrometer

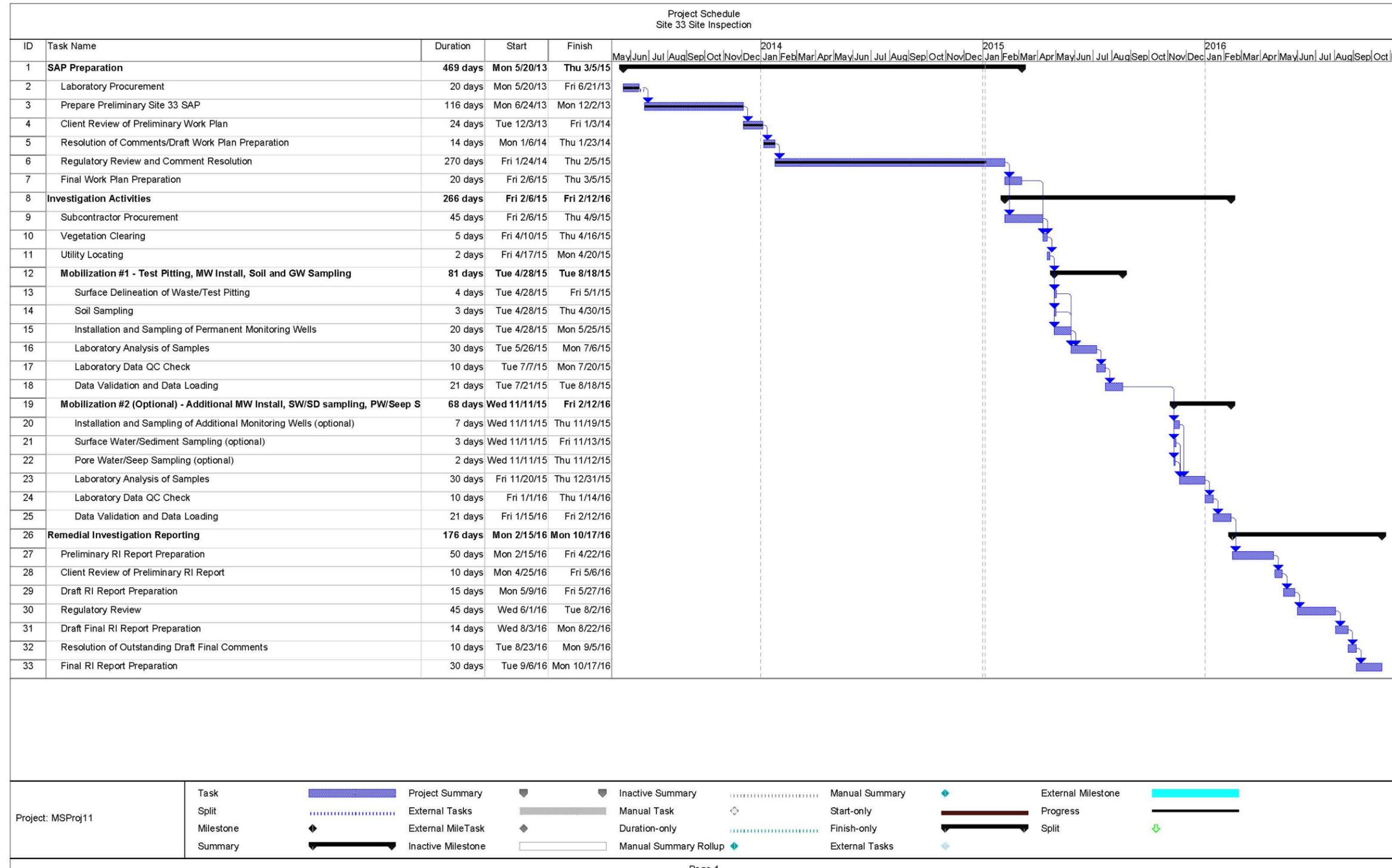
% = percent

PCT_P = percent passing

PCT = percent

SAP Worksheet #16—Project Schedule/Timeline Table

(UFP-QAPP Manual Section 2.8.2)



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SAP Worksheet #17—Sampling Design and Rationale

[\(UFP-QAPP Manual Section 3.1.1\)](#)

Matrix	Depths to Sample	Analysis	Number of Samples	Rationale	* Sampling Strategy
Groundwater (monitoring well—14 initially installed permanent wells)	Middle of well screen	Total and Dissolved Metals	14 (may be modified based on observed site conditions)	Sampling locations to provide sufficient spatial coverage between source and receptor; sampling parameters based what historical data showed to be above risk-based screening levels. Monitoring well locations will be selected to ensure that the wells are optimally placed to assess Site 33 groundwater impacts for Former Building 530 and the waste disposal areas and to evaluate potential transport to the unnamed stream located west of the site.	Two groundwater wells (MWO1 and MWO4) will be located upgradient and two groundwater wells (MWO2 and MWO3) will be located downgradient of the southern waste area. Three groundwater wells (MWO5 to MWO7) will be located downgradient of former Building 530. One groundwater well (MWO8) will be located east of the site to evaluate groundwater flow in that direction. One groundwater well (MWO9) will be located where the previous site monitoring well had been located. One groundwater well (MW10) will be located upgradient and two groundwater wells (MW11 and MW12) will be located downgradient of the northern waste area. Two groundwater wells (MW13 and MW14) will be located in the southern portion of the former Building 530 footprint to characterize historical disposal areas.
		VOCs			
		SVOCs (including PAHs by SIM)			
		PCBs			
		Pesticides			
		Cyanide			
Groundwater (monitoring well—An estimated two additional permanent wells)	Middle of well screen	TBD	Approximately 2 (may be modified based on observed site conditions)		Additional permanent monitoring well locations will be selected based on historical site data, site lithology, waste disposal area locations, and groundwater sampling results from the 14 initially installed monitoring wells.
Soil (Former Building 530)	Surface Soil (0-6 inches bgs) and Subsurface Soil (6-24 inches bgs).	Metals	21 sampling locations, for a total of two sampling intervals at each location (may be modified based on observed site conditions)	Sampling locations provide sufficient spatial coverage to evaluate the nature and extent of soil contamination associated with Former Building 530 activities.	Surface and subsurface soil sampling locations have been selected to focus in suspected waste dumping locations and drainage swales within the vicinity of Former Building 530. Eight soil sample locations (SO02, SO08, SO09, SO11, SO12, SO14, SO15, and SO16) will be located within the drainage swale east of former Building 530. Three soil sample locations (SO06, SO10, and SO13) will be located within the drainage swale west of former Building 530. Four soil sample locations (SO01, SO03, SO04, and SO05) will be located south of former Building 530. Five soil sample locations (SO17, SO18, SO19, SO20, and SO21) will be located within the intermittent drainage ditch located to the west/northwest of former Building 530.
		VOCs			
		SVOCs (Including PAHs by SIM)			
		PCBs			
		Pesticides			
		pH			
		TOC			
		Cyanide			

SAP Worksheet #17—Sampling Design and Rationale (continued)

Matrix	Depths to Sample	Analysis	Method	Number of Samples	Rationale	* Sampling Strategy
Soil (Waste Disposal Areas)	0 – 6 inches bgs, subsurface samples collected at the vertical extent of waste or from intervals of visual or olfactory contamination (sheen, staining, odor, etc.), and of the waste material itself.	Metals	SW846 6010B/7471A	Approximately 10 surface soil, 15 subsurface soil, and 5 waste samples (may be modified based on observed site conditions)	Sampling locations located to define the extent of the waste disposal areas. Surface soil samples will be placed in the vicinity of the waste areas. Subsurface soil samples will either be collected immediately below the waste extent to determine impacts immediately below the waste, from intervals of visual or olfactory impacts to characterize contamination, or of the waste material for waste characterization.	Soil sampling locations will be selected based on waste disposal locations
		VOCs	SW846 8260B			
		SVOCs (Including PAHs by SIM)	SW846 8270C/8270C-SIM			
		PCBs	SW846 8082A			
		Pesticides	SW846 8081B			
		pH	SW846-9045			
		TOC	Lloyd Kahn			
		Cyanide	SW846 9012B			
Groundwater Seeps/Pore Water	Grab sample directly at source (seep)	TBD	TBD	Approximately 5	Sampling locations where contaminated groundwater may be discharging to stream, as well as upgradient and downgradient stream locations	Sampling locations TBD based on groundwater and soil results and site characteristics
Surface Water	Grab sample just below the water surface	TBD	TBD	Approximately 5	Co-located with seep/pore water samples	Sampling locations TBD based on groundwater and soil results and site characteristics
Sediment	Grab sample at 0 to 4 inches bgs	TBD	TBD	Approximately 5	Co-located with seep/pore water samples	Sampling locations TBD based on groundwater and soil results and site characteristics

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table

Sampling Station	Sample ID ¹	Matrix	Depth	Analytical Group	Number of Samples	Sampling SOP Reference
Monitoring Well Locations (Initial 14 Installed wells)²						
YS33-GW01	YS33-GW01-MMY	GW	Middle of well screen	VOCs, SVOCs, Pesticides, PCBs, Total and Dissolved Metals, Cyanide	Approximately 14, plus quality control (QC) samples	Refer to Worksheet #21
YS33-GW02	YS33-GW02-MMY					
	YS33-GW02P-MMY					
YS33-GW03	YS33-GW03-MMY					
YS33-GW04	YS33-GW04-MMY					
YS33-GW05	YS33-GW05-MMY					
YS33-GW06	YS33-GW06-MMY					
YS33-GW07	YS33-GW07-MMY					
YS33-GW08	YS33-GW08-MMY					
YS33-GW09	YS33-GW09-MMY					
YS33-GW10	YS33-GW10-MMY					
	YS33-GW10-MMY-MS					
	YS33-GW10-MMY-SD					
YS33-GW11	YS33-GW11-MMY					
	YS33-GW11P-MMY					
YS33-GW12	YS33-GW12-MMY					
YS33-GW13	YS33-GW13-MMY					
YS33-GW14	YS33-GW14-MMY					
Soil Locations, Former Building 530						
YS33-SO01	YS33-SS01-MMY	Surface Soil	0-6 inches bgs	VOCs, SVOCs, Pesticides, PCBs, Metals, Cyanide, pH, TOC Note: Field duplicates and MS/MSDs will not be sampled for pH or TOC	Approximately 21, plus QC samples	Refer to Worksheet #21
YS33-SO02	YS33-SS02-MMY					
YS33-SO03	YS33-SS03-MMY					
YS33-SO04	YS33-SS04-MMY					
YS33-SO05	YS33-SS05-MMY					
YS33-SO06	YS33-SS06-MMY					
	YS33-SS06-MMY-MS					
	YS33-SS06-MMY-SD					
YS33-SO07	YS33-SS07-MMY					
YS33-SO08	YS33-SS08-MMY					
YS33-SO09	YS33-SS09-MMY					
YS33-SO10	YS33-SS10-MMY					
	YS33-SS10P-MMY					
YS33-SO11	YS33-SS11-MMY					
YS33-SO12	YS33-SS12-MMY					
YS33-SO13	YS33-SS13-MMY					
YS33-SO14	YS33-SS14-MMY					
YS33-SO15	YS33-SS15-MMY					

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (continued)

Sampling Station	Sample ID ¹	Matrix	Depth	Analytical Group	Number of Samples	Sampling SOP Reference
YS33-SO16	YS33-SS16-MMY					
YS33-SO17	YS33-SS17-MMY					
YS33-SO18	YS33-SS18-MMY					
YS33-SO19	YS33-SS19-MMY					
YS33-SO20	YS33-SS20-MMY					
YS33-SO21	YS33-SS21-MMY					
YS33-SO01	YS33-SB01-MMY	Subsurface Soil	6-24 inches bgs	VOCs, SVOCs, Pesticides, PCBs, Metals, Cyanide, pH, TOC Note: Field duplicates and MS/MSDs will not be sampled for pH or TOC	Approximately 21, plus QC samples	Refer to Worksheet #21
	YS33-SB01P-MMY					
YS33-SO02	YS33-SB02-MMY					
YS33-SO03	YS33-SB03-MMY					
YS33-SO04	YS33-SB04-MMY					
YS33-SO05	YS33-SB05-MMY					
YS33-SO06	YS33-SB06-MMY					
	YS33-SB06-MMY-MS					
	YS33-SB06-MMY-SD					
YS33-SO07	YS33-SB07-MMY					
YS33-SO08	YS33-SB08-MMY					
YS33-SO09	YS33-SB09-MMY					
YS33-SO10	YS33-SB10-MMY					
	YS33-SB10P-MMY					
YS33-SO11	YS33-SB11-MMY					
YS33-SO12	YS33-SB12-MMY					
YS33-SO13	YS33-SB13-MMY					
YS33-SO14	YS33-SB14-MMY					
YS33-SO15	YS33-SB15-MMY					
YS33-SO16	YS33-SB16-MMY					
YS33-SO17	YS33-SB17-MMY					
YS33-SO18	YS33-SB18-MMY					
YS33-SO19	YS33-SB19-MMY					
YS33-SO20	YS33-SB20-MMY					
YS33-SO21	YS33-SB21-MMY					

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (continued)

Sampling Station	Sample ID ¹	Matrix	Depth	Analytical Group	Number of Samples	Sampling SOP Reference
Soil Locations, Waste Disposal Areas						
YS33-SO22	YS33-SS22-MMY	Surface Soil	0-6 inches bgs	VOCs, SVOCs, Pesticides, PCBs, Metals, Cyanide, pH, TOC Note: Field duplicates and MS/MSDs will not be sampled for pH or TOC	Approximately 10, plus QC samples	Refer to Worksheet #21
	YS33-SS22P-MMY					
YS33-SO23	YS33-SS23-MMY					
YS33-SO24	YS33-SS24-MMY					
YS33-SO25	YS33-SS25-MMY					
YS33-SO26	YS33-SS26-MMY					
YS33-SO27	YS33-SS27-MMY					
	YS33-SS27-MMY-MS					
	YS33-SS27-MMY-SD					
YS33-SO28	YS33-SS28-MMY					
YS33-SO29	YS33-SS29-MMY					
YS33-SO30	YS33-SS30-MMY					
YS33-SO31	YS33-SS31-MMY					
	YS33-SS31P-MMY					
YS33-SO22	YS33-SB22-TDBD-MMY	Subsurface Soil	VOCs, SVOCs, Pesticides, PCBs, Metals, Cyanide, pH, TOC Note: Field duplicates and MS/MSDs will not be sampled for pH or TOC	Approximately 15, plus QC samples	Refer to Worksheet #21	
	YS33-SB22P-TDBD-MMY					
YS33-SO23	YS33-SB23-TDBD-MMY					
YS33-SO24	YS33-SB24-TDBD-MMY					
YS33-SO25	YS33-SB25-TDBD-MMY					
YS33-SO26	YS33-SB26-TDBD-MMY					
YS33-SO27	YS33-SB27-TDBD-MMY					
	YS33-SB27-TDBD-MMY-MS					
	YS33-SB27-TDBD-MMY-SD					
YS33-SO28	YS33-SB28-TDBD-MMY					
YS33-SO29	YS33-SB29-TDBD-MMY					
YS33-SO30	YS33-SB30-TDBD-MMY					
YS33-SO31	YS33-SB31-TDBD-MMY					
	YS33-SB31P-TDBD-MMY					
YS33-SO32	YS33-SB32-TDBD-MMY					
YS33-SO33	YS33-SB33-TDBD-MMY					
YS33-SO34	YS33-SB34-TDBD-MMY					
YS33-SO35	YS33-SB35-TDBD-MMY					
YS33-SO36	YS33-SB36-TDBD-MMY					
Optional Samples or Media ^{2,3}						
YS33-GW15	YS33-GW15-MMY	GW ²	Middle of well screen	TBD	Approximately 2	Refer to Worksheet #21
YS33-GW16	YS33-GW16-MMY					

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (continued)

Sampling Station	Sample ID ¹	Matrix	Depth	Analytical Group	Number of Samples	Sampling SOP Reference					
YS33-WS01	YS33-WS01-MMY	Waste Material (Optional) ³	Within the extent of the waste material	VOCs, SVOCs, Pesticides, PCBs, Metals, Cyanide, pH, TOC	Approximately 5, plus QC samples	Refer to Worksheet #21					
	YS33-WS01P-MMY										
YS33-WS02	YS33-WS02-MMY										
	YS33-WS02-MMY-MS										
	YS33-WS02-MMY-SD										
YS33-WS03	YS33-WS03-MMY										
YS33-WS04	YS33-WS04-MMY										
YS33-WS05	YS33-WS05-MMY										
YS33-SPO1	YS33-SPO1-MMY						Seeps (Optional) ³	N/A	TBD to include hardness	Approximately 5, plus QC samples	Refer to Worksheet #21
YS33-SPO2	YS33-SPO2-MMY										
	YS33-SPO2P-MMY										
YS33-SPO3	YS33-SPO3-MMY										
	YS33-SPO3-MMY-MS										
	YS33-SPO3-MMY-SD										
YS33-SPO4	YS33-SPO4-MMY										
YS33-SPO5	YS33-SPO5-MMY										
YS33-SWSD01	YS33-SW01-MMY	Surface Water (Optional) ³	N/A	TBD to include hardness	Approximately 5, plus QC samples	Refer to Worksheet #21					
YS33-SWSD02	YS33-SW02-MMY										
	YS33-SW02P-MMY										
YS33-SWSD03	YS33-SW03-MMY										
	YS33-SW03-MMY-MS										
	YS33-SW03-MMY-SD										
YS33-SWSD04	YS33-SW04-MMY										
YS33-SWSD05	YS33-SW05-MMY										
YS33-SWSD01	YS33-SD01-MMY						Sediment (Optional) ³	0-4 inches bgs	TBD to include pH, TOC, grain-size, and AVS/SEM	Approximately 5, plus QC samples	Refer to Worksheet #21
YS33-SWSD02	YS33-SD02-MMY										
	YS33-SD02P-MMY										
YS33-SWSD03	YS33-SD03-MMY										
	YS33-SD03-MMY-MS										
	YS33-SD03-MMY-SD										
YS33-SWSD04	YS33-SD04-MMY										
YS33-SWSD05	YS33-SD05-MMY										

Notes:

¹ Additional nomenclature instructions are as follows.

- duplicates will have "P" added after the station indicator, for example: YS33-SB01P-MMY

- for all sample IDs, "MMYY" will be replaced with the two-digit month and year in which the sample was collected

- equipment blanks will be identified with the two digit month, day and year, and what matrix it is relevant to, for example: YS33-EBMMDDYY

- trip blanks will be identified with the two digit month, day and year, and whether it is the first or other trip blank of the day, for example: YS33-TB01-MMDDYY

- subsurface soil samples will include the top depth and bottom depth in feet (TDBD) from which the sample was collected; an H will be used to designate 0.5ft intervals. For example, if station YS33-SO25 has subsurface soil collected from 0.5-2ft bgs, the sample ID will be: YS33-SB25-OH02-MMY.

² The optional groundwater wells will be installed and samples collected if the results from the first 14 wells warrant additional well installation.

³ Several media are optional. Seeps will only be sampled if they are observed, and if groundwater and soil data indicates the seeps may be impacted. Surface water and sediment will be sampled for COPCs identified through historical site information and the groundwater and soil analytical results.

SAP Worksheet #19—Analytical SOP Requirements Table

Matrix	Analytical Group ¹	Preparation and Analytical Method/ SOP Reference	Containers (Number, Size, and Type)	Minimum Sample Amount Required for Analysis	Preservation Requirements (Chemical, Temperature, Light Protected)	Maximum Holding Time ² (Preparation/Analysis)
Groundwater, Seep, or Surface Water	TCL or Select VOCs	SW-846 5030B, 8260B/CA-202	Three 40-milliliter (ml) volatile organic analyte (VOA) vials	40 ml	Hydrochloric acid (HCl) to pH < 2, cool to ≤ 6 °C.	14 days to analysis
	SVOCs	SW-846 3510C, 3520C, 8270C/CA-226, CA-502	Two 1-liter (L) amber glass bottles	1,000 ml	Cool to ≤ 6°C	7 days to extraction 40 days to analysis
		SW-846 3510C, 3520C, 8270C SIM/CA-213, CA-502				
		SW-846 3510C, 3520C, 8270C SIM low level/CA-213, CA-502				
	Pesticides	SW-846 3510C, 3520C, 8081B/CA-302, CA-515	Two 1-L amber glass bottles	1,000 ml	7 days to extraction 40 days to analysis	
	PCBs	SW-846 3510C, 3520C, 8082/CA-327, CA-515	1,000 ml	7 days to extraction 40 days to analysis		
	TAL or Select Metals	SW-846 3010A, 6010B/CA-604, CA-608	One 250-ml polyethylene bottle	50 ml	Nitric Acid (HNO ₃) to pH<2.	6 months to analysis
		SW-846 7470A/CA-615		25 ml		28 days to analysis
	TAL or Select Filtered Metals	SW-846 3010A, 6010B/CA-604, CA-608	One 250-ml polyethylene bottle	50 ml		6 months to analysis
		SW-846 7470A/CA-615		25 ml		28 days to analysis
	Cyanide	SW-846 9012B/CA-773	One 250-ml polyethylene bottle	50 ml	Sodium hydroxide (NaOH) to pH < 2, cool to ≤ 6°C	14 days to analysis
Hardness	EPA 130.2/CA-707	One of 250mL polyethylene bottle	25 ml	HNO ₃ to pH < 2, Cool to ≤ 6 °C	180 days to analysis	

SAP Worksheet #19—Analytical SOP Requirements Table (continued)

Matrix	Analytical Group ¹	Preparation and Analytical Method/ SOP Reference	Containers (Number, Size, and Type)	Minimum Sample Amount Required for Analysis	Preservation Requirements (Chemical, Temperature, Light Protected)	Maximum Holding Time ² (Preparation/Analysis)	
Waste Material, Sediment, Surface Soil, or Subsurface Soil	VOCs	SW-846 3035, 8260B/CA-202, CA-214	Three 40-ml VOA vials	5 grams (g)	5 ml reagent water, cool to 4 ± 2 °C	48 hours to freezing, 14 days to analysis	
			One 40-ml VOA vial	5 g	5 ml methanol, cool to 4 ± 2 °C		
	SVOCs	SW-846 3540C, 3550C, 8270C/ CA-226, CA-512, CA-526	One 4-ounce (oz) wide-mouth jar	30 g	Cool to ≤ 6°C	14 days to extraction, 40 days to analysis	
		SW-846 3540C, 3550C, 8270C SIM/CA-213, CA-512, CA-526					
	Pesticides	SW-846 3546, 3550C, 8081B/CA-302, CA-500, CA-549					30 g
	PCBs	SW-846 3546, 3550C, 8082/CA-329, CA-500, CA-549					30 g
	Total Metals	SW-846 3050B, 6010B/CA-605, CA-608	One 4-oz wide-mouth jar	2 g	Cool to ≤ 6°C	6 months to analysis	
		SW-846 7471A/CA-611				0.6 g	28 days to analysis
	Cyanide	SW-846 9012B/CA-773				1 g	14 days to analysis
	pH	SW846-9045D/CA-709	2-oz wide-mouth jar	25 g	Cool to ≤ 6 ° C	28 days to analysis	
	TOC	Lloyd Kahn/CA-741	2-oz wide-mouth jar	0.5 g	Cool to ≤ 6 ° C	28 days to analysis	
	Grain Size	ASTM D 422-63 BR-GT-006(A)	8-oz wide mouth jar	500 g	NA	NA	
AVS/SEM	821_R-91-100/CA-738	2-oz wide-mouth jar	10 g	Protected from oxygen, Cool to ≤ 6 °C	14 days to analysis		

Notes:

¹ Refer to **Worksheet #18** for details regarding analytical groups to be tested for each media.

² Holdtime is from the time of sample collection, not the time of sample receipt.

SAP Worksheet #20—Field Quality Control Sample Summary Table

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSDs	No. of Equip. Blanks	No. of Trip Blanks	Total No. of Samples to Lab ¹
Groundwater ³	VOCs	14 to 16	2	1/1	5	5	28 to 30
	SVOCs	14 to 16	2	1/1	5	-	23 to 25
	Pesticides	14 to 16	2	1/1	5	-	23 to 25
	PCBs	14 to 16	2	1/1	5	-	23 to 25
	Total Metals	14 to 16	2	1/1	5	-	23 to 25
	Dissolved Metals	14 to 16	2	1/1	5	-	23 to 25
	Cyanide	14 to 16	2	1/1	5	-	23 to 25
Surface Soil	VOCs	31	4	2/2	5	5	49
	SVOCs	31	4	2/2	5	-	44
	Pesticides	31	4	2/2	5	-	44
	PCBs	31	4	2/2	5	-	44
	Total Metals	31	4	2/2	5	-	44
	Cyanide	31	4	2/2	5	-	44
	pH	31	-	-	-	-	31
	TOC	31	-	-	-	-	31
Subsurface Soil	VOCs	36	4	2/2	5	5	54
	SVOCs	36	4	2/2	5	-	49
	Pesticides	36	4	2/2	5	-	49
	PCBs	36	4	2/2	5	-	49
	Total Metals	36	4	2/2	5	-	49
	Cyanide	36	4	2/2	5	-	49
	pH	36	-	-	-	-	36
	TOC	36	-	-	-	-	36

SAP Worksheet #20—Field Quality Control Sample Summary Table (continued)

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/ MSDs	No. of Equip. Blanks	No. of Trip Blanks	Total No. of Samples to Lab ¹
Waste Material	VOCs	Approximately 5	1	1/1	1	1	10
	SVOCs	Approximately 5	1	1/1	1	-	9
	Pesticides	Approximately 5	1	1/1	1	-	9
	PCBs	Approximately 5	1	1/1	1	-	9
	Total Metals	Approximately 5	1	1/1	1	-	9
	Cyanide	Approximately 5	1	1/1	1	-	9
	pH	Approximately 5	-	-	-	-	5
Surface Water ²	TOC	Approximately 5	-	-	-	-	5
	VOCs	Approximately 5	1	1/1	1	1	10
	SVOCs	Approximately 5	1	1/1	1		9
	Pesticides	Approximately 5	1	1/1	1		9
	PCBs	Approximately 5	1	1/1	1		9
	Total Metals	Approximately 5	1	1/1	1		9
	Cyanide	Approximately 5	1	1/1	1		9
Seep ²	Dissolved Metals	Approximately 5	1	1/1	1		9
	Hardness	Approximately 5	-	-	-		5
	VOCs	Approximately 5	1	1/1	1	1	10
	SVOCs	Approximately 5	1	1/1	1		8
	Pesticides	Approximately 5	1	1/1	1		8
	PCBs	Approximately 5	1	1/1	1		8
	Total Metals	Approximately 5	1	1/1	1		8
	Cyanide	Approximately 5	1	1/1	1		8
Seep ²	Dissolved Metals	Approximately 5	1	1/1	1		8
	Hardness	Approximately 5	-	-	-		5

SAP Worksheet #20—Field Quality Control Sample Summary Table (continued)

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSDs	No. of Equip. Blanks	No. of Trip Blanks	Total No. of Samples to Lab ¹
Sediment ²	VOCs	Approximately 5	1	1/1	1	1	10
	SVOCs	Approximately 5	1	1/1	1	-	9
	Pesticides	Approximately 5	1	1/1	1	-	9
	PCBs	Approximately 5	1	1/1	1	-	9
	Total Metals	Approximately 5	1	1/1	1	-	9
	Cyanide	Approximately 5	1	1/1	1	-	9
	Total Organic Compound (TOC)	Approximately 5	-	-	-	-	5
	Grain-size	Approximately 5	-	-	-	-	5
	AVS/SEM	Approximately 5	-	-	-	-	5
pH	Approximately 5	-	-	-	-	5	

Notes:

¹ The number of field QC samples in this table are approximate to be collected is dependent on the number of parent samples and the number of days of the sampling event.

- Field duplicates are collected at a frequency of 1 per 10 field samples per matrix.
- MS/MSD pairs are collected at a frequency of 1 per 20 samples per matrix sent to the laboratory (including duplicates).
- Equipment Blanks for decontaminated equipment are collected once per day of sampling, per type of equipment. Equipment Blanks for disposable equipment are collected once per lot.
- Trip Blanks are collected for each cooler to the laboratory containing VOC samples.
- Field Blanks will not be collected as part of this investigation.

² Several media are optional. Seeps will only be sampled if they are observed at the time of sampling. Surface water and sediment will be sampled for COPCs identified during the groundwater and soil sampling effort or based on historical site information.

³ Thirteen permanent shallow groundwater monitoring wells and one permanent deep groundwater monitoring well will be installed initially. After evaluation of groundwater sampling results from the 14 initially installed wells, additional permanent monitoring wells may be installed and sampled for select compounds identified after the first round of groundwater sampling.

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SAP Worksheet #21—Project Sampling SOP References Table

[\(UFP-QAPP Manual Section 3.1.2\)](#)

Reference	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)
BlankPrep	<i>Equipment Blank and Field Blank Preparation 8/2013</i>	CH2M HILL	Lab grade water, gloves, sample bottles	N
COC	<i>Chain-of-custody, 8/2013</i>	CH2M HILL	Bottle labels, indelible pen, blank COC form, sample cooler, ice, temperature blank, packaging tape, zip-lock bags	N
DeconRig	<i>Decontamination of Drilling Rigs and Equipment, 8/2013</i>	CH2M HILL	Drill rig, water level meter, probes	N
Dispose	<i>Disposal of Waste Fluids and Solids, 8/2013</i>	CH2M HILL	Fluids – 55-gallon drum, tools to secure drum, funnel, labels, marking pen, seals for drum Solids – 55-gallon drum, tools to secure drum, plastic sheets, labels, marking pen	N
DrumSample	<i>Sampling Contents of Tanks and Drums, 8/2013</i>	CH2M HILL	Drum/tank, sampling instrument, gloves, plastic sheets, labels, monitoring instrument	N
LogBooks	<i>Preparing Field Log Books, 8/2012</i>	CH2M HILL	Log book, Indelible pen	N
LowFlow-EPA Reg I&III	<i>Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region I and III, 8 /2013</i>	CH2M HILL	Adjustable-rate positive-displacement pump, submersible pump, or peristaltic pump, Horiba® U-22 or equivalent water quality meter, Flow-through cell with inlet/outlet ports, generator, water-level meter, disposable tubing, disposable filters, sample containers, graduated cylinder, plastic sheeting, log book, shipping supplies	N
GPS	<i>Global Positioning System, 8/2013</i>	CH2M HILL	Trimble® GPS Unit	N
Homog	<i>Homogenization of Soil and Sediment Samples, 8/2013</i>	CH2M HILL	Sample containers, stainless steel spoons or spatulas, and stainless steel pans.	N
MiniRAE	<i>Mini RAE photoionization Detector (PID), 8/2013</i>	CH2M HILL	Operations manual, Minirae 2000, 100 parts per million (ppm) isobutylene as calibration gas, T-type feeder tube with regulator	N
MultiRAE_Plus_RevB1	<i>MultiRAE_Plus_RevB1—User’s Manual, 11/2003</i>	Rae Systems	MultiRae, calibration gas, T-type feeder tube with regulator	N

SAP Worksheet #21—Project Sampling SOP References Table (continued)

Reference	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)
MWInstall	<i>General Guidance for Monitoring Well Installation, 8/2013</i>	CH2M HILL	Drill rig, well construction materials (surface casing, screens, riser, casing, caps, bottom plugs, centering guides, sand, bentonite, grout, and surface finish materials, development equipment.	N
ShipLowConc	<i>Packaging and Shipping Procedures for Low-Concentration Samples, 8/2013</i>	CH2M HILL	Coolers, duct tape, ice, strapping tape, packaging material, Ziploc bags, custody seals, chain of custody	N
SBlog	<i>Logging of Soil Borings, 8/2013</i>	CH2M HILL	Indelible pens, tape measure or ruler, field logbook, spatula, soil color chart, grain size chart, Unified Soil Classification System index charts	N
SedSamp	<i>Sediment Sampling, 8/2013</i>	CH2M HILL	Stainless-steel trowel, stainless steel bowl, sample bottles, gloves	N
Seep	<i>Seep Groundwater Sample Collection, 8/2013</i>	CH2M HILL	Stainless-steel or PVC drive points and drive rods, slide hammer or sledge hammer, peristaltic pump with dedicated sampling tubing or small bailer, sample bottles.	N
Soils	<i>Soil Sampling, 8/2013</i>	CH2M HILL	Stainless-steel trowel, thin-walled sampling tubes, drilling rig, stainless steel bowl, sample bottles	N
SplitSpoon	<i>Soil Boring Sampling-Split Spoon, 8/2013</i>	CH2M HILL	Gloves, stainless steel pan, Log book, stainless steel spoon or disposable plastic scoop, sample bottles, decontamination equipment.	N
SWSamp	<i>Surface Water Sampling, 8/2013</i>	CH2M HILL	Sample containers, gloves	N
TerraCoreUseDirections	<i>Recommended Use of the TerraCore®</i>	En Novative Technologies, Inc.	TerraCore sampler, gloves, indelible pen, Logbook	
Utility Location_General	<i>Locating and Clearing Underground Utilities, 8/2013</i>	CH2M HILL	Subsurface locating instruments, spray paint (provided by utility locating contractor), historical documents, facility as built diagrams	N
VOCAq	<i>VOC Sampling-Water, 8/2013</i>	CH2M HILL	Sample containers, gloves	
WaterLevels	<i>Water-Level Measurements, 8/2013</i>	CH2M HILL	Water level meter	N
WaterQual-Horiba_YSI	<i>Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, ORP, and Temperature Using a Horiba or YSI Water Quality Parameter Meter with Flow-through Cell, 8/2013</i>	CH2M HILL	Horiba water quality meter	N

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

[\(UFP-QAPP Manual Section 3.1.2.4\)](#)

Field Equipment	Activity	Frequency	Acceptance Criteria	CA	Resp. Person	SOP Reference
Horiba U-22	Check mechanical and electronic parts, verify system continuity, check battery, and clean probes. Calibration check.	Daily before use, at the end of the day, and when unstable readings occur.	Stable readings after 3 minutes. pH reads 4.0 ± 3 percent conductivity reads 4.49 ± 3 percent turbidity reads $0 \pm 3\%$	Clean probe with deionized water and calibrate again. Do not use instrument if not able to calibrate properly.	FTL	Water Qual-Horiba-YSI
Miniram Model PDM-3	Zero the Miniram using Z-Gag TM Calibrator that provides a clean-air environment Recharge instrument and the outside of the instrument should be wiped clean with a soft cloth. Other maintenance per operator's manual	Daily, before use and as atmospheric conditions change	A zero value less than 3 ppm	When the zero value exceeds ppm, the sensing chamber may need to be cleaned following the instructions provided in the manufacturer's operating manual	FTL	OVA
Groundwater sampling pumps and tubing	Visual inspection of equipment and materials	During each use	Maintained in good working order per manufacturer's recommendations	Replace items	FTL	LowFlow

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SAP Worksheet #23—Analytical SOP References Table

Lab SOP Number	Title, Revision Date, and Number	Date reviewed if not revised	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Variance to QSM	Modified for Project Work?
CA-202	Analysis of VOAs by Purge and Trap Gas Chromatograph/Mass Spectrometer GC/MS: SW-846 Method 8260, 04/13, Revision 14.		Definitive	Water and Solid/VOCs	Gas Chromatograph (GC)/Mass Spectrometer (MS)	Katahdin Analytical Services	No Variance	No
CA-213	Analysis of SVOCs By: SW 846 Method 8270 – Modified For SIM, 03/13, Revision 11.		Definitive	Water and Solid/PAHs	GC/MS			No
CA-214	Closed-System Purge-And-Trap And Extraction For Volatile Organics In Soil And Waste Samples Using Sw846 Method 5035, 03/12, Revision 6	5/1/2013	Definitive	Solid/VOCs	Purge and Trap			No
CA-226	Analysis of SVOAs by Capillary Column GC/MS: SW-846 Method 8270D, 04/13, Revision 4		Definitive	Water and Solid/SVOCs	GC/MS			No
CA-302	Analysis of Pesticides By Gas Chromatography/Electron Capture Detector (GC/ECD): SW-846 Method 8081, 02/13, Revision 13		Definitive	Water and Solid/PEST	Gas Chromatograph (GC)/Electron Capture Detector (ECD)			Aqueous samples will be prepared with a final volume of 2 ml.
CA-329	Analysis Of PCBs as Total Arochlors By GC/ECD: SW-846 Method 8082, 02/13, Revision 13		Definitive	Water and Solid/PCB	GC/ECD			Aqueous samples will be prepared with a final volume of 2 ml.
CA-500	Preparation Of Sediment/Soil Samples By Sonication Using Method 3550 For Subsequent Pesticides/PCBs Analysis, 03/12, Revision 8	3/1/2013	Definitive	Sediment/PEST/PCB	Sonication			No
CA-502	Preparation Of Aqueous Samples For Extractable Semivolatile Analysis, 05/13, Revision 8.		Definitive	Water/SVOCs and PAHs	Separatory Funnel/Continuous Liquid-Liquid Extraction (CLLE)			No
CA-512	Preparation Of Sediment/Soil Samples By Sonication Using Method 3550 For Subsequent Extractable Semi-Volatiles Analysis, 04/12, Revision 9.	03/2013	Definitive	Solid/SVOCs and PAHs	Sonication			No
CA-515	Preparation of Aqueous Samples for Pesticides/PCBs Analysis, 05/13, Revision 9.		Definitive	Water/PEST	Separatory Funnel/CLLE			Aqueous samples will be prepared with a final volume of 2 ml.
CA-526	Preparation Of Sediment/Soil Samples By Soxhlet Extraction Using Method 3540 For Subsequent Extractable Semivolatile Analysis, 04/12, Revision 8.	03/2013	Definitive	Solid/SVOCs and PAHs	Sonication			No
CA-549	Preparation of Sediment/Soil Samples by Microwave Using Method 3546 for Subsequent Diesel Range Organics (DRO), Total Petroleum Hydrocarbons (TPH), Pesticides, PCBs, or Semi-Volatiles Analysis, 03/12, Revision 0	4/1/2013	Definitive	Solid/ PEST/PCB	Microwave			No
CA-604	Acid Digestion of Aqueous Samples by USEPA Method 3010 for Inductively Coupled Plasma (ICP) Analysis of Total or Dissolved Metals, 04/10, Revision 5.	2/1/2013	Definitive	Water/TAL Metals	Hot-block			No
CA-605	Acid Digestion of Solid Samples by USEPA Method 3050 for Metals by ICP-Atomic Emission Spectrometer (AES) and Graphite Furnace Atomic Absorption (GFAA), 09/10, Revision 5.	2/1/2013	Definitive	Solid/TAL Metals	Hot-block			No
CA-608	Trace Metals Analysis By ICP-AES Using USEPA Method 6010, 05/13, Revision 14.		Definitive	Water and Solid/TAL Metals	Inductively-coupled Plasma (ICP)-AES			No
CA-611	Digestion and Analysis of Solid Samples for Mercury by USEPA Method 7471, 04/12, Revision 9.	02/2013	Definitive	Solid/Mercury	Mercury Analyzer			No
CA-615	Digestion and Analysis of Aqueous Samples for Mercury by USEPA Method 7470, 04/12, Revision 7.	02/2013	Definitive	Water/Mercury	Mercury Analyzer			No
CA-707	Titrimetric Determination of Total Hardness by Addition of EDTA using EPA Method 130.2 and SM 2340C, 05/12, Revision 7.	02/2013	Screening	Water/Hardness	Titration	No		
CA-709	pH Concentration Measurements In Soil Matrices – SW 846 Method 9045, 05/12, Revision 9.	02/2013	Screening	Solid/pH	pH Meter	No		

SAP Worksheet #23—Katahdin Labs Analytical SOP References Table (continued)

Lab SOP Number	Title, Revision Date, and Number	Date reviewed if not revised	Definitive or Screening Data	Matrix and Analytical Group	Instrument		Variance to QSM	Modified for Project Work?
CA-738	Determination of Acid Volatile Sulfide and Simultaneously Extractable Metals in Sediments, 05/12, Revision 3.		Screening	Sediments/Acid Volatile Sulfide and Simultaneously Extractable Metals	Spectrophotometer – AVS ICP-SEM	Katahdin Analytical Services	No Variance	No
CA-741	Determination of Total Organic Carbon in Solids Using the EPA Region II Lloyd Kahn Method, 02/13, Revision 5.		Screening	Water/Total Organic Carbon	TOC Analyzer			No
CA-773	Colorimetric Analysis Of Total And Ammenable Cyanide Using The Automated Konelab Multiwavelength Photometric Analyzer, 07/11, Revision 5.	3/1/2012	Definitive	Water and Solid/Cyanide	Konelab			No
BR-GT-006	<i>Particle Size Analysis (ASTM D 2217 and D422-63)</i> <i>SOP No. BR-GT-006, Rev 6, 03/17/10</i>		Screening	Solid/Sediments Geotechnical	NA	TestAmerica- Burlington	No Variance	N

Notes:
 DoD Environmental Laboratory Accreditation Program (ELAP) certification is required for all definitive data. Katahdin's DoD ELAP certification expires February 2016 (Appendix B).

SAP Worksheet #24—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference ¹
GC/MS (VOCs)	Initial Calibration (ICAL) - Six-points	Instrument receipt, instrument change (new column, source cleaning, and so forth), when continuing calibration verification (CCV) is out of criteria.	The average response factors (RFs) for system performance check compounds (SPCCs) must be ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachlorobenzene and ≥ 0.10 for chloromethane, 1,1-DCA and bromoform. The Percent Relative Standard Deviation (%RSD) for RFs for Calibration check compounds (CCCs) must be $\leq 30\%$, and one option below must be met: Option 1: %RSD $< 15\%$ for all other compounds; Option 2: Linear least squares regression: correlation coefficient (r) ≥ 0.995 ; Option 3: Non-linear regression: coefficient of determination (r^2) ≥ 0.99 (6 points for second order).	Repeat calibration if criterion is not met	Analyst, Supervisor	CA-202
	Initial Calibration Verification (ICV)	Once after each ICAL.	The Percent Recovery (%R) must be within 80-120% for all target compounds.	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.		
	Calibration Verification (CV)	At the beginning of each 12 hour shift immediately after 4-bromofluorobenzene (BFB) tune.	CCCs < 20 percent difference (%D); SPCCs (chloromethane, bromoform, 1,1-DCA) Response Factor (RF) ≥ 0.10 & (chlorobenzene and 1,1,2,2-tetrachloroethane) ≥ 0.30 .	Repeat ICAL and reanalyze all samples analyzed since the last successful CV		
	BFB Tune	Every 12 hours	Criteria listed in section 7.3 current revision of SOP CA-202.	Retune and/or clean source		
GC/MS (SVOCs)	ICAL - 6 point curve	Instrument receipt, instrument change (new column, source cleaning, and so forth), when CCV is out of criteria.	The average RF for SPCCs must be > 0.050 ; The %RSD for RFs for CCCs must be $\leq 30\%$, and one option below must be met: Option 1: %RSD $\leq 15\%$ for each analyte Option 2: Linear least squares regression: $r \geq 0.995$ Option 3: Non-linear regression: $r^2 \geq 0.99$ (6 points for second order).	Repeat calibration if criterion is not met.	Analyst, Supervisor	CA-213
	ICV	Once after each ICAL.	The %R must be within 80-120% of true value for all target compounds.	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.		
	CCV	At the beginning of each 12 hour shift immediately after decafluorotriphenylphosphine (DFTPP) tune.	CCCs $\leq 20\%D$; SPCCs RF ≥ 0.050	Repeat ICAL and reanalyze all samples analyzed since the last successful CV.		
	DFTPP Tune	Every 12 hours	Criteria listed in section 7.4 current revision of SOP CA-204.	Retune and/or clean source.		
ICP-AES	ICAL - one standard and one calibration blank	At the beginning of each day or if QC is out of criteria.	If more than one calibration standard is used, $R \geq 0.995$.	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards.	Analyst, Supervisor	CA-608
	ICV	Once after each ICAL, prior to beginning a sample run.	Recovery must be within 90-110% of true value for all analytes.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct the problem and repeat ICAL.		
	CCV	At the beginning and end of each run sequence and every 10 samples	Recovery must be within 90-110% of the true value for all analytes.	Check problem, recalibrate and reanalyze any samples not bracketed by passing CCVs.		
	Low-level Calibration Check Standard	Daily, after one-point ICAL	Recovery must be within 80-120% of the true value for all analytes.	Correct problem, then reanalyze.		
	Interference Check Solutions (ICS)	At the beginning of an analytical run.	ICS-A: Absolute value of concentration for all non-spiked analytes $< LOD$ (unless they are a verified trace impurity from one of the spike analytes) ICS-AB: Within $\pm 20\%$ of true value.	Terminate analysis; locate and correct problem; reanalyze ICS; reanalyze all samples.		

SAP Worksheet #24—Analytical Instrument Calibration Table (continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference ¹
Cold Vapor Atomic Absorption (CVAA) (Mercury)	ICAL - 5 standards and a calibration blank	Instrument receipt, major instrument change, at the start of each day	$R \geq 0.995$.	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards.	Analyst, Supervisor	CA-611, CA-615
	ICV	Once after each ICAL, prior to beginning a sample run.	The %R must be within 90-110% of true value for mercury.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL.		
	CCV	At beginning and end of each run sequence and every 10 samples.	80-120% of True Value.	Check problem, recalibrate and reanalyze any samples not bracketed by passing CCVs.		
Cyanide Analyzer	ICAL - Minimum of a 5-point calibration curve plus a blank is prepared.	Daily ICAL prior to sample analysis.	r must be ≥ 0.995 .	Correct problem, then repeat ICAL.	Analyst, Department Manager	CA-773
	ICV	Once after each ICAL, prior to beginning a sample run.	%R must be within 85-115%.	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.		
	CCV	CCV (undistilled)	One after every 10 samples analyzed and at close of run	90%-110 % %R.		
GC/ECD (PESTs)	ICAL	Instrument receipt, major instrument change, when CV does not meet criteria.	One of the options below must be met: Option 1: Relative standard deviation (RSD) for each analyte $\leq 20\%$ Option 2: linear least squares regression: $r \geq 0.995$ Option 3: Non-linear regression: $r^2 \geq 0.99$ (6 points will be used for second order)	Repeat ICAL and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst, Supervisor	CA-329
	ICV	Once after each ICAL.	The %D must be $\leq 20\%D$ for all project analytes.	Correct problem, rerun ICV. If that fails, repeat ICAL.		
	CCV	After every 10 samples; If calibration curve previously analyzed, analyze daily before samples.	%D ≤ 20 for both the quantitation and confirmation columns.	Evaluate the samples: If the %D $\geq 15\%$ and sample results are $<$ practical quantitation limit (PQL), narrate. If %D $\geq 15\%$ only on one channel, narrate. If %D $\geq 15\%$ for closing CCV, and is likely a result of matrix interference, narrate. Otherwise, reanalyze all samples back to last acceptable CCV.		
	Breakdown Check for Endrin and DDT	At the beginning of each 12-hour period, prior to sample analysis.	Degradation $\leq 15\%$ for both Endrin and DDT.	Correct the problem and repeat the breakdown check.		
GC/ECD (PCBs)	ICAL - 6 point calibration of Aroclors 1016, 1260, 1242, 1248, and 1254	Instrument receipt, major instrument change, when CV does not meet criteria.	One of the options below must be met: Option 1: RSD for each analyte $\leq 20\%$ Option 2: Linear least squares regression: $r \geq 0.995$ Option 3: Non-linear regression: $r^2 \geq 0.99$ (6 points will be used for second order) Mid-point calibration of Aroclors 1221 and 1232; if targets are detected, 6-point calibration is performed.	Repeat ICAL and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data. If an Aroclor that is only single-point calibrated is identified in analysis of sample, then instrument will be calibrated for that analyte and the sample reanalyzed.	Analyst, Supervisor	CA-329
	ICV	Once after each ICAL.	The %D must be $\leq 20\%D$ for all project analytes.	Correct problem, rerun ICV. If that fails, repeat ICAL.		
	CCV	After every 10 samples; If calibration curve previously analyzed, analyze daily before samples.	%D ≤ 20 for both the quantitation and confirmation columns.	Evaluate the samples: If the %D $\geq 15\%$ and sample results are $<$ PQL, narrate. If %D $\geq 15\%$ only on one channel, narrate. If %D $\geq 15\%$ for closing CCV, and is likely a result of matrix interference, narrate. Otherwise, reanalyze all samples back to last acceptable CCV.		

SAP Worksheet #24—Analytical Instrument Calibration Table (continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference ¹
Total Organic Carbon Analyzer/ Total Organic Carbon	ICAL – Minimum of a 5-point calibration curve plus a blank is prepared.	Prior to sample analysis	Correlation coefficient (r) must be ≥ 0.995 .	Investigate source of problem, recalibrate.	Analyst, Department Manager	CA741
	ICV	Once after each ICAL prior to sample analysis.	Recovery within 80-120% of the true value.	Investigate source of problem. If the LCS recovery is high but the sample results are <PQL, narrate. Otherwise, reprep a blank and the remaining samples.		
	CCV	CCV at the beginning of the analysis and one after every 10 samples	Recovery within 80-120% of the true value.	Investigate source of problem. If the LCS recovery is high but the sample results are <PQL, narrate. Otherwise, reanalyze all samples back to last acceptable CCV recovery.		
Spectrophotometer/ AVS	ICAL – Minimum of a 5-point calibration curve plus a blank is prepared.	Prior to sample analysis	Correlation coefficient (r) must be ≥ 0.995 .	Investigate source of problem, recalibrate.	Analyst, Department Manager	CA-738
	ICV	Once after each ICAL prior to sample analysis.	Recovery within 80-120% of the true value.	Investigate source of problem. If the LCS recovery is high but the sample results are <PQL, narrate. Otherwise, reprep a blank and the remaining samples.		
	CCV	CCV at the beginning of the analysis and one after every 10 samples	Recovery within 80-120% of the true value.	Investigate source of problem. If the LCS recovery is high but the sample results are <PQL, narrate. Otherwise, reanalyze all samples back to last acceptable CCV recovery.		
Probe/pH	2-point calibration with pH buffers with a midrange cal. check	Once per day	± 0.05 pH units for every buffer	If calibration is not achieved, check meter, buffer solutions, and probe; replace if necessary; repeat calibration	Analyst, Department Manager	CA-708
	ICV	One per batch of twenty or fewer samples	Recovery within 90-110% of the true value.	Correct problem, recalibrate		

Notes:

¹ Refer to Worksheet #23 for a complete reference to relevant analytical SOPs.

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

Instrument/Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	CA	Responsible Person	SOP Reference
GC/MS (VOCs)	Check pressure and gas supply daily. Bake out trap and column, manual tune if BFB not in criteria, change septa as needed, cut column as needed, change trap as needed. Other maintenance specified in lab Equipment Maintenance SOP.	QC standards	Ion source, injector liner, column, column flow, purge lines, purge flow, trap	Prior to ICAL and/or as necessary.	Acceptable Tune	Correct the problem and repeat tune check	Analyst	VGCMS-05
GC/MS (SVOCs)	Check pressure and gas supply daily. Manual tune if DFTPP not in criteria, change septa as needed, change liner as needed, cut column as needed. Other maintenance specified in lab Equipment Maintenance SOP.	QC standards	Ion source, injector liner, column, column flow	Prior to ICAL and/or as necessary	Acceptable Tune	Correct the problem and repeat tune check	Analyst, Supervisor	CA-213
ICP-AES (METALS)	Clean torch assembly and spray chamber when discolored or when degradation in data quality is observed. Clean nebulizer, check argon, and replace peristaltic pump tubing as needed. Other maintenance specified in lab Equipment Maintenance SOP.	QC standards	Torch, nebulizer chamber, pump, pump tubing	Prior to ICAL and as necessary	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Supervisor	CA-608
Mercury Analyzer	Replace peristaltic pump tubing, replace mercury lamp, replace drying tube, clean optical cell and/or clean liquid/gas separator as needed. Other maintenance specified in lab Equipment Maintenance SOP.	QC standards	Tubing, sample probe, optical cell	Prior to ICAL and as necessary	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Supervisor	CA-611, CA-615
Konelab (Cyanide)	Check and clean segments weekly, clean reagent tubes monthly. Change lamp, change diluent and wash tubes, change mixing paddles and syringes, change dispensing needle, all as needed.	Cyanide, Ammonia, ortho-Phosphorus	Reagent tubes, lamp, wash tubes, paddles, syringes, dispensing needles.	Prior to ICAL and/or as necessary.	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Department Manager	CA-773
GC/ECD (Pest/PCBs)	Check pressure and gas supply daily. Change septa and/or liner as needed, replace or cut column as needed. Other maintenance specified in lab Equipment Maintenance SOP.	QC standards	Injector liner, septa, column, column flow.	Prior to ICAL and/or as necessary.	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Supervisor	CA-302 and CA-329
TOC Combustion Analyzer	Check level of dilution water, drain vessel water, humidifier water, auto sampler rinse water and phosphoric acid vessel and fill as needed. Replace oxygen cylinder.	Total Organic Carbon	Tubing, sample boat, syringe, humidifier, rinse reservoir, phosphoric acid vessel, oxygen pressure	Prior to initial calibration and as necessary	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Department Manager	CA-741
Spectrophoto-meter	Clear cuvettes and lense as necessary. Outside calibration annually.	Acid Volatile Sulfide	Cuvettes, cuvette holder, lenses	As necessary	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Department Manager	CA-738
Buret - Hardness	N/A	Hardness	Visual inspection for cracks or chips	Each use	N/A	Remove from service	Analyst, Department Manager	CA-707
Probe - Ion-Selective Electrode, pH, Conductivity	Clean, drain, and refill reference electrode as needed.	Fluoride, pH, Conductivity	Reference electrode for white crystals, Inspect electrode for damage.	Before use	pH 7 ± 0.05 pH units (pH)	Correct problem and repeat calibration.	Analyst, Department Manager	CA-709

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SAP Worksheet #26—Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): Field Team/CH2M HILL Sample Packaging (Personnel/Organization): FTL/CH2M HILL Coordination of Shipment (Personnel/Organization): FTL/CH2M HILL Type of Shipment/Carrier: Overnight Carrier/FedEx
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Logins/Katahdin Labs and TestAmerica-Burlington ¹ Sample Custody and Storage (Personnel/Organization): Logins/Katahdin Labs and TestAmerica-Burlington Sample Preparation (Personnel/Organization): Inorganic Prep and Organic Prep/Katahdin Labs and TestAmerica-Burlington Sample Determinative Analysis (Personnel/Organization): Analysts/Katahdin Labs and TestAmerica-Burlington
SAMPLE ARCHIVING
Field Sample Storage (Number of days from sample collection): 45 Sample Extract/Digestate Storage (Number of days from extraction/digestion): 45
SAMPLE DISPOSAL
Personnel/Organization: Sample Custody Personnel/Katahdin Labs and Test-America Burlington Number of Days from Analysis: 45

¹ All samples will be received by Katahdin Labs, which will send grain-size samples to TestAmerica-Burlington for analysis. CH2M HILL will not ship grains-size samples directly to TestAmerica-Burlington.

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SAP Worksheet #27—Sample Custody Requirements Table

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

Samples will be collected by field team members under the supervision of the FTL. As samples are collected, they will be placed into containers and labeled. Labels will be taped to the containers to ensure they do not separate. Samples will be cushioned with packaging material and placed into coolers containing enough ice to keep the samples <6°C until they are received by the laboratory.

The chain of custody will be placed into the cooler in a Ziploc bag. Coolers will be taped up and shipped to the laboratories via Fed Ex overnight, with the air bill number indicated on the chain of custody (to relinquish custody). Upon delivery, the laboratory will log in each cooler and report the status of the samples to CH2M HILL.

See Worksheet #21 for SOPs containing sample custody guidance. A blank chain of custody is included in this worksheet.

All samples will be shipped to Katahdin, including samples for grain-size analysis.

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

Laboratory custody procedures can be found in the laboratory SOPs, which are referenced in Worksheet #23. Laboratory SOPs will be provided upon request.

Sample ID Procedures:

Sample labels will include, at a minimum, client name, site, sample ID, date/time collected, analysis group or method, preservation, and sampler's initials. The field logbook will identify the sample ID with the location and time collected and the parameters requested. The laboratory will assign each field sample a laboratory sample ID based on information in the chain of custody and Worksheet #18. The laboratory will send sample log-in forms to the PC to check that sample IDs and parameters are correct.

Chain of Custody Procedures:

Chains of custody will include, at a minimum, laboratory contact information, client contact information, sample information, and relinquished by/received by information. Sample information will include sample ID, date/time collected, number and type of containers, preservative information, analysis method, and comments. The chain of custody will link location of the sample from the field logbook to the laboratory receipt of the sample. The laboratory will use the sample information to populate the Laboratory Information Management Systems (LIMS) database for each sample.

SAP Worksheet #28-1—Laboratory QC Samples Table – VOCs in Groundwater, Surface Water or Seeps

Matrix: Groundwater, Surface Water, Seeps

Analytical Group: VOCs

Analytical Method/SOP Reference: SW-846 8260B/CA-202

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method blank	One per preparatory batch.	No analytes detected > 1/2 reporting limit (RL) and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL.	Correct problem, reanalyze samples. If acceptance criteria still not met, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst, Supervisor	Accuracy/Bias, Contamination	Same as Method/SOP QC Acceptance Limits.
LCS	One per preparatory batch.	Refer to Worksheet #15. In-house limits are provided when DoD QSM v. 4.2 does not specify.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. Refer to Appendix G of DoD QSM v. 4.2. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst, Supervisor	Accuracy/Bias	
MS	One per preparatory batch per matrix.	Same as LCS.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.	Analyst, Supervisor	Accuracy/Bias	
MSD	One per preparatory batch per matrix.	Same as MS and refer to Worksheet #15.	Same as MS.	Analyst, Supervisor	Accuracy/Bias, Precision	
Internal Standards (ISs)	Every field sample, standard, and QC sample.	Retention time ±30 seconds from retention time of the midpoint standard in the ICAL; extracted ion current profile (EICP) area within -50% to +100% of ICAL midpoint standard.	Inspect GC/MS for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst, Supervisor	Accuracy	
Surrogates	4 Per Sample	1,2-DCA-d4: 70-120%R BFB: 75-120%R Dibromofluoromethane: 85-115%R Toluene-d8: 85-120%R	For field and QC sample, correct problem then re-prepare and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst, Supervisor	Accuracy/Bias	

Notes:

The specifications in this table meet the requirements of DoD QSM 4.2.

SAP Worksheet #28-2—Laboratory QC Samples Table – SVOCs in Groundwater, Surface Water or Seeps

Matrix: Groundwater, Surface Water, Seep

Analytical Group: SVOCs, except PAHs

Analytical Method/SOP Reference: SW-846 8270C/CA-213

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparatory batch.	No analytes detected > 1/2 RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL.	Correct problem, reanalyze samples. If acceptance criteria still not met, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst, Supervisor	Accuracy/Bias, Contamination	Same as SOP QC Acceptance Limits.
LCS		Refer to Worksheet #15. In-house limits are provided when DoD QSM v. 4.2 does not specify.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias	
MS		Same as LCS.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.		Accuracy/Bias	
MSD		Same as MS and refer to Worksheet #15.	Same as MS.		Accuracy/Bias, Precision	
ISs	Every field sample, standard, and QC sample.	Retention time ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect GC/MS for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.		Accuracy	
Surrogates	5 per sample	2-Fluorobiphenyl: 50-110% Terphenyl-D ₁₄ : 50-135% 2,4,6-Tribromophenol: 40-125% 2-Fluorophenol: 35-105% Phenol-d ₅ /d ₆ : 20-110% NB-d ₅ : 40-110%	For field and QC sample, correct problem then re-prepare and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.		Accuracy/Bias	

Notes:

The specifications in this table meet the requirements of DoD QSM 4.2.

SAP Worksheet #28-3—Laboratory QC Samples Table – PAHs in Groundwater, Surface Water or Seeps

Matrix: Groundwater, Surface Water, Seep

Analytical Group: PAHs

Analytical Method/SOP Reference: SW-846 8270C SIM and SW-846 8270C SIM low level/CA-213

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparatory batch.	No analytes detected > 1/2 RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL.	Correct problem, reanalyze samples. If acceptance criteria still not met, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst, Supervisor	Accuracy/Bias, Contamination	Same as SOP QC Acceptance Limits.
LCS		Refer to Worksheet #15. In-house limits are provided when DoD QSM v. 4.2 does not specify.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias	
MS		Same as LCS.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.		Accuracy/Bias	
MSD		Same as MS and ≤30% for RPD between MS and MSD.	Same as MS.		Accuracy/Bias, Precision	
Internal Standard (IS) Verification		Every field sample, standard, and QC sample.	Retention time ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.		Inspect GC/MS for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	
Surrogates	3 per sample for SW-846 8270D SIM	2-Methylnaphthalene-d ₁₀ : 43-92%R Fluorene-d ₁₀ : 29-101%R Pyrene-d ₁₀ : 53-166%R	For field and QC sample, correct problem then re-prepare and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Accuracy/Bias		

SAP Worksheet #28-4—Laboratory QC Samples Table – Pesticides in Groundwater, Surface Water and Seeps

Matrix: Groundwater, Surface Water, Seeps

Analytical Group: Pesticides

Analytical Method/SOP Reference: SW-846 8081B/CA-302

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparatory batch.	No analytes detected > 1/2 RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	Correct problem, then reanalyze samples. If acceptance criteria are still not met, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst	Accuracy/Bias, Contamination	Same as SOP QC Acceptance Limits.
LCS		Refer to Worksheet #15. Limits are as per DoD QSM v. 4.2.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias	
MS		Same as LCS.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.		Accuracy/Bias	
MSD		Same as MS and refer to Worksheet #15.	Same as MS.		Accuracy/Bias, Precision	
Surrogates	2 Per Sample	Tetrachloro-m-xylene (TCMX): 25-140% Decahlorobiphenyl: 30-135%	For field and QC sample, correct problem then re-prepare and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.		Accuracy/Bias	
Confirmation of positive results (second column or second detector)	All positive results must be confirmed.	Calibration and QC criteria are the same as for initial or primary column analysis. Results between primary and second column RPD ≤ 40%.	N/A.		Accuracy	

Notes:

The specifications in this table meet the requirements of DoD QSM 4.2.

SAP Worksheet #28-5—Laboratory QC Samples Table – PCBs in Groundwater, Surface Water or Seeps

Matrix: Groundwater, Surface Water, Seeps

Analytical Group: PCBs

Analytical Method/SOP Reference: SW-846 8082A/CA-329

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparatory batch.	No analytes detected > 1/2 RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	Correct problem, then reanalyze samples. If acceptance criteria are still not met, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst	Accuracy/Bias, Contamination	Same as SOP QC Acceptance Limits.
LCS		Refer to Worksheet #15. Limits are as per DoD QSM v. 4.2. In-house laboratory limits are provided when DoD QSM v. 4.2 does not specify.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias	
MS		Same as LCS.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.		Accuracy/Bias	
MSD		Same as MS and refer to Worksheet #15.	Same as MS.		Accuracy/Bias, Precision	
Surrogates ¹	2 Per Sample	<i>TCMX: 62-111%</i> Decahlorobiphenyl: 40-135%	For field and QC sample, correct problem then re-prepare and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.		Accuracy/Bias	
Confirmation of positive results (second column or second detector)	All positive results must be confirmed.	Calibration and QC criteria are the same as for initial or primary column analysis. Results between primary and second column RPD ≤ 40%.	N/A.		Accuracy	

Notes:

¹ Italicized limits are laboratory in-house limits; DoD QSM v. 4.2 does not specify limits for this surrogate.

SAP Worksheet #28-6—Laboratory QC Samples Table – Metals in Groundwater, Surface Water or Seeps

Matrix: Groundwater, Surface Water, Seep

Analytical Group: Total and Dissolved Metals (except mercury and cyanide)

Analytical Method/SOP Reference: SW-846 6010C/CA-608

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Calibration Blank	Before beginning a sample run, after every 10 samples, and at the end of the analysis sequence.	No analytes detected > LOQ.	Correct problem. Re-prepare and reanalyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed.	Analyst, Supervisor	Accuracy/Bias, Contamination	Same as Method/SOP QC Acceptance Limits.
Method Blank	One per preparatory batch.	No analytes detected > 1/2 LOQ and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > LOQ.	Correct problem, then reanalyze samples. If acceptance criteria still not met, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias, Contamination	
LCS		Refer to Worksheet #15. Limits are as per DoD QSM v. 4.2.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias	
MS		Same as LCS.	Examine the project-specific DQOs. If the MS falls outside of DoD criteria, additional QC tests are required to evaluate matrix effects.		Accuracy/Bias	
MSD		Same as MS and refer to Worksheet #15.	Same as MS.		Accuracy/Bias, Precision	
Serial Dilution	One per preparatory batch.	Five-fold dilution must agree within ±10% of the original measurement. Only applicable for samples with concentrations > 50X LOQ.	Perform post-digestion spike (PDS) addition.		Accuracy	
PDS	When dilution test fails or analyte concentration in all samples < 50X LOD.	Recovery within 75-125%	Run all associated samples in the preparatory batch by method of standard additions (MSA). Or, for the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met.		Accuracy	

Notes:

The specifications in this table meet the requirements of DoD QSM 4.2.

SAP Worksheet #28-7—Laboratory QC Samples Table – Mercury in Groundwater, Surface Water or Seeps

Matrix: Groundwater, Surface Water, Seep

Analytical Group: Total and Dissolved Metals (Mercury)

Analytical Method/SOP Reference: SW-846 7470A/CA-615

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Calibration Blank	Before beginning a sample run, after every 10 samples, and at the end of the analysis sequence.	No analytes detected > LOQ.	Correct problem. Re-prepare and reanalyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed.		Accuracy/Bias, Contamination	
Method Blank	One per preparatory batch.	No analytes detected > 1/2 LOQ and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > LOQ.	Correct problem, then reanalyze samples. If acceptance criteria still not met, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst, Supervisor	Accuracy/Bias, Contamination	Same as Method/SOP QC Acceptance Limits.
LCS	One per preparatory batch.	Refer to Worksheet #15. Limits are as per DoD QSM v. 4.2.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias	
MS	One per preparatory batch per matrix.	Same as LCS.	Examine the project-specific DQOs. If the MS falls outside of DoD criteria, additional QC tests are required to evaluate matrix effects.		Accuracy/Bias	
MSD	One per preparatory batch per matrix.	Same as MS and refer to Worksheet #15.	Same as MS.		Accuracy/Bias, Precision	

Notes:

The specifications in this table meet the requirements of DoD QSM 4.2.

SAP Worksheet #28-8—Laboratory QC Samples Table – Cyanide in Groundwater, Surface Water or Seeps

Matrix: Groundwater, Surface Water, Seeps

Analytical Group: Metals (Cyanide)

Analytical Method/SOP Reference: SW-846 9012B/CA-773

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per digestion batch of 20 or fewer samples of similar matrix.	No target analyte > ½ LOQ and > 1/10 the amount measured in any sample or 1/10 the PAL, whichever is greater. For negative blanks, absolute value must be < LOD.	Correct the problem. Report sample results that are <LOD or >10x the blank concentration. Re-prepare and reanalyze the method blank and all associated samples with results > LOD and < 10x the contaminated blank result.	Analyst, Laboratory Department Manager and Data Validator	Bias/contamination	Same as Method/SOP QC Acceptance Limits.
LCS	One per digestion batch of 20 or fewer samples of similar matrix (varies by lot).	%R must be within 88-115%.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch, if sufficient sample material is available	Analyst, Laboratory Department Manager and Data Validator	Accuracy/Bias/Contamination	
MS	One per sample delivery group (SDG) or every 20 samples.	%R should be within 85-115% if sample < 4x spike added.	If the MS falls outside of criteria, the MSA (post-digestion) will be used for the analysis.	Analyst, Laboratory Department Manager and Data Validator	Accuracy/Bias	
Laboratory Duplicate	One per 10 samples	Project-specific criteria: If values are ≥ 5x LOQ, RPD should be ≤ 20%. If values are < 5x LOQ, Absolute Difference should be ≤ LOQ.	(1) Investigate and correct problem and reanalyze sample in duplicate. (2) If RPD still >20, report original result with flagging and narration.	Analyst, Laboratory Department Manager and Data Validator	Precision	

Notes:

The specifications in this table meet the requirements of DoD QSM 4.2.

SAP Worksheet #28-9—Laboratory QC Samples Table

Matrix: Surface Water, Seeps

Analytical Group: Wet Chemistry (Hardness)

Analytical Method/SOP Reference: EPA 130.2/CA-707

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	One per analytical batch of 20 or fewer samples.	No target analytes > LOQ and > 1/10 the amount measured in any sample or 1/10 the PIL, whichever is greater.	Correct the problem. Report sample results that are <LOD or >10x the blank concentration. Re-prepare and reanalyze the method blank and all associated samples with results > LOD and < 10x the contaminated blank result.	Analyst, Laboratory Department Manager	Bias/contamination	Same as Method/SOP QC Acceptance Limits.
LCS ¹	One per analytical batch of 20 or fewer samples.	Recovery within 80-120% of the true value.	(1) Investigate source of problem. (2) If the LCS recovery is high but the sample results are <PQL, narrate. Otherwise, reprep a blank and the remaining samples.		Accuracy/Bias/Contamination	
MS ²	One for every set 10 samples	Recovery within 75-125% of the true value.	(1) Evaluate the samples and associated QC: i.e. If the LCS results are acceptable, narrate. (2) If both the LCS and MS are unacceptable reprep and reanalyze the samples and QC. (3) Notate sample result in raw data if matrix interference suspected.		Accuracy/Bias	

Notes:

¹. Refer to Worksheet #15 for LCS QC acceptance limits

². MS/MSD QC acceptance limits are the same as LCS acceptance limits

SAP Worksheet #28-10—Laboratory QC Samples Table – VOCs in Soil or Sediment Matrix: Surface Soil, Subsurface Soil, Sediment

Analytical Group: VOCs

Analytical Method/SOP Reference: SW-846 8260B/CA-202

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparatory batch.	No analytes detected > 1/2 RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL.	Correct problem, reanalyze samples. If acceptance criteria still not met, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst, Supervisor	Accuracy/Bias, Contamination	Same as Method/SOP QC Acceptance Limits.
LCS	One per preparatory batch.	Refer to Worksheet #15. In-house limits are provided when DoD QSM v. 4.2 does not specify.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. Refer to Appendix G of DoD QSM v. 4.2. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst, Supervisor	Accuracy/Bias	
MS	One per preparatory batch per matrix.	Same as LCS.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.	Analyst, Supervisor	Accuracy/Bias	
MSD	One per preparatory batch per matrix.	Same as MS and 30% RPD between MS and MSD.	Same as MS.	Analyst, Supervisor	Accuracy/Bias, Precision	
IS Verification	Every field sample, standard, and QC sample.	Retention time ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect GC/MS for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst, Supervisor	Accuracy	
Surrogates	4 per sample	1,2-DCA-d4: 70-120%R BFB: 75-120%R Dibromofluoromethane: 85-115%R Toluene-d8: 85-120%R	For field and QC sample, correct problem then re-prepare and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst, Supervisor	Accuracy/Bias	

SAP Worksheet #28-11—Laboratory QC Samples Table – SVOCs in Soil or Sediment

Matrix: Surface Soil, Subsurface Soil, Sediment

Analytical Group: SVOCs (except PAHs)

Analytical Method/SOP Reference: SW-846 8270C/CA-213

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparatory batch.	No analytes detected > 1/2 RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL.	Correct problem, reanalyze samples. If acceptance criteria still not met, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst, Supervisor	Accuracy/Bias, Contamination	Same as SOP QC Acceptance Limits.
LCS		Refer to Worksheet #15. In-house limits are provided when DoD QSM v. 4.2 does not specify.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias	
MS		Same as LCS.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.		Accuracy/Bias	
MSD		Same as MS and ≤30% for RPD between MS and MSD.	Same as MS.		Accuracy/Bias, Precision	
IS Verification		Every field sample, standard, and QC sample.	Retention time ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.		Inspect GC/MS for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	
Surrogates	5 per sample	2-Fluorobiphenyl: 45-105% Terphenyl-D ₁₄ : 30-125% 2,4,6-Tribromophenol: 35-125% 2-Fluorophenol: 35-105% Phenol-d ₅ /d ₆ : 40-100% NB-d ₅ : 35-100%	For field and QC sample, correct problem then re-prepare and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Accuracy/Bias		

SAP Worksheet #28-12—Laboratory QC Samples Table – PAHs in Soil or Sediment

Matrix: Surface Soil, Subsurface Soil, Sediment

Analytical Group: PAHs

Analytical Method/SOP Reference: SW-846 8270C SIM/CA-213

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparatory batch.	No analytes detected > 1/2 RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL.	Correct problem, reanalyze samples. If acceptance criteria still not met, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst, Supervisor	Accuracy/Bias, Contamination	Same as SOP QC Acceptance Limits.
LCS		Refer to Worksheet #15. In-house limits are provided when DoD QSM v. 4.2 does not specify.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias	
MS		Same as LCS.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.		Accuracy/Bias	
MSD		Same as MS and ≤30% for RPD between MS and MSD.	Same as MS.		Accuracy/Bias, Precision	
Internal Standard (IS) Verification		Every field sample, standard, and QC sample.	Retention time ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.		Inspect GC/MS for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	
Surrogates	2 per sample for SW-846 8270D SIM	Fluorene-d ₁₀ : 18-77%R Pyrene-d ₁₀ : 34-131%R	For field and QC sample, correct problem then re-prepare and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Accuracy/Bias		

SAP Worksheet #28-13—Laboratory QC Samples Table – Pesticides in Soil or Sediment

Matrix: Surface Soil, Subsurface Soil, Sediment

Analytical Group: Pesticides

Analytical Method/SOP Reference: SW-846 8081B/CA-302

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparatory batch.	No analytes detected > 1/2 RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	Correct problem, then reanalyze samples. If acceptance criteria are still not met, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst	Accuracy/Bias, Contamination	Same as SOP QC Acceptance Limits.
LCS		Refer to Worksheet #15. Limits are as per DoD QSM v. 4.2.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias	
MS		Same as LCS.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.		Accuracy/Bias	
MSD		Same as MS and RPD ≤30% between MS and MSD.	Same as MS.		Accuracy/Bias, Precision	
Surrogates	2 Per Sample	TCMX: 70-125% Decachlorobiphenyl: 55-130%	For field and QC sample, correct problem then re-prepare and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.		Accuracy/Bias	
Confirmation of positive results (second column or second detector)	All positive results must be confirmed.	Calibration and QC criteria are the same as for initial or primary column analysis. Results between primary and second column RPD ≤ 40%.	N/A.		Accuracy	

Notes:

The specifications in this table meet the requirements of DoD QSM 4.2.

SAP Worksheet #28-14—Laboratory QC Samples Table – PCBs in Soil or Sediment

Matrix: Surface Soil, Subsurface Soil, Sediment

Analytical Group: PCBs

Analytical Method/SOP Reference: SW-846 8082A/CA-329

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparatory batch.	No analytes detected > 1/2 RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	Correct problem, then reanalyze samples. If acceptance criteria are still not met, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst	Accuracy/Bias, Contamination	Same as SOP QC Acceptance Limits.
LCS		Refer to Worksheet #15. Limits are as per DoD QSM v. 4.2. In-house laboratory limits are provided when DoD QSM v. 4.2 does not specify.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias	
MS		Same as LCS.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.		Accuracy/Bias	
MSD		Same as MS and RPD ≤30% between MS and MSD.	Same as MS.		Accuracy/Bias, Precision	
Surrogates ¹	2 Per Sample	<i>TCMX: 56-115%</i> Decachlorobiphenyl: 60-125%	For field and QC sample, correct problem then re-prepare and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.		Accuracy/Bias	
Confirmation of positive results (second column or second detector)	All positive results must be confirmed.	Calibration and QC criteria are the same as for initial or primary column analysis. Results between primary and second column RPD ≤ 40%.	N/A.		Accuracy	

Notes:

¹ Italicized limits are laboratory in-house limits; DoD QSM v. 4.2 does not specify limits for this surrogate.

SAP Worksheet #28-15—Laboratory QC Samples Table – Metals in Soil or Sediment

Matrix: Surface Soil, Subsurface Soil, Sediment

Analytical Group: Metals

Analytical Method/SOP Reference: SW-846 6010C/CA-608

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Calibration Blank	Before beginning a sample run, after every 10 samples, and at the end of the analysis sequence.	No analytes detected > LOQ.	Correct problem. Re-prepare and reanalyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed.	Analyst, Supervisor	Accuracy/Bias, Contamination	Same as Method/SOP QC Acceptance Limits.
Method Blank	One per preparatory batch.	No analytes detected > 1/2 LOQ and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > LOQ.	Correct problem, then reanalyze samples. If acceptance criteria still not met, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias, Contamination	
LCS		Refer to Worksheet #15. Limits are as per DoD QSM v. 4.2.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias	
MS		Same as LCS.	Examine the project-specific DQOs. If the MS falls outside of DoD criteria, additional QC tests are required to evaluate matrix effects.		Accuracy/Bias	
MSD		Same as MS and refer to Worksheet #15.	Same as MS.		Accuracy/Bias, Precision	
Serial Dilution		One per preparatory batch.	Five-fold dilution must agree within ±10% of the original measurement. Only applicable for samples with concentrations > 50X LOQ.		Perform PDS addition.	
PDS	When dilution test fails or analyte concentration in all samples < 50X LOD.	Recovery within 75-125%	Run all associated samples in the preparatory batch by MSA. Or, for the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met.		Accuracy	

SAP Worksheet #28-16—Laboratory QC Samples – Mercury in Soil or Sediment

Matrix: Surface Soil, Subsurface Soil, Sediment

Analytical Group: Metals (mercury)

Analytical Method/SOP Reference: SW-846 7471A/CA-611

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Calibration Blank	Before beginning a sample run, after every 10 samples, and at the end of the analysis sequence.	No analytes detected > LOQ.	Correct problem. Re-prepare and reanalyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed.	Analyst/Laboratory Area Supervisor	Accuracy/Bias, Contamination	Same as Method/SOP QC Acceptance Limits.
Method Blank	One per preparatory batch.	No analytes detected > 1/2 RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. See Box D-1 of DoD QSM v 4.2.	Correct problem, then see criteria in Box D-1 of DoD QSM v. 4.2. If required, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias, Contamination	
LCS	One per preparatory batch.	Refer to Worksheet #15. Limits are as per DoD QSM v. 4.2.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.		Accuracy/Bias	
MS	One per preparatory batch per matrix.	Same as LCS.	Examine the project-specific DQOs. If the MS falls outside of DoD criteria, additional QC tests are required to evaluate matrix effects.		Accuracy/Bias	
MSD	One per preparatory batch per matrix.	Same as MS and refer to Worksheet #15.	Same as MS.		Accuracy/Bias, Precision	

SAP Worksheet #28-17—Laboratory QC Samples – Cyanide in Soil or Sediment

Matrix: Surface Soil, Subsurface Soil, Sediment

Analytical Group: Metals (Cyanide)

Analytical Method/SOP Reference: SW-846 9012/CA-773

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per digestion batch of 20 or fewer samples of similar matrix.	No target analyte > ½ LOQ and > 1/10 the amount measured in any sample or 1/10 the PAL, whichever is greater. For negative blanks, absolute value must be < LOD.	Correct the problem. Report sample results that are <LOD or >10x the blank concentration. Re-prepare and reanalyze the method blank and all associated samples with results > LOD and < 10x the contaminated blank result.	Analyst, Laboratory Department Manager and Data Validator	Bias/contamination	Same as Method/SOP QC Acceptance Limits.
LCS	One per digestion batch of 20 or fewer samples of similar matrix (varies by lot).	%R must be within 88-115%.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch, if sufficient sample material is available.	Analyst, Laboratory Department Manager and Data Validator	Accuracy/Bias/Contamination	
MS	One per SDG or every 20 samples.	%R should be within 85-115% if sample < 4x spike added.	If the MS falls outside of criteria, the MSA (post-digestion) will be used for the analysis.	Analyst, Laboratory Department Manager and Data Validator	Accuracy/Bias	
Laboratory Duplicate	One per 10 samples	Project-specific criteria: If values are ≥ 5x LOQ, RPD should be ≤ 20%. If values are < 5x LOQ, Absolute Difference should be ≤ LOQ.	(1) Investigate and correct problem and reanalyze sample in duplicate. (2) If RPD still >20, report original result with flagging and narration.	Analyst, Laboratory Department Manager and Data Validator	Precision	

SAP Worksheet #28-18—Laboratory QC Samples Table

Matrix: Subsurface Soil, Surface Soil, Sediment

Analytical Group: Wet Chemistry (TOC)

Analytical Method/SOP Reference: Lloyd Kahn / CA-741

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	One per analytical batch of 20 or fewer samples.	No target analytes > LOQ and > 1/10 the amount measured in any sample or 1/10 the PIL, whichever is greater.	Correct the problem. Report sample results that are <LOD or >10x the blank concentration. Re-prepare and reanalyze the method blank and all associated samples with results > LOD and < 10x the contaminated blank result.	Analyst, Laboratory Department Manager	Bias/contamination	Same as Method/SOP QC Acceptance Limits.
LCS ¹	One per analytical batch of 20 or fewer samples.	Recovery within 80-120% of the true value.	(1) Investigate source of problem. (2) If the LCS recovery is high but the sample results are < PQL, narrate. Otherwise, reprep a blank and the remaining samples.		Accuracy/Bias/Contamination	
MS ²	One for every set 10 samples	Recovery within 75-125% of true value.	Evaluate the samples and associated QC: i.e. If the LCS results are acceptable, narrate.		Accuracy/Bias	
Laboratory Quadruplicate	One sample quadruplicate per 20 samples.	RPD ≤30 for samples >3X the PQL, <100% RPD for samples <3X the PQL.	(1) Investigate problem and reanalyze sample in duplicate (2) If RPD still >20, report original result with notation or narration.		Precision	

Notes:

¹ For LCS QC acceptance limits please refer to Worksheet #15

² MS/MSD QC acceptance limits are the same as LCS acceptance limits

SAP Worksheet #28-19—Laboratory QC Samples Table

Matrix: Subsurface Soil, Surface Soil, Sediment

Analytical Group: Wet Chemistry (pH)

Analytical Method/SOP Reference: pH / CA-709

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	One per analytical batch of 20 or fewer samples.	No target analytes > LOQ and > 1/10 the amount measured in any sample or 1/10 the PIL, whichever is greater.	Correct the problem. Report sample results that are <LOD or >10x the blank concentration. Re-prepare and reanalyze the method blank and all associated samples with results > LOD and < 10x the contaminated blank result.	Analyst, Laboratory Department Manager	Bias/contamination	Same as Method/SOP QC Acceptance Limits.
LCS ¹	One per analytical batch of 20 or fewer samples.	Recovery within 90-110% of the true value.	(1) Investigate source of problem. (2) If the LCS recovery is high but the sample results are < PQL, narrate. Otherwise, reprep a blank and the remaining samples.		Accuracy/Bias/Contamination	
Laboratory Duplicate	One sample duplicate per 20 samples.	RPD ≤20 for samples >3X the PQL, <100% RPD for samples <3X the PQL.	(1) Investigate problem and reanalyze sample in duplicate (2) If RPD still >20, report original result with notation or narration.		Precision	

Notes:

¹ For LCS QC acceptance limits please refer to Worksheet #15

SAP Worksheet #28-20—Laboratory QC Samples Table

Matrix: Sediment

Analytical Group: Wet Chemistry (AVS/SEM)

Analytical Method/SOP Reference: EPA 821_R-91-100/CA-738

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	One per preparation batch.	No analyte detected >LOQ	Investigate source of contamination. Reprep and analyze method blank and all samples processed with the contaminated blank	Analyst, Laboratory Department Manager	Bias/contamination	Same as Method/SOP QC Acceptance Limits.
LCS ¹	One per preparation batch.	Recovery within 80-120% of the true value.	Recalibrate and reanalyze sample batch		Accuracy/bias	
MS ²	One for every set of 10 samples	Recovery within 75-125% of the true value.	If lab QC is in criteria and the MS is out, narrate. If both the lab QC and the MS is out, reanalyze.		Accuracy/bias	
Laboratory Duplicate	One per preparation batch.	RPD \leq 20	If lab QC in criteria and matrix interference suspected, flag data. Else, reanalyze		Precision	

Notes:

¹ For LCS QC acceptance limits please refer to Worksheet #15

² MS/MSD QC acceptance limits are the same as LCS acceptance limits

SAP Worksheet #29—Project Documents and Records Table

[\(UFP-QAPP Manual Section 3.5.1\)](#)

Sample Collection Documents and Records	Onsite Analysis Documents and Records	Offsite Analysis Documents and Records ¹	Data Assessment Documents and Records	Other
<ul style="list-style-type: none"> • Field Notebooks • Chain-of-Custody Records • Air Bills • Custody Seals • CA Forms • Electronic Data Deliverables • ID of QC Samples • Meteorological Data from Field (Logging daily weather) • Sampling Instrument Calibration Logs • Sampling Locations and Sampling Plan • Sampling Notes and Drilling Logs • Monitoring Well Completion Forms • Groundwater Sampling Monitoring Forms 	<ul style="list-style-type: none"> • No onsite analysis will take place other than visual inspection of test pit excavations and collecting water quality parameters. These readings will be recorded in field logbooks as they are collected 	<ul style="list-style-type: none"> • Sample Receipt, Chain-of-Custody, and Tracking Records • Standard Traceability Logs • Equipment Calibration Logs • Sample Prep Logs • Run Logs • Equipment Maintenance, Testing, and Inspection Logs • CA Forms • Reported Field Sample Results • Reported Result for Standards, QC Checks, and QC Samples • Instrument printouts (raw data) for Field Samples, Standards, QC Checks, and QC Samples • Data Package Completeness Checklists • Sample disposal records • Extraction/Clean-up Records • Raw Data (stored on disk) 	<ul style="list-style-type: none"> • Fixed Laboratory Audit Checklists • DV Reports • CA Forms • Laboratory QA Plan • Method detection limit (MDL) Study Information 	

Notes:

¹ Offsite documents except for analytical laboratory data are archived with Iron Mountain, Inc., which is headquartered at 745 Atlantic Avenue, Boston, MA 02111. Analytical laboratory data are archived with the Federal Records Center.

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SAP Worksheet #30—Analytical Services Table

Matrix	Analytical Group	Sample Locations/ID Number	Analytical Method	Data Package Turnaround Time	Laboratory/Organization	Backup Laboratory/Organization ¹
Groundwater	VOCs	Refer to Worksheet #18 and #20	SW-846 8260B	28 calendar days	Katahdin Analytical Services 600 Technology Way Scarborough, ME 04074 Jennifer Obrin - (207) 874-2400 Saturday delivery address: Katahdin Analytical Services 95 Hutchins Drive Portland, ME 04102	TBD
	SVOCs		SW-846 8270C			
			SW-846 8270C SIM			
	Pesticides		SW-846 8081B			
	PCBs		SW-846 8082			
	Total Metals		SW-846 6010B, 7470A			
	Dissolved Metals		SW-846 6010B, 7470A			
Cyanide	SW-846 9012B					
Surface Water	VOCs		SW-846 8260B			
	SVOCs		SW-846 8270C			
			SW-846 8270C SIM			
	Pesticides		SW-846 8081B			
	PCBs		SW-846 8082			
	Total Metals		SW-846 6010B, 7470A			
	Dissolved Metals	SW-846 6010B, 7470A				
Cyanide	SW-846 9012B					
Hardness	EPA SM2340C					
Seep	VOCs	SW-846 8260B				
	SVOCs	SW-846 8270C				
		SW-846 8270C SIM				
	Pesticides	SW-846 8081B				
	PCBs	SW-846 8082				
	Total Metals	SW-846 6010B, 7470A				
	Dissolved Metals	SW-846 6010B, 7470A				
Cyanide	SW-846 9012B					
Hardness	EPA SM2340C					

SAP Worksheet #30—Analytical Services Table (continued)

Matrix	Analytical Group	Sample Locations/ID Number	Analytical Method	Data Package Turnaround Time	Laboratory/Organization	Backup Laboratory/Organization ¹
Surface Soil	VOCs	Refer to Worksheet #18 and #20	SW-846 8260B	28 calendar days	Katahdin Analytical Services 600 Technology Way Scarborough, ME 04074 Jennifer Obrin - (207) 874-2400 Saturday deliver address: Katahdin Analytical Services 95 Hutchins Drive Portland, ME 04102	TBD
	SVOCs		SW-846 8270C			
	Pesticides		SW-846 8270C SIM			
	PCBs		SW-846 8081B			
	Total Metals		SW-846 8082			
	Cyanide		SW-846 6010B, 7471A			
	TOC		SW-846 9012B			
	pH		Lloyd Kahn			
Subsurface Soil	VOCs		SW-846 8260B			
	SVOCs		SW-846 8270C			
	Pesticides		SW-846 8270C SIM			
	PCBs		SW-846 8081B			
	Total Metals		SW-846 8082			
	Cyanide		SW-846 6010B, 7471A			
	TOC		SW-846 9012B			
	pH		Lloyd Kahn			
Sediment	VOCs		SW-846 8260B			
	SVOCs		SW-846 8270C			
	Pesticides		SW-846 8270C SIM			
	PCBs		SW-846 8081B			
	Total Metals		SW-846 8082			
	Cyanide		SW-846 6010B, 7471A			
	AVS/SEM		SW-846 9012B			
	TOC		821_R-91-100			
	pH	Lloyd Kahn				
		SW846-9045				

SAP Worksheet #30—Analytical Services Table (continued)

Matrix	Analytical Group	Sample Locations/ID Number	Analytical Method	Data Package Turnaround Time	Laboratory/Organization	Backup Laboratory/Organization ¹
Sediment	Grain-size		ASTM D422		TestAmerica Burlington 30 Community Drive, Suite 11 South Burlington, VT 05403 Kathryn Kelly 802.660.1990	TBD

Notes:

¹ A backup laboratory has not been determined. If circumstances render the subcontracted laboratory unable to perform analytical services, another laboratory will be identified at that time.

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SAP Worksheet #31—Planned Project Assessments Table

[\(UFP-QAPP Manual Section 4.1.1\)](#)

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (title and organizational affiliation)	Person(s) Responsible for Responding to Assessment Findings (title and organizational affiliation)	Person(s) Responsible for Identifying and Implementing CA (title and organizational affiliation)	Person(s) Responsible for Monitoring Effectiveness of CA (title and organizational affiliation)
Field QA and H&S Audit	Once	Internal	CH2M HILL	Stephen Brand	TBD, FTL, and Field Staff	Stephen Brand	Brett Doerr Mark Orman
Onsite Laboratory Technical Systems Audit (applies to definitive data only)	Laboratory must have a current accreditation from the DoD ELAP, which will identify the period of performance and scope of analytical methods. The laboratory must be re-evaluated prior to expiration of period of performance	External	Third-Party Accrediting Body	Third Party Accrediting Body (TBD)	Respective Laboratory QAO	Respective Laboratory QAO	Anita Dodson, Program Chemist, CH2M HILL

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SAP Worksheet #32—Assessment Findings and Corrective Action Responses Table

[\(UFP-QAPP Manual Section 4.1.2\)](#)

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (name, title, organization)	Timeframe of Notification	Nature of CA Response Documentation	Individual(s) Receiving CA Response (name, title, organization)	Timeframe for Response
Field QA and H&S Audit	Checklist and Written Audit Report	Renee Hunt/CH2M HILL, PM	Within 1 week of audit	Memorandum	TBD FTL CH2M HILL Doug Bitterman AQM CH2M HILL	Within 1 week of receipt of CA Form
Onsite Laboratory Technical Systems Audit	Written audit report from DoD Laboratory Accrediting Body	Respective Laboratory QAO	Within 2 months of audit	Memorandum	DoD Laboratory Accrediting Body (TBD)	Within 2 months of receipt of initial notification

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SAP Worksheet #33—Quality Assurance Management Reports Table

[\(UFP QAPP Manual Section 4.2\)](#)

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, and so forth)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (title and organizational affiliation)	Report Recipient(s) (title and organizational affiliation)
SI Report	Post-field-event	TBD	Renee Hunt/CH2M HILL PM	Stakeholders, See Worksheet #3

Notes:

The SI Report will address the following:

- Summary of project QA/QC requirements/procedures

- Conformance of project to UFP-SAP requirements/procedures

- Deviations from the UFP-SAP and approved amendments that were made

- Results of data review activities (how much usable data was generated)

- CAs if needed and their effectiveness

- Data usability with regards to: precision, accuracy, representativeness, completeness, comparability, and sensitivity

- Limitations on data use

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SAP Worksheets #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process Table

Data Review Input	Description	Responsible for Verification/Validation ²	Step I / IIa / IIb ¹	Internal/External ³
Field Notebooks	Field notebooks will be reviewed internally and placed into the project file for archival at project closeout.	FTL/CH2M HILL	Step I	Internal
Chains of Custody and Shipping Forms	Chain-of-custody forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the chain of custody will be initialed by the reviewer, a copy of the chains of custody retained in the site file, and the original and remaining copies taped inside the cooler for shipment. Chains of custody will also be reviewed for adherence to the SAP by the PC.	FTL/CH2M HILL PC/CH2M HILL	Step I	Internal & External
Sample Condition upon Receipt	Any discrepancies, missing, or broken containers will be communicated to the PC in the form of laboratory logins.	PC/CH2M HILL	Step I	External
Documentation of Laboratory Method Deviations	Laboratory Method Deviations will be discussed and approved by the PC. Documentation will be incorporated into the case narrative which becomes part of the final hardcopy data package.	PC/CH2M HILL	Step I	External
Electronic Data Deliverables	Electronic Data Deliverables will be compared against hardcopy laboratory results (10 percent check).	PC/CH2M HILL	Step I	External
Case Narrative	Case narratives will be reviewed by the data validator during the DV process. This is verification that they were generated and applicable to the data packages.	Data Validator/CH2M HILL	Step I	External
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal.	Respective Laboratory QAO	Step I	Internal
Laboratory Data	The data will be verified for completeness by the PC. In order to ensure completeness, EDDs will be compared to the SAP. This is verification that all samples were included in the laboratory data and that correct analyte lists were reported.	PC/CH2M HILL	Step I	External
Audit Reports	Upon report completion, a copy of all audit reports will be placed in the site file. If CAs are required, a copy of the documented CA taken will be attached to the appropriate audit report in the QA site file. Periodically, and at the completion of site work, site file audit reports and CA forms will be reviewed internally to ensure that all appropriate CAs have been taken and that CA reports are attached. If CAs have not been taken, the site manager will be notified to ensure action is taken.	PM/CH2M HILL PC/CH2M HILL	Step I	Internal
CA Reports	CA reports will be reviewed by the PC or PM and placed into the project file for archival at project closeout.	PM/CH2M HILL PC/CH2M HILL	Step I	External
Laboratory Methods	Ensure the laboratory analyzed samples using the correct methods.	PC/CH2M HILL	Step IIa	External
TCL and TAL	Ensure the laboratory reported all analytes from each analysis group.	PC/CH2M HILL	Step IIa	External

SAP Worksheets #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process Table (continued)

Data Review Input	Description	Responsible for Verification/Validation ²	Step I / IIa / IIb ¹	Internal/External ³
RLs	Ensure the laboratory met the project-designated QLs. If QLs were not met, the reason will be determined and documented.	PC/CH2M HILL	Step IIb	External
Laboratory SOPs	Ensure that approved analytical laboratory SOPs were followed.	Respective Laboratory QAO	Step IIa	Internal
Raw Data	10 percent review of raw data to confirm laboratory calculations.	Data Validator/ CH2M HILL	Step IIa	External
Onsite Screening	All non-analytical field data will be reviewed against SAP requirements for completeness and accuracy based on the field calibration records.	FTL/CH2M HILL	Step IIb	Internal
Documentation of Method QC Results	Establish that all required QC samples were run.	Data Validator/ CH2M HILL	Step IIa	External
Documentation of Field QC Sample Results	Establish that all required QC samples were run.	PC/CH2M HILL	Step IIa	Internal
DoD ELAP Evaluation	Ensure that each laboratory is DoD ELAP-certified for the analyses they are to perform. Ensure evaluation timeframe does not expire.	PC/CH2M HILL	Step I	External
Analytical data for VOCs, SVOCs, Pesticides, PCBs, Metals (total and dissolved), Cyanide in groundwater, DPT groundwater, surface water, seeps, surface soil, subsurface soil and waste material	Analytical methods and laboratory SOPs as presented in this SAP will be used to evaluate compliance against QA/QC criteria. Should adherence to QA/QC criteria yield deficiencies, data may be qualified. The data qualifiers used are those presented in <i>Region III Modifications to the National Functional Guidelines for Organic Data Review</i> (USEPA, 1994) and in <i>Region III Modifications to the Laboratory Data Validation Guidelines for Inorganic Data Review</i> (USEPA, 1993). National Functional Guidelines will not be used for DV; however, the specific qualifiers listed therein may be applied to data should non-conformances against the QA/QC criteria as presented in this SAP be identified.	Data Validator/ CH2M HILL	Step IIa and IIb	External
Analytical data for wet chemistry, AVS/SEM, or grain-size, in all matrixes analyzed, e.g. surface water, seeps, surface soil, subsurface soil, or sediment.	Wet chemistry, AVS/SEM, and grain-size data will not undergo third-party DV, but are subject to all other data review protocols detailed above.	NA	Step IIa and IIb	NA

Notes:

¹ Verification (Step I) is a completeness check that is performed before the data review process continues in order to determine whether the required information (complete data package) is available for further review. Validation (Step IIa) is a review that the data generated is in compliance with analytical methods, procedures, and contracts. Validation (Step IIb) is a comparison of generated data against MPC in the SAP (both sampling and analytical).

² Should CH2M HILL find discrepancies during the verification or validation procedures above, an email documenting the issue will be circulated to the internal project team, and a Corrections to File Memo will be prepared identifying the issues and the corrective action needed. This Memo will be sent to the laboratory, or applicable party, and maintained in the project file.

³ Internal or external is in relation to the data generator.

SAP Worksheet #37—Usability Assessment

[\(UFP-QAPP Manual Section 5.2.3\)](#)

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms that will be used:

Non-detected site contaminants will be evaluated to ensure that project required QLs in **Worksheet #15** were achieved. If project QLs were achieved and the verification and validation steps yielded acceptable data, then the data are considered usable. If project QLs were not achieved, then the reason will be investigated and documented, and the impact on data usability will be discussed.

During verification and validation steps, data may be qualified as estimated with the following qualifiers: J, UJ, K, L, or UL. These qualifiers represent minor QC deficiencies which will not affect the usability of the data. When major QC deficiencies are encountered, data will be qualified with an R and in most cases are not considered usable for project decisions.

J	Analyte present. Reported value is estimated and may or may not be accurate or precise
UJ	Analyte not detected. QL may be inaccurate or imprecise
K	Analyte present. Reported value is estimated and may be biased high. Actual value is expected to be lower
L	Analyte present. Reported value is estimated and may be biased low. Actual value is expected to be higher
UL	Analyte not detected. QL is probably higher
R	Rejected result. Result is not usable

Additional qualifiers that may be given by the validator include B, N, NJ, and U:

B	Not detected more than 5 times than that in an associated blank (10 times for common laboratory contaminants in VOCs)
N	Tentative ID. Consider Present. Special methods may be needed to confirm its presence or absence in future sampling efforts
NJ	Qualitative ID questionable due to poor resolution. Presumptively present at approximate quantity
U	Not Detected

- For statistical comparison, non-detect values will be represented by a concentration equal to one-half the sample RL. For duplicate sample results, the greater of values will be used for project decisions.
- Analytical data will be checked to ensure the values and any qualifiers are appropriately transferred to the electronic database. These checks include comparison of hardcopy data and qualifiers to the electronic data deliverable. Once the data have been uploaded into the electronic database, another check will be performed to ensure all results were loaded accurately.
- Field and laboratory precision will be assessed as RPD between the two results.
- Deviations from the SAP will be reviewed to assess whether CA is warranted and to assess impacts to achievement of project objectives.
- Identify the personnel responsible for performing the usability assessment:
- The PM, PC, and other team members will be responsible for compiling the data. The data will then be presented to the Partnering Team who, as a whole, will evaluate the data usability according to project objectives.

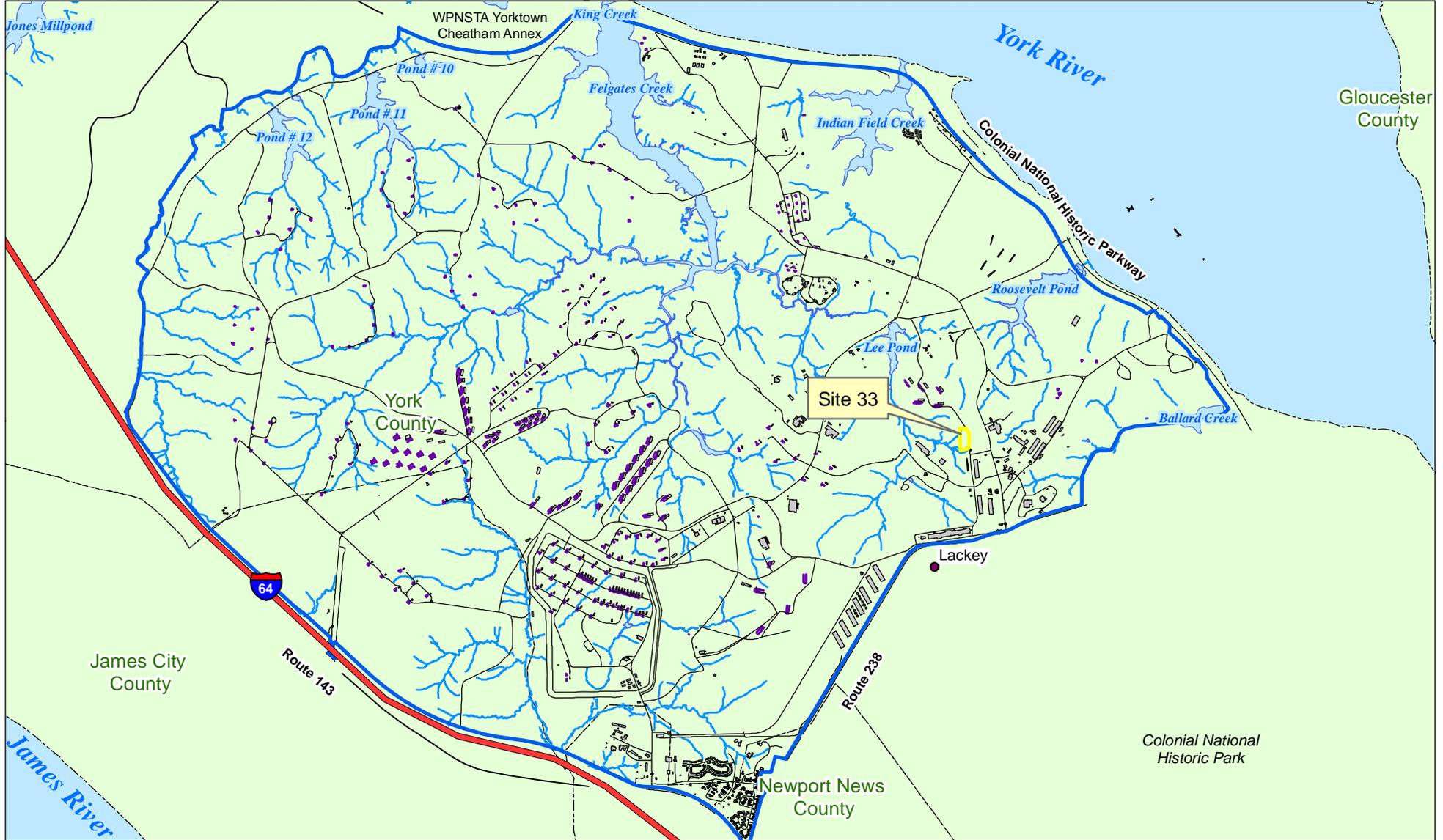
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Figures



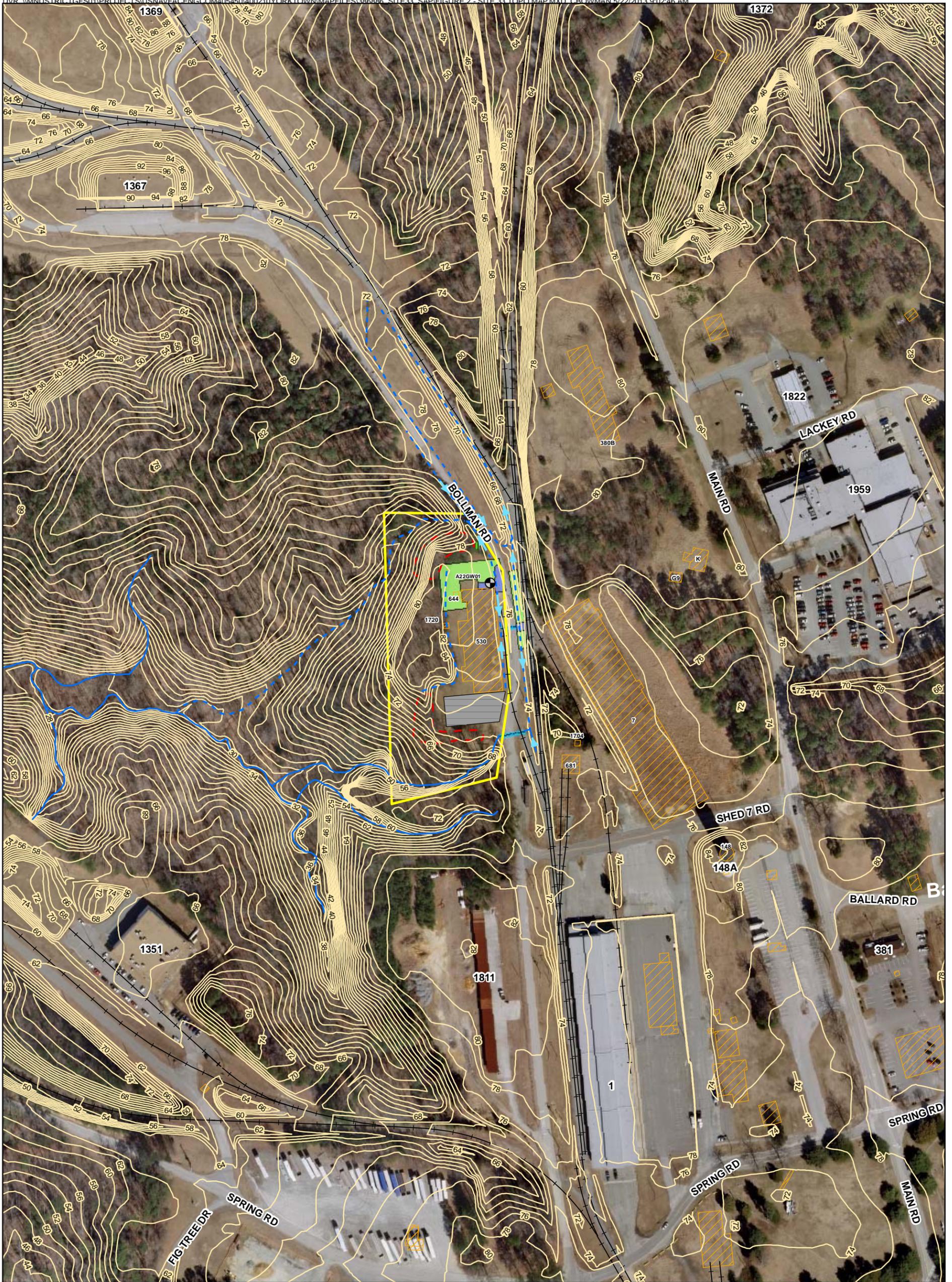
Legend

- Magazines
- Naval Weapons Station Yorktown Boundary
- Study Area Boundary
- Buildings and Structures
- County Boundary



Figure 1
 WPNSTA Yorktown Location Map
 Sampling and Analysis Plan
 Naval Weapons Station Yorktown
 Yorktown, Virginia





- Legend**
- Abandoned Monitoring Well
 - Culvert
 - Discharge Pipe of Unknown Origin
 - Drainage Flow Direction
 - Drainage Ditch
 - Intermittent Drainage Ditch
 - Elevation Contour (10 ft interval)
 - Former Railroad
 - Study Area Boundary
 - Demolished Building
 - Approximate Area of Debris
 - Historical Parking Lot
 - 24" Excavation Depth
 - 6" Excavation Depth

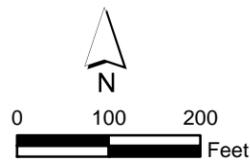
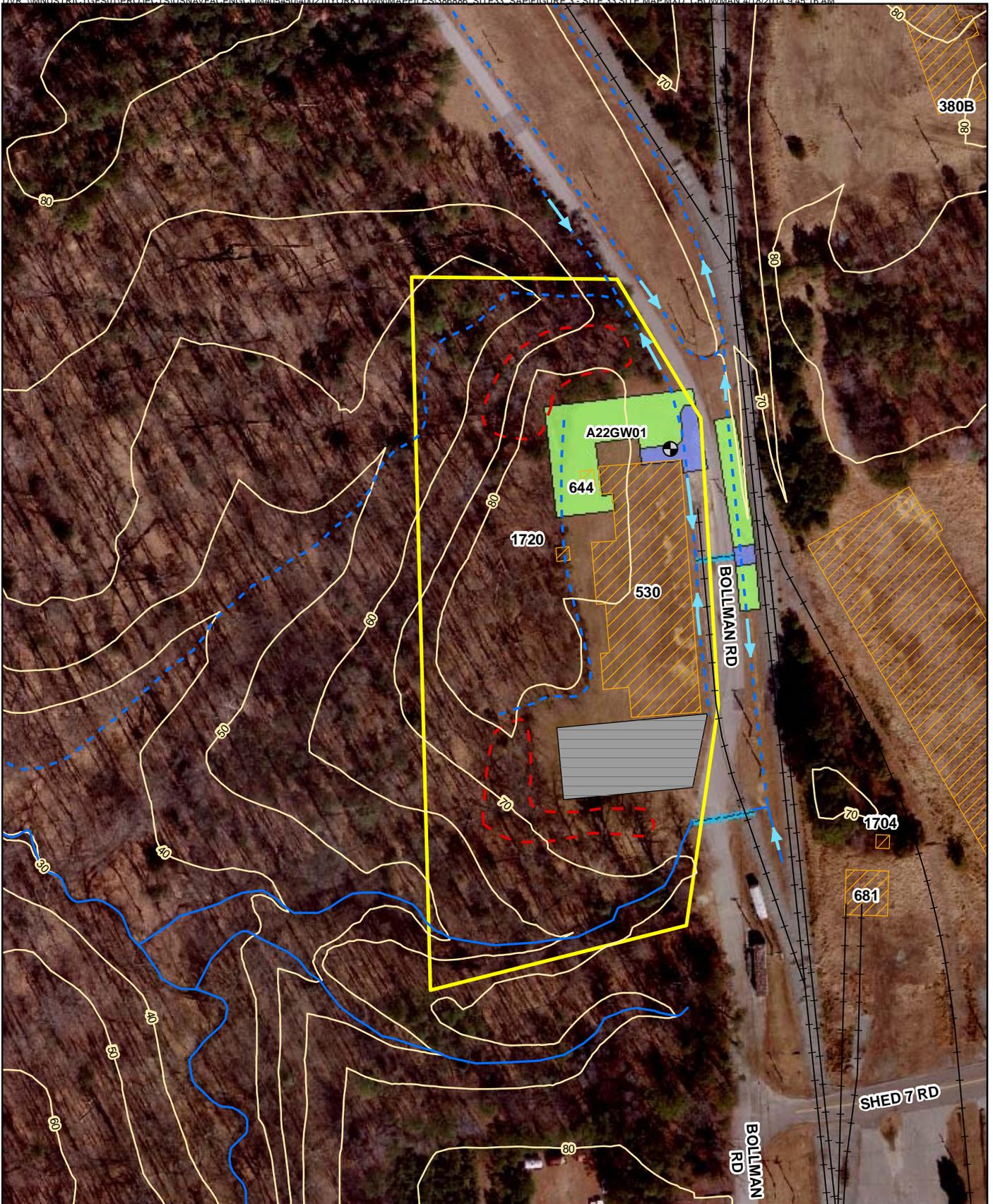


Figure 2
Site 33 Topographic Map
Sampling and Analysis Plan
Naval Weapons Station Yorktown
Yorktown, Virginia



Legend

- Abandoned Monitoring Well
- Culvert
- Drainage Flow Direction
- Drainage Ditch
- Intermittent Drainage Ditch
- Former Railroad
- Elevation Contour (10 ft interval)
- Historical Parking Lot
- Approximate Area of Debris
- Demolished Building
- Study Area Boundary
- 1999/2000 Soil Removal Area (0-24")
- 1999/2000 Soil Removal Area (0-6")

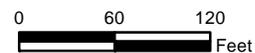


Figure 3
 Site 33 Site Map
 Building 530 Paint Shop and Sand Blasting
 Operations, Sampling and Analysis Plan
 Naval Weapons Station Yorktown
 Yorktown, Virginia





Figure 4
 Site 33 Historical Building Configuration
 Building 530 Paint Shop and Sand Blasting Operations
 Sampling and Analysis Plan
 Naval Weapons Station Yorktown
 Yorktown, Virginia

Legend

-  Railroad
-  Doorway
-  Dust/Grit Accumulation Area



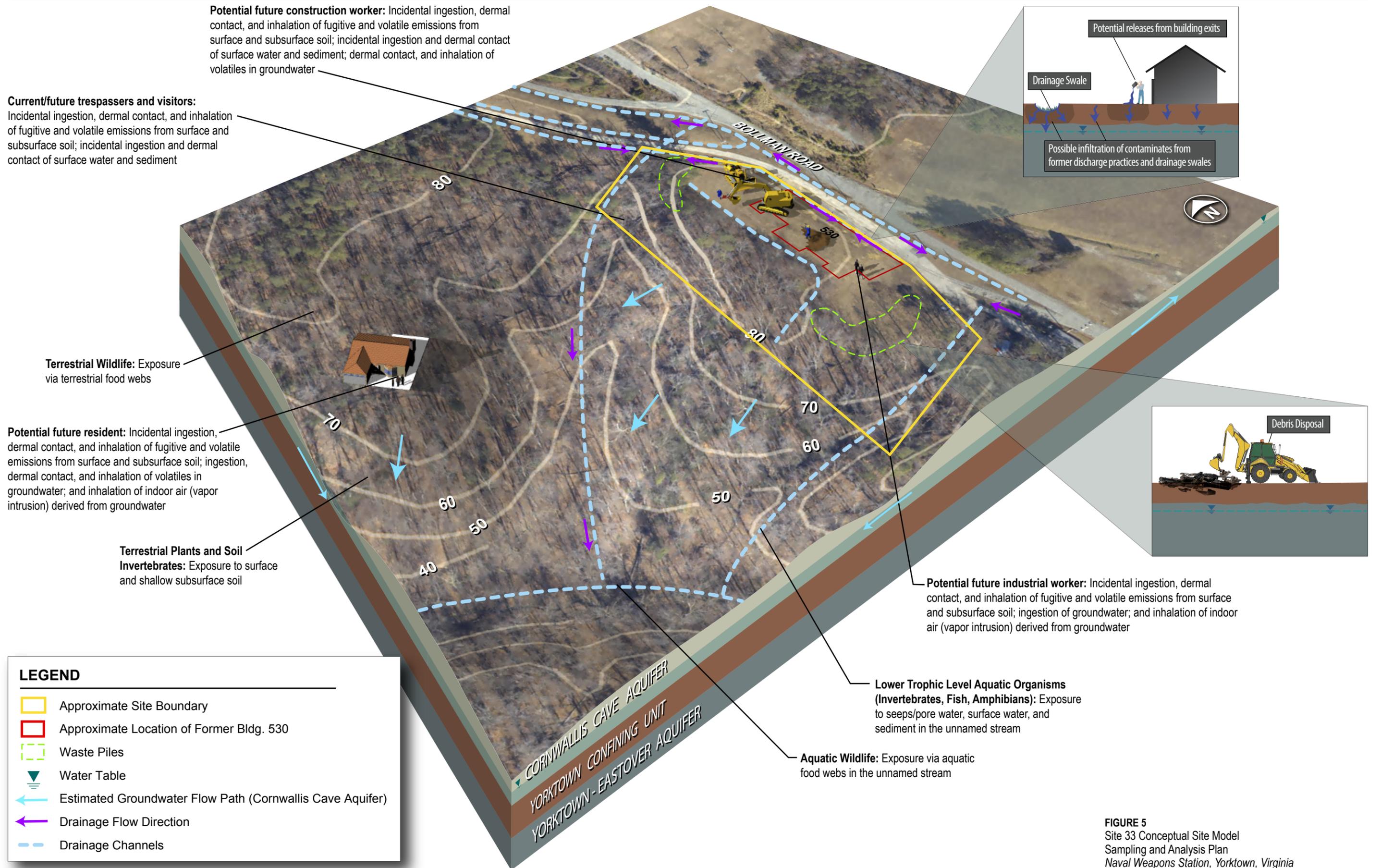
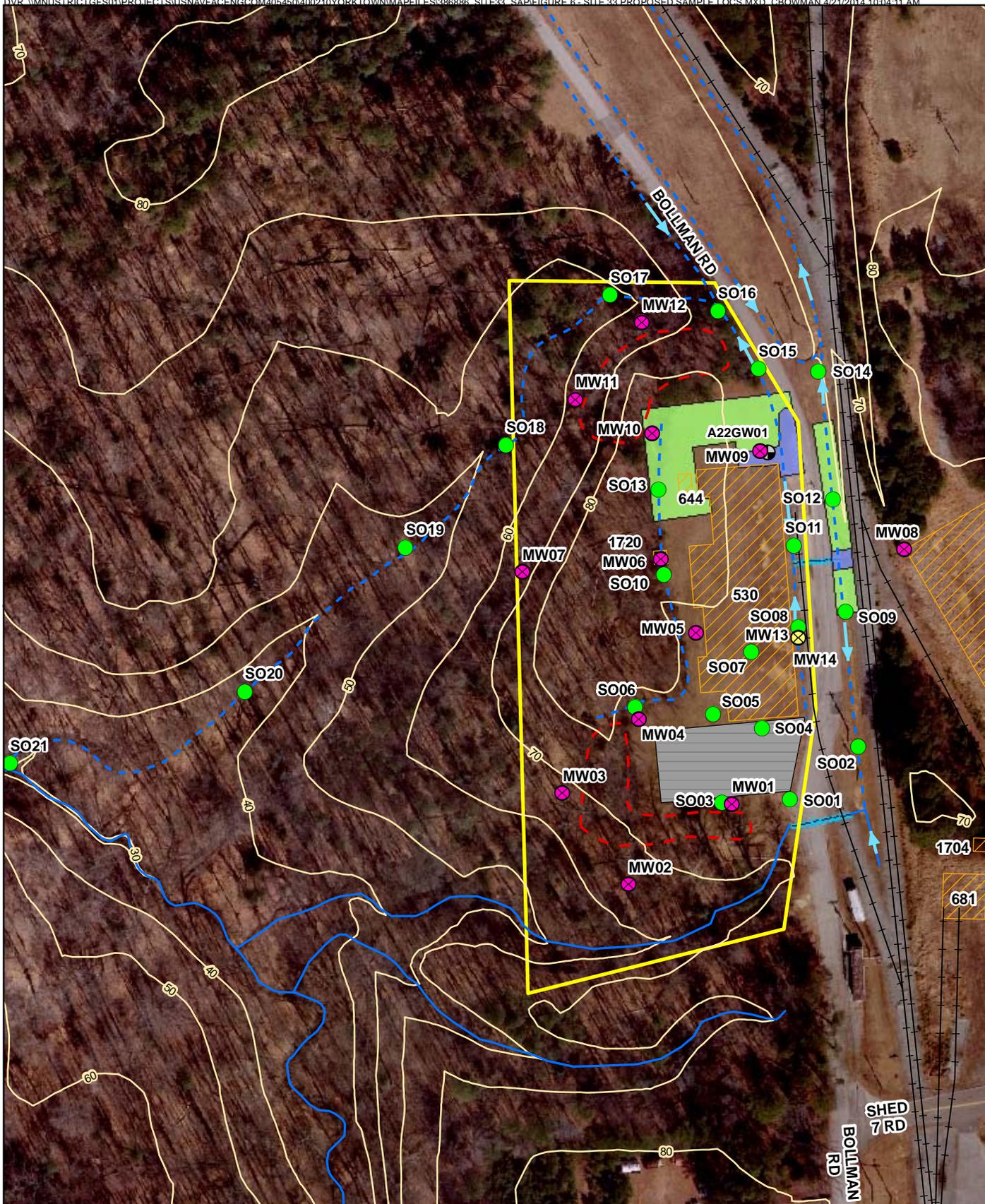


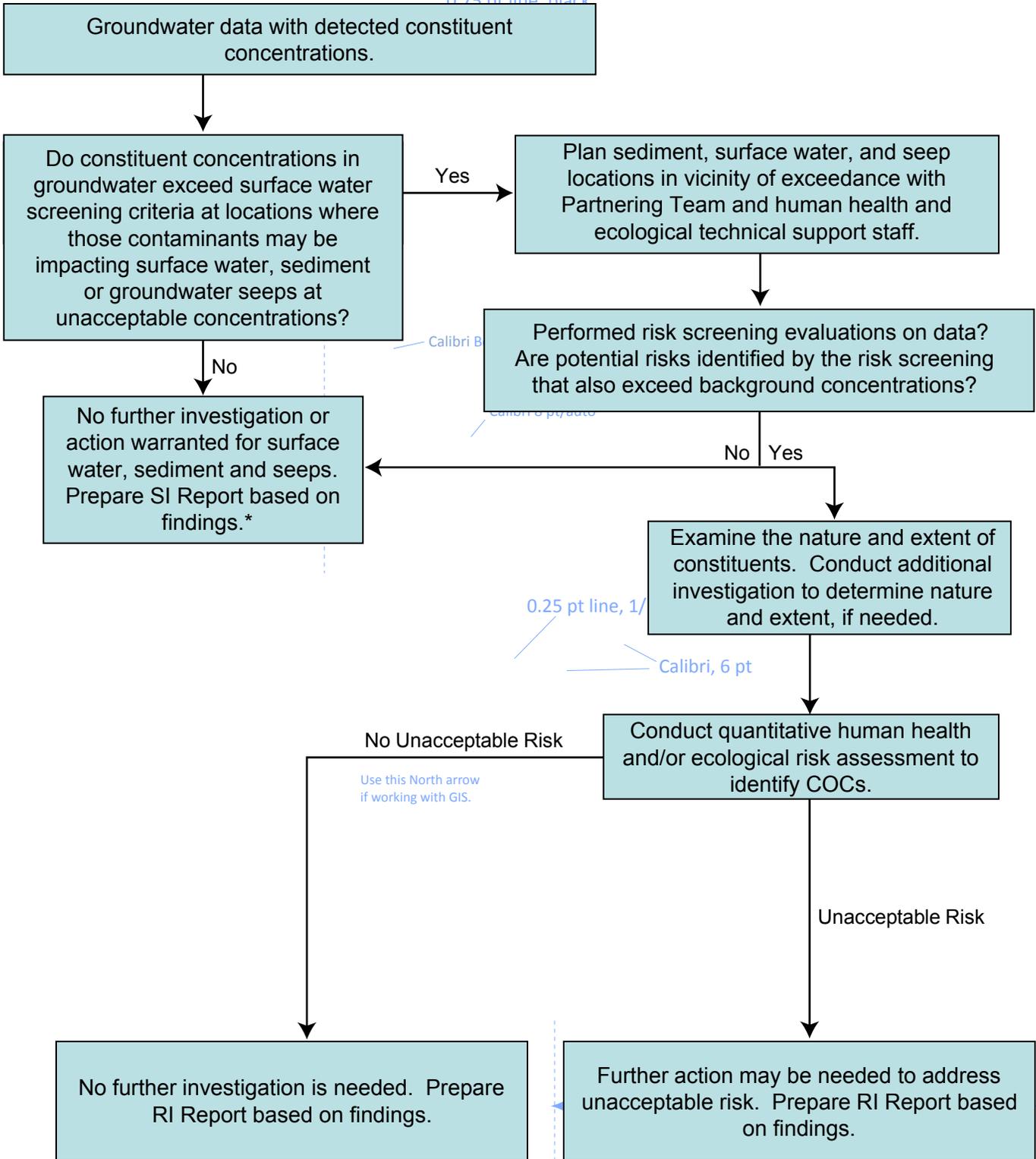
FIGURE 5
 Site 33 Conceptual Site Model
 Sampling and Analysis Plan
 Naval Weapons Station, Yorktown, Virginia



Legend			
Proposed Shallow Groundwater Well	Drainage Ditch		
Proposed Shallow/Deep Groundwater Well	Intermittent Drainage Ditch		
Proposed Soil Sample Location	Former Railroad		
Abandoned Monitoring Well	Historical Parking Lot		
Elevation Contour (10 ft interval)	Approximate Area of Debris		
Culvert	Demolished Building		
Drainage Flow Direction	Study Area Boundary		
	1999/2000 Soil Removal Area (0-24")		
	1999/2000 Soil Removal Area (0-6")		

Figure 6
 Site 33 Proposed Sample Locations
 Building 530 Paint Shop and Sand Blasting
 Operations, Sampling and Analysis Plan
 Naval Weapons Station Yorktown
 Yorktown, Virginia

0.75 pt line, black



Calibri B

Calibri 6 pt auto

0.25 pt line, 1/

Calibri, 6 pt

No Unacceptable Risk
Use this North arrow if working with GIS.

Unacceptable Risk

FIGURE NUMBER - Calibri, all caps, 10/11
Figure Title - Calibri, initial caps, bold, 10/11
Figure Caption or Project Name - Calibri, initial caps, italics, 10/11

Figure 7
Sediment, Surface Water, and Seep Sampling Decision Tree
Sampling and Analysis Plan
Naval Weapons Station Yorktown
Yorktown, Virginia

space = height of logo

Footer, or Slugline:

Arial Narrow, 6 pt, all caps.
Will ALWAYS include the J211 number, Project Acronym and FileName.
* An SI Report will only be prepared if no potential risk is identified for all areas of the site. Otherwise, the NFA determination for the portions of the site with no potential risk will be presented in the RI Report.

0.75 pt line, black

For each waste dumping area, begin test pitting in the central portion of the area. Advance test pit through the central portion of the waste dumping area. Continue excavation until native material is encountered in each area. *

Continue test pitting activities at perimeter of waste dumping area to delineate the horizontal extent of the waste material.

Buried Debris is Located / No Buried Debris is Located

Move 20 feet away from perimeter test pit and begin next test pit. *

Move 20 feet toward the center of the debris area and begin next test pit.

Buried Debris is Located

No Buried Debris is Located

Buried Debris is Located

No Buried Debris is Located

Continue to move away 20 feet until no buried debris is encountered. *

Continue to move toward the center of the waste material until buried debris is encountered.

No Buried Debris is Located

Buried Debris is Located

Horizontal extent of waste has been sufficiently delineated. Stop test pitting on that perimeter of anomaly.

.7" Left Margin

0.7" Right Margin

Use this North arrow if working with GIS.

0.25 pt line, 1/16" (4.5 pt) high

Calibri 8 pt/auto

Calibri, 6 pt

4" from edge of paper

* Waste samples and subsurface soil samples below the waste may be collected at the discretion of the field geologist based on the waste characteristics and observed site conditions. Up to 5 discretionary waste samples and 5 subsurface soil samples may be collected during the test pit investigation.

Footer, or Slugline:

Arial Narrow, 6 pt, all caps.

Will ALWAYS include the JETT number, Project Acronym and FileName.

From the toolset:

FIGURE-NUMBER - Calibri, all caps, 10/11

Figure Title - Calibri, initial caps, bold, 10/11

Figure Caption or Project Name -

Calibri, initial caps, italics, 10/11

Figure 8 Test Pitting Decision Tree Sampling and Analysis Plan Naval Weapons Station Yorktown Yorktown, Virginia

space = height of logo

0.75 pt line, black

Appendix A
Field Standard Operating Procedures

Equipment Blank and Field Blank Preparation

I. Purpose

To prepare blanks to determine whether decontamination procedures are adequate and whether any cross-contamination is occurring during sampling due to contaminated air and dust.

II. Scope

The general protocols for preparing the blanks are outlined. The actual equipment to be rinsed will depend on the requirements of the specific sampling procedure.

III. Equipment and Materials

- Blank liquid (use ASTM Type II or lab grade water)
- Millipore™ deionized water
- Sample bottles as appropriate
- Gloves
- Preservatives as appropriate

IV. Procedures and Guidelines

- A. Decontaminate all sampling equipment that has come in contact with sample according to SOP *Decontamination of Personnel and Equipment*.
- B. To collect an equipment blank for volatile analysis from the surfaces of sampling equipment other than pumps, pour blank water over one piece of equipment and into two 40-ml vials until there is a positive meniscus, then seal the vials. Note the sample number and associated piece of equipment in the field notebook as well as the type and lot number of the water used.

For non-volatiles analyses, one aliquot is to be used for equipment. For example, if a pan and trowel are used, place trowel in pan and pour blank fluid in pan such that pan and trowel surfaces which contacted the sample are contacted by the blank fluid. Pour blank fluid from pan into appropriate sample bottles.

Do not let the blank fluid come in contact with any equipment that has not been decontaminated.

- C. When collecting an equipment blank from a pump, run an extra gallon of deionized water through the pump while collecting the pump outflow into appropriate containers. Make sure the flow rate is low when sampling VOCs. If a Grundfos Redi-Flo2 pump with disposable tubing is used, remove the disposable tubing after sampling but before decon. When decon is complete, put a 3- to 5-foot segment of new tubing onto the pump to collect the equipment blank.
- D. To collect a field blank, slowly pour ASTM Type II or lab grade water directly into sample containers.
- E. Document and ship samples in accordance with the procedures for other samples.
- F. Collect next field sample.

V. Attachments

None.

VI. Key Checks and Items

- Wear gloves.
- Do not use any non-decontaminated equipment to prepare blank.
- Use ASTM-Type II or lab grade water.

Chain-of-Custody

I Purpose

The purpose of this SOP is to provide information on chain-of-custody procedures to be used under the CLEAN Program.

II Scope

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region specific or site-specific requirements for chain-of-custody.

III Definitions

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

IV. Procedures

The term “chain-of-custody” refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When *in situ* measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s),
- Contract Task Order (CTO) Number,
- Project Sample Number,
- Sample location or sampling station number,
- Date and time of sample collection and/or measurement,
- Field observations,
- Equipment used to collect samples and measurements, and
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

Sample Label

Samples, other than for *in situ* measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project - CTO Number.
- Station Location - The unique sample number identifying this sample.
- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 08/21/12).

- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name of the sampler.
- Remarks - Any pertinent additional information.

Using only the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing the analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site). The field team should always follow the sample ID system prepared by the project EIS and reviewed by the Project Manager.

Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.
- A Chain-of-Custody Record will be prepared for each individual cooler shipped and will include *only* the samples contained within that particular cooler. The Chain-of-Custody Record for that cooler will then be sealed in a zip-log bag and placed in the cooler prior to sealing. This ensures that the laboratory properly attributes trip blanks with the correct cooler and allows for easier tracking should a cooler become lost during transit.
- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.
- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once downloaded to the server or developed, the electronic files or photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographic prints will be stored in the project files. To identify sample

locations in photographs, an easily read sign with the appropriate sample location number should be included.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions (e.g., a logbook notation would explain that a pencil was used to fill out the sample label if the pen would not function in freezing weather.)

Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. **A Chain-of-Custody Record Form must be completed for each cooler and should include only the samples contained within that cooler.** A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below:

- Enter header information (CTO number, samplers, and project name).
- Enter sample specific information (sample number, media, sample analysis required and analytical method grab or composite, number and type of sample containers, and date/time sample was collected).
- Sign, date, and enter the time under “Relinquished by” entry.
- Have the person receiving the sample sign the “Received by” entry. If shipping samples by a common carrier, print the carrier to be used in this space (i.e., Federal Express).
- If a carrier is used, enter the airbill number under “Remarks,” in the bottom right corner;
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample-shipping package. Retain the copy with field records.
- Sign and date the custody seal, a 1-inch by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.
- Place the seal across the shipping container opening (front and back) so that it would be broken if the container were to be opened.
- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

V Quality Assurance Records

Once samples have been packaged and shipped, the Chain-of-Custody copy and airbill receipt become part of the quality assurance record.

VI Attachments

- A. Sample Label
- B. Chain of Custody Form
- C. Custody Seal

VII References

USEPA. *User's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

Attachment A
Example Sample Label



Quality Analytical Laboratories, Inc.
2567 Fairlane Drive
Montgomery, Alabama 36116
PH. (334)271-2440

Client _____

Sample No. _____

Location _____

Analysis _____

Preservative **HCL** _____

Date _____ By _____

**CEIMIC
CORPORATION**

10 Dean Knauss Drive, Narragansett, R.I. 02882 • (401) 782-8900

SITE NAME _____ DATE _____

ANALYSIS _____ TIME _____

PRESERVATIVE _____

SAMPLE TYPE

Grab Composite Other _____

COLLECTED BY: _____

Attachment B
Example Chain-of-Custody Record

CH2M Hill Project #		Purchase Order #		# O F C O N T A I N E R S	LAB TEST CODES										SHADED AREA- FOR LAB USE ONLY					
Project Name															Lab 1 #		Lab 2 #			
Company Name CH2M HILL Office															Quote #		Kit Request #			
Project Manager & Phone #		Report Copy to:			ANALYSES REQUESTED										Project #					
Requested Completion Date:		Sampling Requirements			Sample Disposal:												No. of Samples		Page	of
		SDWA NPDES RCRA OTHER			Dispose Return												Login		LIMS Ver	
		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>			<input type="checkbox"/> <input type="checkbox"/>												REMARKS		LAB 1 ID	LAB 2 ID
Sampling	Type	Matrix			CLIENT SAMPLE ID (9 CHARACTERS)															
Date	Time	COMP	GRAB												WATER	SOIL	AIR			
Sampled By & Title (Please sign and print name)					Date/Time		Relinquished By (Please sign and print name)				Date/Time		QC Level: 1 2 3 Other: _____							
Received By (Please sign and print name)				Date/Time		Relinquished By (Please sign and print name)				Date/Time		COC Rec		ICE						
Received By (Please sign and print name)				Date/Time		Relinquished By (Please sign and print name)				Date/Time		Ana Req		TEMP						
Received By (Please sign and print name)				Date/Time		Shipped Via				Shipping #		Cust Seal		Ph						
Work Authorized By (Please sign and print name)				Date/Time		UPS BUS Fed-Ex Hand Other _____														
Remarks																				

Attachment C
Example Custody Seal



CUSTODY SEAL

Date

Signature

Decontamination of Drilling Rigs and Equipment

I. Purpose and Scope

The purpose of this guideline is to provide methods for the decontamination of drilling rigs, downhole drilling tools, and water-level measurement equipment. Personnel decontamination procedures are not addressed in this SOP; refer to the site safety plan and SOP *Decontamination of Personnel and Equipment*. Sample bottles will not be field decontaminated; instead they will be purchased with certification of laboratory sterilization.

II. Equipment and Materials

- Portable steam cleaner and related equipment
- Potable water
- Phosphate-free detergent such as Liquinox®
- Buckets
- Brushes
- Isopropanol, pesticide grade
- Personal Protective Equipment as specified by the Health and Safety Plan
- ASTM-Type II grade water or Lab Grade DI Water
- Aluminum foil

III. Procedures and Guidelines

A. Drilling Rigs and Monitoring Well Materials

Before the onset of drilling, after each borehole, before drilling through permanent isolation casing, and before leaving the site, heavy equipment and machinery will be decontaminated by steam cleaning at a designated area. The steam-cleaning area will be designed to contain decontamination wastes and waste waters and can be an HDPE-lined, bermed pad. A pumping system will be used to convey decontaminated water from the pad to drums.

Surface casings may be steam cleaned in the field if they are exposed to contamination at the site prior to use.

B. Downhole Drilling Tools

Downhole tools will be steam cleaned before the onset of drilling, prior to drilling through permanent isolation casing, between boreholes, and prior to leaving the site. This will include, but is not limited to, rods, split spoons or similar samplers, coring equipment, augers, and casing.

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for physical characterization, the sampler shall be cleaned by scrubbing with a detergent solution followed by a potable water rinse.

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for chemical analysis, the sampler shall be decontaminated following the procedures outlined in the following subsection.

C. Field Analytical Equipment

1. Water Level Indicators

Water level indicators that consist of a probe that comes into contact with the groundwater must be decontaminated using the following steps:

- a. Rinse with tap water
- b. Rinse with de-ionized water
- c. Solvent rinse with isopropanol
- d. Rinse with de-ionized water

2. Probes

Probes, for example, pH or specific ion electrodes, geophysical probes, or thermometers that would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise. For probes that make no direct contact, for example, OVM equipment, the probe will be wiped with clean paper-towels or cloth wetted with isopropanol.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- The effectiveness of field cleaning procedures may be monitored by rinsing decontaminated equipment with organic-free water and submitting the rinse water in standard sample containers for analysis.

Disposal of Waste Fluids and Solids

I. Purpose and Scope

This SOP describes the procedures used to dispose of hazardous fluid and solid materials generated as a result of the site operations. This SOP does not provide guidance on the details of Department of Transportation regulations pertaining to the transport of hazardous wastes; the appropriate Code of Federal Regulations (49 CFR 171 through 177) should be referenced. Also, the site investigation-derived waste management plan should be consulted for additional information and should take precedence over this SOP.

II. Equipment and Materials

A. Fluids

- DOT-approved 55-gallon steel drums or Baker® Tanks
- Tools for securing drum lids
- Funnel for transferring liquid into drum
- Labels
- Paint Pens
- Marking pen for appropriate labels
- Seals for 55-gallon steel drums

B. Solids

- DOT-approved 55-gallon steel drums or rolloffs
- Tools for securing drum lids
- Paint Pens
- Plastic sheets
- Labels
- Marking pen for appropriate labels

III. Procedures and Guidelines

A. Methodology

Clean, empty drums or rolloffs or Baker® Tanks will be brought to the site by the drilling subcontractor for soil and groundwater collection and storage. The empty drums will be located at the field staging area and moved to drilling locations as required. The drums will be filled with the drilling and well installation wastes, capped, sealed, and moved to the onsite drum storage area by the drilling subcontractor. The full drums will separate types of wastes by media. The drums will

be labeled as they are filled in the field and labels indicating that the contents are pending analysis affixed.

The drum contents will be sampled to determine the disposal requirements of the drilling wastes. The drum sampling will be accomplished through the collection and submittal of composite samples, one sample per 10 drums (check with disposal facility to determine sample frequency) containing the same media. Similar compositing will be performed in each rolloff to obtain a representative sample. The compositing of the sample will be accomplished by collecting a specific volume of the material in each drum into a large sample container. When samples from each of the drums being sampled in a single compositing are collected, the sample will be submitted for TCLP, ignitability, corrosivity, and reactivity analysis. The analysis will be used to determine if drilling wastes are covered by land disposal restrictions.

If rolloffs are used, compositing and sampling of soil will comply with applicable state and federal regulations.

B. Labels

Drums and other containers used for storing wastes from drilling operations will be labeled when accumulation in the container begins. Labels will include the following minimum information:

- Container number
- Container contents
- Origin (source area including individuals wells, piezometers, and soil borings)
- Date that accumulation began
- Date that accumulation ended
- Generator Contact Information
- When laboratory results are received, drum labels will be completed or revised to indicate the hazardous waste constituents in compliance with Title 40 of the Code of Federal Regulations, Part 262, Subpart C if the results indicate hazardous waste or labeled as non-hazardous if applicable.

C. Fluids

Drilling fluids generated during soil boring and groundwater discharged during development and purging of the monitoring wells will be collected in 55-gallon, closed-top drums. When a drum is filled, the bung will be secured tightly. Fluids may also be transferred to Baker® Tanks after being temporarily contained in drums to minimize the amount of drums used.

When development and purging is completed, the water will be tested for appropriate hazardous waste constituents. Compositing and sampling of fluids will comply with applicable state and federal regulations.

D. Solids

The soil cuttings from well and boring drilling will constitute a large portion of the solids to be disposed of.

The solid waste stream also will include plastic sheeting used for decontamination pads, Tyveks, disposable sampling materials, and any other disposable material used during the field operations that appears to be contaminated. These materials will be placed in designated drums.

E. Storage and Disposal

The wastes generated at the site at individual locations will be transported to the drum storage area by the drilling services subcontractor. Drums should be stored on pallets on plastic sheeting with a short berm wall (hay bales or 2 x 4 planks or equivalent) to capture small spills.

Waste solid materials that contain hazardous constituents will be disposed of at an offsite location in a manner consistent with applicable solid waste, hazardous waste, and water quality regulations. Transport and disposal will be performed by a commercial firm under subcontract.

The liquid wastes meeting acceptable levels of discharge contamination may be disposed of through the sanitary sewer system at the site. However, prior to disposal to the sanitary sewer system, approval and contract arrangements will be made with the appropriate authorities. Wastes exceeding acceptable levels for disposal through the sanitary sewer system will be disposed of through contract with a commercial transport and disposal firm.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- Check that representative samples of the containerized materials are obtained.
- Be sure that all state and federal regulations are considered when classifying waste for disposal.

Sampling Contents of Tanks and Drums

I. Scope and Application

This procedure provides an overview approach and guidelines for the routine sampling of drums and tanks. Its purpose is to describe standard procedures and precautions which are applied in sampling drums and tanks. Procedures for opening drums with the individual instruments are included in Attachment D.

The samples obtained may be used to obtain physical chemical or radiological data. The resulting data may be qualitative or quantitative in nature, and are appropriate for use in preliminary surveys as well as confirmatory sampling.

II. Summary of Methods

Drums are generally sampled by means of sampling tubes such as glass sample tubes or COLIWASA samplers. In either case, the sampling tube is manually inserted into the waste material. A sample of the drum contents is withdrawn by the sampling device. Should a drum contain bottom sludge, a glass tube will be used to retrieve a sample of this as well.

Storage tank and tank trailers, because of their greater depths, require sampling devices that can be lowered from the top, filled at a particular depth, then withdrawn. Such devices are a COLIWASA, a Kemmerer depth sampler, or a Bacon Bomb. Where samples of bottom sludge are desired, a gravity corer can be utilized. This heavy tube with a tapered nose piece will penetrate the sludge as it free falls through the tank.

III. Comments

The sampling of tanks, containers, and drums present unique problems not associated with environmental samples. Containers of this sort are generally closed except for small access ports, manways, or hatches on the larger vessels, or taps and bungs on smaller drums. The physical size, shape, construction material, and location of access limit the types of equipment and methods of collection that can be used.

When liquids are contained in sealed vessels, gas vapor pressure can build up, sludges can settle out, and density layerings (stratification) can develop. Bulging drums may be under pressure and extreme caution should be exercised. The potential exists for explosive reactions or the release of noxious gases when containers are opened. All vessels should be opened with extreme caution. Check the HSP for the level of personnel protection to be worn. A preliminary sampling of any headspace gases is warranted. As a minimum, a preliminary check with an

explosimeter and an organic vapor analyzer may be of aid in selecting a sampling method.

In most cases it is impossible to observe the contents of these sealed or partially sealed vessels. Since some layering or stratification is likely in any solution left undisturbed over time, a sample must be taken that represents the entire depth of the vessel.

IV. Required Equipment and Apparatus

- A. **Health and safety equipment/materials:** As listed in the site safety plan.
- B. **Sampling equipment:** COLIWASA, glass sample tubes, Kemmerer depth sampler, Bacon Bomb, gravity corer.
- C. **Tools:** Rubber mallet, bung wrench, speed wrench with socket, etc., (all non-sparking), paint marker.
- D. **Heavy equipment:** Backhoe equipped with explosion shield, drum grappler, and 3-foot copper-beryllium (non-sparking) spike with 6-inch collar (to puncture top of drums for sampling, if necessary).
- E. **Sample Containers:** As specified in the field sampling plan.

V. Procedures

A. Drums

NOTE: DO NOT open more than one drum at a time. Each drum must be handled and sampled as a separate entity to reduce vapors in the sampling area.

1. Drums will be sampled on an area-by-area basis. Drums will be sampled after they have been placed in overpack drums but before they are transferred from the excavation to the onsite storage area.
2. Record, in logbook, all pertinent information from visual inspection of drum (e.g., physical condition, leaks, bulges, and labels). Label each drum with a unique identifying number.
3. If possible, stage drums for easy access.
4. If necessary, attach ground strap to drums and grounding point.
5. Remove any standing material (water, etc.) from container top.
6. Using non-sparking tools, carefully remove the bung or lid while monitoring air quality with appropriate instruments. If necessary (and as a last resort), the non-sparking spike affixed to the backhoe can also be used to puncture the drum for sampling. See Attachment D for method of drum opening. Record air-quality monitoring results.

7. When sampling a previously sealed vessel, a check should be made for the presence of bottom sludge. This is accomplished by measuring the depth to apparent bottom, then comparing it to the known interior depth.
8. Agitation to disrupt the layers and rehomogenize the sample is physically difficult and almost always undesirable. If the vessel is greater than 3 feet in depth (say, a 55-gallon drum), the appropriate sampling method is to slowly lower the sampling device (i.e., suction line of peristaltic pump, glass tube) in known increments of length. Discrete samples can be collected from various depths, then combined or analyzed separately. If the depth of the vessel is greater than the lift capacity of the pump, an at-depth water sampler, such as the Kemmerer or Bacon Bomb type, may be required.
9. Extract a representative sample from the drum using a glass rod, COLIWASA, Bacon Bomb, Kemmerer bottle, or gravity corer (See Attachments). Ensure that the entire depth of material is penetrated. Depending on the size of the opening of the drum, three to four takes should be collected from random locations across the drum surface, to ensure a representative sample. Any observed stratification must be recorded in logbook, including number and thickness of the layers and a conceptualized sketch.
10. Record a visual description of the sample (e.g., liquid, solid, color, viscosity, and percent layers).
11. When possible, sampling equipment (like glass tubes) should be expendable and be left inside the drum for disposal with drum contents, once sampling is completed.
12. Place lid, bung, cap, etc., back in place on drum. Tighten hand tight. If necessary, the sampling port can be sealed using a cork.
13. Wipe up spilled material with lab wipes. Wipe off sample containers.
14. Mark the drum with a unique sample identification number and date using a paint marker.
15. Samples will be handled as high hazard samples. Samples will be placed in containers defined according to the analytical needs, wiped clean, and then packed in paint cans for shipping. Packaging, labeling, and preparation for shipment procedures will follow procedures as specified in the field sampling plan.

B. Underground Storage Tanks

1. A sampling team of at least two people is required for sampling – one will collect samples, the other will relay required equipment and implements.

2. Sampling team will locate a sampling port on the tank. Personnel should be wearing appropriate protective clothing at this time and carrying sampling gear.
3. Do not attempt to climb down into tank. Sampling MUST BE accomplished from the top.
4. Collect a sample from the upper, middle, and lower section of the tank contents with one of the recommended sampling devices.
5. If compositing is necessary, ship samples to laboratory in separate containers for laboratory compositing.
6. Samples will be handled as hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging, labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

C. Tank Trailers or Above-Ground Storage Tanks

1. A sampling team of two is required. One will collect samples, the other will relay required equipment and implements.
2. Samples will be collected through the manhole (hatch) on top of the tanker or the fill port. Do not open valves at the bottom. Before opening the hatch, check for a pressure gauge or release valve. Open the release valve slowly to bring the tank to atmospheric pressure.
3. If tank pressure is too great, or venting releases large amounts of toxic gas, discontinue venting and sampling immediately. Measure vented gas with organic vapor analyzer and explosimeter.
4. If no release valve exists, slowly loosen hatch cover bolts to relieve pressure in the tank. (Again, stop if pressure is too great.)
5. Once pressure in tank has been relieved, open the hatch and withdraw sample using one of the recommended sampling devices.
6. Sample each trailer compartment.
7. If compositing is necessary, ship samples to laboratory in separate containers for laboratory compositing.
8. Samples will be handled as hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging, labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

- D. Refer to Attachment B for procedures for sampling with appropriate devices as follows:

Drum

Glass tube	–	Procedure 1
COLIWASA	–	Procedure 2

Storage Tank and Tank Trailer

COLIWASA	–	Procedure 2
Bacon Bomb	–	Procedure 3
Gravity Corer (for bottom sludge)	–	Procedure 4

VI. Contamination Control

Sampling tools, instruments, and equipment will be protected from sources of contamination prior to use and decontaminated after use as specified in SOP *Decontamination of Personnel and Equipment*. Liquids and materials from decontamination operations will be handled in accordance with the waste management plan. Sample containers will be protected from sources of contamination. Sampling personnel shall wear chemical resistant gloves when handling any samples. Gloves will be decontaminated or disposed of between samples.

VIII. Attachments

- A. Collection of Liquid-Containerized Wastes Using Glass Tubes
- B. Sampling Containerized Wastes Using the Composite Liquid Waste Sample (COLIWASA)
- C. Sampling Containerized Wastes Using the Bacon Bomb Sampler
- D. Gravity Corer for sampling Sludges in Large Containers
- E. Construction of a Typical COLIWASA
- F. Drum Opening Techniques and Equipment

IX. References

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X. Field Checklist

- | | |
|--------------------------------------|--|
| _____ Sampling Instruments | _____ Labels |
| _____ Tools | _____ Sampling and Analysis Plan |
| _____ Rubber Mallet | _____ Health and Safety Plan |
| _____ Logbook | _____ Decontamination Equipment |
| _____ Safety Glasses or Monogoggles | _____ Lab Wipes |
| _____ Safety Shoes | _____ Lab Spatulas or Stainless Steel Spoons |
| _____ Ice/Cooler, as required | _____ Chemical Preservatives, as required |
| _____ Custody Seals, as required | _____ Appropriate Containers for Waste and Equipment |
| _____ Chain-of-Custody Forms | _____ Duct Tape |
| _____ Drum Labels, as required | _____ Plastic Sheeting |
| _____ Paint Marker, if drum sampling | |
| _____ Black Indelible Pen | |
| _____ Monitoring Instruments | |

Attachment A Collection of Liquid-Containerized Wastes Using Glass Tubes

Discussion

Liquid samples from opened containers (i.e., 55-gallon drums) are collected using lengths of glass tubing. The glass tubes are normally 122 centimeters long and 6 to 16 millimeters inside diameter. Larger diameter tubes may be used for more viscous fluids if sampling with the small diameter tube is not adequate. The tubing is broken and discarded in the container after the sample has been collected, eliminating difficult cleanup and disposal problems. This method should not be attempted with less than a two-person sampling team.

Uses

This method provides for a quick, relatively inexpensive means of collecting concentrated containerized wastes. The major disadvantage is from potential sample loss that is especially prevalent when sampling low-viscosity fluids. Splashing can also be a problem and proper protective clothing should always be worn.

Note: A flexible tube with an aspirator attached is an alternative method to the glass tube, and allows various levels to be sampled discretely.

Procedures for Use

1. Remove cover from sample container.
2. Insert glass tubing almost to the bottom of the container. Tubing should be of sufficient length so that at least 30 centimeters extend above the top of the container.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Cap the top of the tube with a safety-gloved thumb or a stopper.
5. Carefully remove the capped tube from the drum. If the tube has passed through more than one layer, the boundary should be apparent in the glass tube.
6. Insert the bottom, uncapped end into the sample container.
7. Partially release the thumb or stopper on the top of the tube and allow the sample to slowly flow into the sample container. If separation of phases is desired, cap off tube before the bottom phase has completely emptied. It may be advisable to have an extra container for "waste," so that the fluid on either side of the phase boundary can be directed into a separate container, allowing collection of pure phase liquids in the sample containers. The liquid remaining after the boundary fluid is removed is collected in yet a third container. NOTE: It is not necessary to put phases in separate containers if analysis of separate phases is not desired.
8. Repeat steps 2 through 6 if more volume is needed to fill the sample container.
9. Remove the tube from the sample container and replace the tube in the drum, breaking it, if necessary, in order to dispose of it in the drum.

Optional Method (if sample of bottom sludge is desired)

1. Remove the cover from the container opening.
2. Insert glass tubing slowly almost to the bottom of the container. Tubing should be of sufficient length so that at least 30 cm extends above the top of the container.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Gently push the tube towards the bottom of the drum into the sludge layer. Do not force it.
5. Cap the top of the tube with a safety-gloved thumb or stopper.
6. Carefully remove the capped tube from the drum and insert the uncapped end into the sample container.
7. Release the thumb or stopper on the top of the tube and allow the sample container to fill to approximately 90 percent of its capacity. If necessary, the sludge plug in the bottom of the tube can be dislodged with the aid of the stainless steel laboratory spatula.
8. Repeat if more volume is needed to fill sample container and recap the tube.

Note:

1. If a reaction is observed when the glass tube is inserted (violent agitation, smoke, light, etc.), the investigators should leave the area immediately.
2. If the glass tube becomes cloudy or smoky after insertion into the drum, the presence of hydrofluoric acid maybe indicated, and a comparable length of rigid plastic tubing should be used to collect the sample.
3. When a solid is encountered in a drum (either layer or bottom sludge) the optional method described above may be used to collect a core of the material, or the material may be collected with a disposable scoop attached to a length of wooden or plastic rod.

Attachment B: Sampling Containerized Wastes using the Composite Liquid Waste Sampler (COLIWASA)

Discussion

The COLIWASA is a much-cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. The sampler is commercially available or can be easily fabricated from a variety of materials, including PVC, glass, or Teflon. In its usual configuration it consists of a 152 cm by 4 cm (inside diameter) section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper. See Attachment E: Construction of a COLIWASA.

Uses

The COLIWASA is primarily used to sample containerized liquids. The PVC COLIWASA is reported to be able to sample most containerized liquid wastes except for those containing ketones, nitrobenzene, dimethylformamide, mesityl oxide, and tetrahydrofuran. A glass COLIWASA is able to handle all wastes unable to be sampled with the plastic unit except strong alkali and hydrofluoric acid solutions. Due to the unknown nature of many containerized wastes, it would therefore be advisable to eliminate the use of PVC materials and use samplers composed of glass or Teflon.

The major drawback associated with using a COLIWASA is concern for decontamination and costs. The sampler is difficult, if not impossible, to decontaminate in the field, and its high cost in relation to alternative procedures (glass tubes) makes it an impractical throwaway item. It still has applications, however, especially in instances where a true representation of a multiphase waste is absolutely necessary.

Procedures for Use

1. Check to make sure the sampler is functioning properly. Adjust the locking mechanism, if present, to make sure the neoprene rubber stopper provides a tight closure.
2. Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.
3. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.
4. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.

5. Slowly withdraw the sampler from the waste container with one hand while wiping the sampler tube with a laboratory wipe with the other hand. A phase boundary, if present, can be observed through the tube.
6. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.
7. Unscrew the T-handle of the sampler and disengage the locking block.

Attachment C: Sampling Containerized Wastes using the Bacon Bomb Sampler

Discussion

The Bacon Bomb is designed for the withdrawal of samples from various levels within a storage tank. It consists of a cylindrical body with an internal tapered plunger that acts as a valve to admit the sample. A line attached to the top of the plunger is used to open and close the valve. A removable cover provides a point of attachment for the sample line and has a locking mechanism to keep the plunger closed after sampling. The Bacon Bomb is usually constructed of chrome-plated brass and bronze with a rubber O-ring acting as the plunger-sealing surface. Stainless steel versions are also available. The volumetric capacity is 8, 16, or 32 oz (237, 473, or 946 ml).

Uses

The Bacon Bomb is a heavy sampler suited best for viscous materials held in large storage tanks or in lagoons. If a more non-reactive sampler is needed, the stainless steel version would be used, or any of the samplers could be coated with Teflon.

Procedures for Use

1. Attach the sample line and the plunger line to the sampler.
2. Measure and then mark the sampling line at the desired depth.
3. Gradually lower the sampler by the sample line until the desired level is reached.
4. When the desired level is reached, pull up on the plunger line and allow the sampler to fill for a sufficient length of time before releasing the plunger line to seal off the sampler.
5. Retrieve the sampler by the sample line, being careful not to pull up on the plunger line, thereby accidentally opening the bottom valve.
6. Wipe off the exterior of the sampler body.
7. Position the sampler over the sample container and release its contents by pulling up on the plunger line.

Attachment D: Gravity Corer for Sampling Sludges in Large Containers

Discussion

A gravity corer is a metal tube with a replaceable tapered nosepiece on the bottom and a ball or other type of check valve on the top. The check valve allows water to pass through the corer on descent but prevents a washout during recovery. The tapered nosepiece facilitates cutting and reduces core disturbance during penetration. Most corers are constructed of brass or steel and many can accept plastic liners and additional weights.

Uses

Corers are capable of collecting samples of most sludges and sediments. They collect essentially undisturbed samples that represent the strata profile that may develop in sediments and sludges during variations in the deposition process. Depending on the density of the substrate and the weight of the corer, penetration to depths of 75 cm (30 in.) can be attained. Exercise care when using gravity corers in vessels or lagoons that have liners because penetration depths could exceed those of the substrate; this could result in damage to the liner material.

Procedures for Use

1. Attach a precleaned corer to the required length of sample line. Solid braided 5-mm (3/16-in.) nylon line is sufficient; however, 20-mm (3/4-in.) nylon is easier to grasp during hand hoisting. An additional weight can be attached to the outside of the corer if necessary.
2. Secure the free end of the line to a fixed support to prevent accidental loss of the corer.
3. Allow corer to free fall through the liquid to the bottom.
4. Retrieve corer with a smooth, continuous, up-lifting motion. Do not bump corer because this may result in some sample loss.
5. Remove nosepiece from corer and slide sample out of corer into stainless steel or Teflon pan (preferred).
6. Transfer sample into appropriate sample bottle with a stainless steel lab spoon or laboratory spatula.

Attachment E: Construction of a Typical COLIWASA

The sampling tube consists of a 1.52-m (5-ft) by 4.13-cm (1-5/8 in) I.D. translucent plastic pipe, usually polyvinyl chloride (PVC) or borosilicate glass plumbing tube. The closure-locking mechanism consists of a short-length, channeled aluminum bar attached to the sampler's stopper rod by an adjustable swivel. The aluminum bar serves both as a T-handle and lock for the samplers' closure system. When the sampler is in the open position, the handle is placed in the T-position and pushed down against the locking block. This manipulation pushes out the neoprene stopper and opens at the sampling tube. In the closed position, the handle is rotated until one leg of the T is squarely perpendicular against the locking block. This tightly seats the neoprene stopper against the bottom opening of the sampling tube and positively locks the sampler in the closed position. The closure tension can be adjusted by shortening or lengthening the stopper rod by screwing it in or out of the T-handle swivel. The closure system of the sampler consists of a sharply tapered neoprene stopper attached to a 0.95-cm (3/8-in) O.D. rod, usually PVC. The upper end of the stopper rod is connected to the swivel of the aluminum T-handle. The sharply tapered neoprene stopper can be fabricated according to specifications by plastic-products manufacturers at an extremely high price, or it can be made in-house by grinding down the inexpensive stopper with a shop grinder.

COLIWASA samplers are typically made out of plastic or glass. The plastic type consists of translucent plastic (usually PVC) sampling tube. The glass COLIWASA uses borosilicate glass plumbing pipe as the sampling tube and a Teflon plastic stopper rod. For purpose of multiphase sampling, clear plastic or glass is desirable in order to observe the profile of the multiphase liquid.

The sampler is assembled as follows:

- a. Attach the swivel to the T-handle with the 3.18-cm (1-1/4 in) long bolt and secure with the 0.48-cm (3/16-in) National Coarse (NC) washer and lock nut.
- b. Attach the PTFE stopper to one end of the stopper rod and secure with the 0.95-cm (3/8-in) washer and lock nut.
- c. Install the stopper and stopper rod assembly in the sampling tube.
- d. Secure the locking block sleeve on the block with glue or screw. This block can also be fashioned by shaping a solid plastic rod on a lathe to the required dimension.
- e. Position the locking block on top of the sampling tube such that the sleeveless portion of the block fits inside the tube, the sleeve sits against the top end of the tube, and the upper end of the stopper rod slips through the center hole of the block.
- f. Attach the upper end of the stopper rod to the swivel of the T-handle.
- g. Place the sampler in the close position and adjust the tension on the stopper by screwing the T-handle in or out.

Attachment F: Drum Opening Techniques and Equipment ¹

I. Introduction

The opening of closed drums prior to sampling entails considerable risk if not done with the proper techniques, tools, and safety equipment. The potential for vapor exposure, skin exposure due to splash or spraying, or even explosion resulting from sparks produced by friction of the tools against the drum, necessitate caution when opening any closed container. Both manual drum opening and remote drum opening will be discussed in the following paragraphs. When drums are opened manually risks are greater than when opened remotely; for this reason, the remote opening of drums is advised whenever possible.

Prior to sampling, the drums should be staged to allow easy access. Also, any standing water or other material should be removed from the container top so that the representative nature of the sample is not compromised when the container is opened. There is also the possibility of encountering a water-reactive substance.

II. Manual Drum Opening

A. Bung Wrench

A common method for opening drums manually is using a universal bung wrench. These wrenches have fittings made to remove nearly all commonly encountered bungs. They are usually constructed of cast iron, brass, or a bronze-beryllium (a non-sparking alloy formulated to reduce the likelihood of sparks). The use of bung wrenches marked "NON SPARKING" is encouraged. However, the use of a "NON SPARKING" wrench does not completely eliminate the possibility of spark being produced. Such a wrench only prevents a spark caused by wrench-to-bung friction, but it cannot prevent sparking between the threads on the drum and the bung.

A simple tool to use, the fitting on the bung wrench matching the bung to be removed is inserted into the bung and the tool is turned counterclockwise to remove the bung. Since the contents of some drums may be under pressure (especially, when the ambient temperature is high), the bung should be turned very slowly. If any hissing is heard, the person opening the drum should back off and wait for the hissing to stop. Since drums under pressure can spray out liquids when opened, the wearing of appropriate eye and skin protection in addition to respiratory protection is critical.

B. Drum Deheader

One means by which a drum can be opened manually when a bung is not removable with a bung wrench is by using a drum deheader. This tool is constructed of forged steel with an alloy steel blade and is designed to cut the lid of a drum off or part way

¹ Taken from EPA Training Course: "Sampling for Hazardous Materials," U.S. Environmental Protection Agency, Office of Emergency and Remedial Response Support Division, March 24, 1987.

off by means of a scissors-like cutting action. A limitation of this device is that it can be attached only to closed head drums (i.e., DOT Specification 17E and 17F drums); drums with removable heads must be opened by other means.

Drums are opened with a drum deheader by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chime will enable the entire top to be rapidly cut off if so desired. If the top chime of a drum has been damaged or badly dented it may not be possible to cut the entire top off. Since there is always the possibility that a drum may be under pressure, the initial cut should be made very slowly to allow for the gradual release of any built-up pressure. A safer technique would be to employ a remote pressure release method prior to using the deheader.

C. Hand Pick or Spike

When a drum must be opened and neither a bung wrench nor a drum deheader is suitable, then it can be opened for sampling by using a hand pick, pickaxe, or spike. These tools are usually constructed of brass or a non-sparking alloy with a sharpened point that can penetrate the drum lid or head when the tool is swung. The hand picks or pickaxes that are most commonly used are commercially available, whereas the spikes are generally uniquely fabricated 4-foot long poles with a pointed end. Often the drum lid or head must be hit with a great deal of force in order to penetrate it. Because of this, the potential for splash or spraying is greater than with other opening methods and therefore this method of drum opening is not recommended, particularly when opening drums containing liquids. Some spikes used for drum opening have been modified by the addition of a circular splash plate near the penetrating end. This plate acts as a shield and reduces the amount of splash in the direction of the person using the spike. Even with this shield, good splash gear is essential.

Since drums, some of which may be under pressure, cannot be opened slowly with these tools, "sprayers" may result and appropriate safety measures must be taken. The pick or spike should be decontaminated after each drum is opened to avoid cross contamination and/or adverse chemical reaction from incompatible materials.

III. Remote Opening

A. Backhoe Spike

The most common means used to open drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket. In addition to being very efficient, this method can greatly reduce the likelihood of personnel exposure.

Drums should be "staged," or placed in rows with adequate aisle space to allow ease in backhoe maneuvering. Once staged, the drums can be quickly opened by punching a hole in the drum head or lid with the spike.

The spike should be decontaminated after each drum is opened to prevent cross contamination. Even though some splash or spray may occur when this method is

used, the operator of the backhoe can be protected by mounting a large shatter-resistant shield in front of the operator's cage. This, combined with the normal sampling safety gear, should be sufficient to protect the operator. Additional respiratory protection can be afforded by providing the operator with an on-board airline system. The hole in the drum can be sealed with a cork.

B. Hydraulic Devices

Recently, remotely operated hydraulic devices have been fabricated to open drums remotely. One such device is discussed here. This device uses hydraulic pressure to pierce through the wall of a drum. It consists of a manually operated pump that pressurizes oil through a length of hydraulic line. A piercing device with a metal point is attached to the end of this line and is pushed into the drum by the hydraulic pressure. The piercing device can be attached so that a hole for sampling can be made in either the side or the head/lid of the drum. Some of the metal piercers are hollow or tube-like so that they can be left in place, if desired, and serve as a permanent tap or sampling port. The piercer is designed to establish a tight seal after penetrating the container.

C. Pneumatic Devices

Pneumatically-operated devices utilizing compressed air have been designed to remove drum bungs remotely. A pneumatic bung remover consists of a compressed air supply (usually SCBA cylinders) that is controlled by a heavy-duty, 2-stage regulator. A high pressure air line of desired length delivers compressed air to a pneumatic drill that is adapted to turn a bung fitting (preferably, a bronze-beryllium alloy) selected to fit the bung to be removed. An adjustable bracketing system has been designed to position and align the pneumatic drill over the bung. This bracketing system must be attached to the drum before the drill can be operated. Once the bung has been loosened, the bracketing system must be removed before the drum can be sampled. This attachment and removal procedure is time-consuming and is the major drawback of this device. This remote bung opener does not permit the slow venting of the container, and therefore appropriate precautions must be taken. It also requires the container to be upright and relatively level. Bungs that are rusted shut cannot be removed with this device.

IV. Summary

The opening of closed containers is one of the most hazardous site activities. Maximum efforts would be made to ensure the safety of the sampling team. Proper protective equipment and a general wariness of the possible dangers will minimize the risk inherent to sampling operations. Employing proper drum opening techniques and equipment will also safeguard personnel. The use of remote sampling equipment whenever feasible is highly recommended.

Global Positioning System

I. Purpose

The procedure describes the calibration, operation, and functions associated with a Trimble® Pro XRS GPS Unit with a TSC-1 Asset Surveyor for datalogging. GPS signal information is differentially corrected to sub-meter accuracy on a continual basis using a second satellite signal broadcast from OmniSTAR satellite subscription service. The procedure applies to all field data collection activities.

II. Scope

This procedure provides information regarding the field operation and general maintenance of a Trimble® Pro XRS GPS Unit with a TSC-1 Asset Surveyor for datalogging. The information contained herein presents the operation procedures for this equipment. Review of the equipment's instruction manual is a necessity for more detailed descriptions pertaining to the operation and maintenance of the equipment.

III. Definitions

GPS: Global Positioning System - A system of 24 satellites developed and operated by the US DOD. Continuous 3D coordinate information is broadcast free of charge on a worldwide basis enabling precise positional location. Three standard categories of positional accuracy are generally used:

1. Uncorrected Signal - accuracy +/-10 meters - a single satellite transmission is used
2. Differentially Corrected Signal - accuracy +/- <1 meter - additional positional transmissions are recorded simultaneously and used to triangulate coordinate position.
3. Carrier Phase Signal- accuracy +/- <1 centimeter - requires a second receiver and additional software. Both receivers need to be equipped to receive Carrier Phase signals.

IV. Procedures and Guidelines

The procedure for calibration, operation, and maintenance of the GPS unit is outlined below. Daily calibration and battery recharging is typical operating procedure; frequencies other than daily shall be noted in the logbook and reason for increased frequency recorded. If using a different instrument, the operation manual supplied by the manufacturer should be consulted for instructions.

The procedures described below include additional features pre-programmed into the GPS datalogger to aid the data collection process.

A. Calibration

1. Check to ensure that the datalogger and antenna cables are properly connected to the receiver and that the batteries are securely connected.
2. Turn the datalogger unit on by pressing the green **On** key in the bottom left corner. The datalogger will perform a self-calibration. Wait to ensure that the antenna is receiving a sufficient number of satellite signals (usually a minimum of 3).
3. Once the datalogger receives a satellite signal then it is ready for operation.

B. Operations for surveying coordinates of a location

1. The datalogger and GPS receiver are ready for use after the initial self-calibration.
2. Field data may be immediately recorded in the datalogger.
3. The first screen view is the 'Main Menu'. Use the round keypad to select 'Data Collection' and press the **Enter** key.
4. Use the round keypad to select either 'Create new file' or 'Open existing file' and press the **Enter** key. It is not necessary to create a new file at each new location; however, it may be useful to create a new file at the beginning of each day.
5. If a new file is created then the GPS unit will automatically assign it a file name. The file name may be changed if desired. Press the enter key after the file name is assigned. If opening an existing file then use the round keypad to scroll through existing file names.
6. The next screen is 'Antenna options'. Press the **Enter** key to move to the next screen.
7. Select the type of activity to be performed. At the beginning of each day 'Sample Site Detail' should be completed. This allows the operator to enter each field team member, weather, objectives, health and safety meetings, etc. Once the 'Sample Site Detail' is completed then data entry activities may begin including well purging, water level elevations, and sample collection
8. The datalogger prompts the operator when a data field is required and by using the round key pad, numeric, alphanumeric, enter, and escape keys, the operator can perform electronic data capture on the GPS datalogger.
9. Once all information pertaining to an individual site has been recorded, press enter to complete data entry. If GPS signal is obstructed (tree canopy, building height, etc) user may choose to remain in same location until satellite transmission clears the obstruction. This usually takes only a few moments. Data may still be captured and recorded electronically even if GPS signal is insufficient for positioning.
10. To shut down, press the **Escape** key to return to the 'Main Menu'. The unit can be turned off by pressing the green key in the left hand corner. The datalogger should only be turned off when the 'Main Menu' screen is displayed.
11. All data from the datalogger should be downloaded into Trimble Pathfinder Office software on a PC a minimum of once daily. It is recommended that data is downloaded twice daily. Data may be viewed and mapped using Pathfinder Office or exported to

other software. Export file formats support standard ASCII text, generic database .dbf and most GIS and CAD software.

C. Operations for locating a point using coordinates/reacquiring a previously surveyed location

1. The datalogger and GPS receiver are ready for use after the initial self-calibration.
2. Use the Trimble Pathfinder software to load the data file containing the coordinates for each desired location ("programmed location").
3. The first screen view is the 'Main Menu'. Use the keypad to select 'Navigation' and press the **Enter** key.
4. Use the round keypad to select 'Open existing file' to open the file loaded in Step 2 above.
5. Select the location to be reacquired from the screen and press the enter key.
6. A circle with an arrow will appear. As you begin walking, the arrow will point in the direction of the programmed location. Walk in the direction indicated by the arrow.
7. Once you are within 10-feet of the location being reacquired, the GPS unit will display a circle (representing the programmed location) and an "X" (representing the GPS unit). Continue to walk in the direction of the circle until the "X" is centered in the circle. Once the "X" is centered, you are standing at the programmed location.
8. To shut down, press the **Escape** key to return to the 'Main Menu'. The unit can be turned off by pressing the green key in the left hand corner. The datalogger should only be turned off when the 'Main Menu' screen is displayed.

D. Preventive Maintenance

The antenna and datalogger are weatherproof. It is recommended that the receiver remain in the provided backpack carrier. Care should be taken not to crease, pinch or bend the antenna cable. Data should be downloaded from the datalogger a minimum of once daily, twice daily is preferred. At the end of each day the receiver batteries should be recharged. For technical assistance call the rental company through which you acquired the Trimble® unit. Guidance is also provided in the manual and at <http://www.trimble.com>.

Homogenization of Soil and Sediment Samples

I. Purpose

The homogenization of soil and sediment samples is performed to minimize any bias of sample representativeness introduced by the natural stratification of constituents within the sample.

II. Scope

Standard techniques for soil and sediment homogenization and equipment are provided in this SOP. These procedures do not apply to aliquots collected for VOCs or field GC screening; samples for these analyses should NOT be homogenized.

III. Equipment and Materials

Sample containers, stainless steel spoons or spatulas, and stainless steel pans.

IV. Procedures and Guidelines

Soil and sediment samples to be analyzed for semivolatiles, pesticides, PCBs, metals, cyanide, or field XRF screening should be homogenized in the field. After a sample is taken, a stainless steel spatula should be used to remove the sample from the split spoon or other sampling device. The sampler should not use fingers to do this, as gloves may introduce organic interferences into the sample.

Samples for VOCs should be taken immediately upon collection and should not be homogenized.

Prior to homogenizing the soil or sediment sample, any rocks, twigs, leaves, or other debris should be removed from the sample. The sample should be placed in a decontaminated stainless steel pan and thoroughly mixed using a stainless steel spoon. The soil or sediment material in the pan should be scraped from the sides, corners, and bottom, rolled into the middle of the pan, and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually, and then rolled to the center of the pan and mixed with the entire sample again.

All stainless steel spoons, spatulas, and pans must be decontaminated following procedures specified in SOP *Decontamination of Personnel and Equipment* prior to homogenizing the sample. A composite equipment rinse blank of homogenization equipment should be taken each day it is used.

V. Attachments

None.

VI. Key Checks and Items

- Take VOC samples immediately and do not homogenize the soil.
- Homogenize soil for analyses other than VOCs in a clean, stainless steel bowl.

Preparing Field Log Books

I. Purpose

This SOP provides general guidelines for entering field data into log books during site investigation and remediation activities.

II. Scope

This is a general description of data requirements and format for field log books. Log books are needed to properly document all field activities in support of data evaluation and possible legal activities.

III. Equipment and Materials

- Log book
- Indelible pen

IV. Procedures and Guidelines

Properly completed field log books are a requirement for much of the work we perform under the Navy CLEAN contract. Log books are legal documents and, as such, must be prepared following specific procedures and must contain required information to ensure their integrity and legitimacy. This SOP describes the basic requirements for field log book entries.

A. PROCEDURES FOR COMPLETING FIELD LOG BOOKS

1. Field notes commonly are kept in bound, hard-cover logbooks used by surveyors and produced, for example, by Peninsular Publishing Company and SESCO, Inc. Pages should be water-resistant and notes should be taken only with water-proof, non-erasable permanent ink, such as that provided in Sanford Sharpie® permanent markers.
2. On the inside cover of the log book the following information should be included:
 - Company name and address
 - Log-holders name if log book was assigned specifically to that person
 - Activity or location

- Project name
 - Project manager's name
 - Phone numbers of the company, supervisors, emergency response, etc.
3. All lines of all pages should be used to prevent later additions of text, which could later be questioned. Any line not used should be marked through with a line and initialed and dated. Any pages not used should be marked through with a line, the author's initials, the date, and the note "Intentionally Left Blank."
 4. If errors are made in the log book, cross a single line through the error and enter the correct information. All corrections shall be initialed and dated by the personnel performing the correction. If possible, all corrections should be made by the individual who made the error.
 5. Daily entries will be made chronologically.
 6. Information will be recorded directly in the field log book during the work activity. Information will not be written on a separate sheet and then later transcribed into the log book.
 7. Each page of the log book will have the date of the work and the note takers initials.
 8. The final page of each day's notes will include the note-takers signature as well as the date.
 9. Only information relevant to the subject project will be added to the log book.
 10. The field notes will be copied and the copies sent to the Project Manager or designee in a timely manner (at least by the end of each week of work being performed).

B. INFORMATION TO BE INCLUDED IN FIELD LOG BOOKS

1. Entries into the log book should be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector's memory. Entries must be legible and complete.
2. General project information will be recorded at the beginning of each field project. This will include the project title, the project number, and project staff.
3. Scope: Describe the general scope of work to be performed each day.
4. Weather: Record the weather conditions and any significant changes in the weather during the day.
5. Tail Gate Safety Meetings: Record time and location of meeting, who was present, topics discussed, issues/problems/concerns identified,

and corrective actions or adjustments made to address concerns/problems, and other pertinent information.

6. Standard Health and Safety Procedures: Record level of personal protection being used (e.g., level D PPE), record air monitoring data on a regular basis and note where data were recording (e.g., reading in borehole, reading in breathing zone, etc). Also record other required health and safety procedures as specified in the project specific health and safety plan.
7. Instrument Calibration; Record calibration information for each piece of health and safety and field equipment.
8. Personnel: Record names of all personnel present during field activities and list their roles and their affiliation. Record when personnel and visitors enter and leave a project site and their level of personal protection.
9. Communications: Record communications with project manager, subcontractors, regulators, facility personnel, and others that impact performance of the project.
10. Time: Keep a running time log explaining field activities as they occur chronologically throughout the day.
11. Deviations from the Work Plan: Record any deviations from the work plan and document why these were required and any communications authorizing these deviations.
12. Health and Safety Incidents: Record any health and safety incidents and immediately report any incidents to the Project Manager.
13. Subcontractor Information: Record name of company, record names and roles of subcontractor personnel, list type of equipment being used and general scope of work. List times of starting and stopping work and quantities of consumable equipment used if it is to be billed to the project.
14. Problems and Corrective Actions: Clearly describe any problems encountered during the field work and the corrective actions taken to address these problems.
15. Technical and Project Information: Describe the details of the work being performed. The technical information recorded will vary significantly between projects. The project work plan will describe the specific activities to be performed and may also list requirements for note taking. Discuss note-taking expectations with the Project Manager prior to beginning the field work.
16. Any conditions that might adversely affect the work or any data obtained (e.g., nearby construction that might have introduced excessive amounts of dust into the air).

17. Sampling Information; Specific information that will be relevant to most sampling jobs includes the following:
- Description of the general sampling area – site name, buildings and streets in the area, etc.
 - Station/Location identifier
 - Description of the sample location – estimate location in comparison to two fixed points – draw a diagram in the field log book indicating sample location relative to these fixed points – include distances in feet.
 - Sample matrix and type
 - Sample date and time
 - Sample identifier
 - Draw a box around the sample ID so that it stands out in the field notes
 - Information on how the sample was collected – distinguish between “grab,” “composite,” and “discrete” samples
 - Number and type of sample containers collected
 - Record of any field measurements taken (i.e. pH, turbidity, dissolved oxygen, and temperature, and conductivity)
 - Parameters to be analyzed for, if appropriate
 - Descriptions of soil samples and drilling cuttings can be entered in depth sequence, along with PID readings and other observations. Include any unusual appearances of the samples.

C. SUGGESTED FORMAT FOR RECORDING FIELD DATA

1. Use the left side border to record times and the remainder of the page to record information (see attached example).
2. Use tables to record sampling information and field data from multiple samples.
3. Sketch sampling locations and other pertinent information.
4. Sketch well construction diagrams.

V. Attachments

Example field notes.

(47)

MAY 12, 2003

EXAMPLE

0715 ARRIVE ON SITE AT XYZ SITE.
 CH2M HILL STAFF:
 John Smith: FIELD TEAM LEADER
 Bob Builder: SITE SAFETY COORD.
 WEATHER: OVERCAST + COOL, 45°F
 CHANCE OF LATE SHOWERS
 SCOPE: • COLLECT GROUNDWATER
 SAMPLES FOR LTM WORK AT SITE 14
 • SUPERVISE SURVEY CREW
 AT SITE 17

0725 BB ~~Calibrates~~ (JS) Calibrates
 PID: 101 ppm/100 ppm OK
 PID Model #, SERIAL #

0730 BB Calibrates HORIBA MEYER
 Model #, SERIAL #
 → List calibration Results

0738 Survey crew ARRIVES on Site
 → List NAMES

0745 BB Holds H+S TALK on Slips,
 Trips, Falls, Ticks + Air Monitoring
 JS + SURVEY CREW ATTEND
 No H+S ISSUES IDENTIFIED as
 CONCERNS. All work is in "Level D."

0755 JS conducts site-wide Air Monitoring
 All readings = 0.0 ppm in

JS
5-12-03

MAY 12, 2003

EXAMPLE

(48)

SITE 14 LTM
 BREATHING ZONE (BZ)

0805 Mobilize to well MW-22 to
 SAMPLE, surveyors setting up
 AT SITE 17

0815 PM (PAUL PAPER PUSHER) CALLS AND
 INFORMS JS TO COLLECT GW SAMPLE
 AT WELL MW-44 TODAY FOR 24 HOUR
 TAT ANALYSIS OF VOC'S

0820 Purging MW-22
 → RECORD WATER QUALITY DATA JS
 5-12-03

0843 Collect SAMPLE AT MW-22 for
 total TAT Metals AND VOC'S. NO
 Dissolved Metals Needed PER PM

0905 JS + BB Mobilize to site 17 to
 show surveyors wells to Survey.

0942 Mobilize to well MW-22 to
 Collect SAMPLE ...

0950 CAN NOT ACCESS WELL MW-22
 due to BASE OPERATIONS; CONTACT
 PAUL PAPER PUSHER AND HE STATED
 HE WILL CHECK ON GAINING ACCESS
 WITH BASE CONTACT.

0955 Mobilize to well MW-19

JS
5-12-03

Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region I and III

I. Purpose and Scope

This SOP presents general guidelines for the collection of groundwater samples from monitoring wells using low-flow purging and sampling procedures. Operations manuals should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Adjustable-rate positive-displacement pump, submersible pump, or peristaltic pump
- Horiba® U-22 or equivalent water quality meters to monitor pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature
- Flow-through cell with inlet/outlet ports for purged groundwater and watertight ports for each probe
- Generator or alternate power source depending on pump type
- Water-level indicator
- Disposable Teflon, Teflon-lined polyethylene tubing or polyethylene tubing for metals and other inorganics
- Plastic sheeting
- Well-construction information
- Calibrated container and stopwatch to determine flow rate
- Sample containers
- In-line disposable 0.45µm filters (QED® FF8100 or equivalent)
- Shipping supplies (labels, coolers, and ice)
- Field book

III. Procedures and Guidelines

A. Setup and Purging

1. Obtain information on well location, diameter(s), depth, and screen interval(s), and the method for disposal of purged water.
2. Calibrate instruments according to manufacturer's instructions.
3. The well number, site, date, and condition are recorded in the field logbook.

4. Plastic sheeting is placed on the ground, and the well is unlocked and opened. All decontaminated equipment to be used in sampling will be placed only on the plastic sheeting until after the sampling has been completed. To avoid cross-contamination, do not let any downhole equipment touch the ground.
5. All sampling equipment and any other equipment to be placed in the well is cleaned and decontaminated before sampling in accordance with *SOP Decontamination of Personnel and Equipment*.
6. Water level measurements are collected in accordance with the *Water Level Measurements SOP*. **Do not measure the depth to the bottom of the well at this time**; this reduces the possibility that any accumulated sediment in the well will be disturbed. Obtain depth to bottom information from well construction log.
7. Attach and secure the tubing to the low-flow pump. Lower the pump slowly into the well and set it at approximately the middle of the screen. Place the pump intake in the middle of the saturated screen length and should be at least two feet above the bottom of the well to avoid mobilization of any sediment present in the bottom.
8. Insert the measurement probes into the flow-through cell. The purged groundwater is directed through the cell, allowing measurements to be collected before the water contacts the atmosphere.
9. If using a generator, locate it 30 feet downwind from the well to avoid exhaust fumes contaminating the samples.
10. Start purging the well at 0.2 to 0.5 liters per minute. Avoid surging. Purging rates for more transmissive formations could be started at 0.5-liter to 1 liter per minute. The initial field parameters of pH, specific conductance, dissolved oxygen, ORP, turbidity, and temperature of water are measured and recorded in the field logbook.
11. The water level should be monitored during purging, and, ideally, the purge rate should equal the well recharge rate so that there is little or no drawdown in the well (i.e., less than 0.3-foot). The water level should stabilize for the specific purge rate. There should be at least 1 foot of water over the pump intake so there is no risk of the pump suction being broken, or entrainment of air in the sample. Record adjustments in the purge rate and changes in depth to water in the logbook. Purge rates should, if needed, be decreased to the minimum capabilities of the pump (0.1- to 0.2-liter per minute) to avoid affecting well drawdown.
12. During purging, the field parameters are measured frequently (every 5 minutes) until the parameters have stabilized. Field parameters are considered stable when measurements meet the following criteria:
 - pH: within 0.1 pH units
 - Specific conductance: within 3 percent

- Dissolved oxygen: within 10 percent
- Turbidity: within 10 percent for values greater than 5 NTU; if 3 turbidity values are less than 5 NTU, consider the values as stabilized
- ORP: within 10 mV
- Temperature: within 3 percent

B. Sample Collection

Once purging is complete the well is ready to sample. The elapsed time between completion of purging and collection of the groundwater sample should be minimized. Typically, the sample is collected immediately after the well has been purged, but this is also dependent on well recovery.

Samples will be placed in sample containers that have been cleaned to laboratory standards and are preserved in accordance with the analytical method. The containers are typically pre-preserved, if required.

VOC samples are normally collected first and directly into pre-preserved sample containers.

During purging and sampling, the centrifugal/peristaltic pump tubing must remain filled with water to avoid aeration of the groundwater. It is recommended that ¼ or 3/8 inch inside diameter tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, collect non-VOC dissolved gasses samples first, then increase flow rate slightly until water completely fills the tubing and collect the VOC/dissolved gases samples. Record new flow rate and drawdown depth.

The steps to be followed for sample collection are as follows:

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.
2. The sample is slowly poured from the bailer or discharged from the pump so that it runs down the inside of the sample bottle with a minimum of splashing. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs.
3. Inorganics, including metals, may be collected and preserved in the filtered form as well as the unfiltered form. Disposable in-line filters (0.45 micron filter), connected to the end of the sample tubing,, are typically used for field filtration. Samples are field filtered as the water is being placed into the sample container. If a bailer is used, filtration may be driven by a peristaltic pump.
4. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to the top with a positive meniscus.

5. The bottle is capped and clearly labeled.
6. Samples are placed in appropriate containers and, if necessary, packed with ice in coolers as soon as practical.
7. Nondedicated equipment is cleaned and decontaminated in accordance with the *Decontamination of Personnel and Equipment SOP*.

The following information, at a minimum, will be recorded in the log book:

1. Sample identification (site name, location, and project number; sample name/ number and location; sample type and matrix; time and date; sampler's identity)
2. Sample source and source description
3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of well volumes purged, and field parameter measurements
4. Sample disposition (preservative; laboratory name, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)
5. Additional remarks

C. Additional remarks

1. If the well goes dry during purging, wait until it recovers sufficiently to remove the required volumes to sample all parameters. It may be necessary to return periodically to the well but a particular sample (e.g., large amber bottles for semivolatile analysis) should be filled at one time rather than over the course of two or more visits to the well.
2. Disposable tubing is disposed of with PPE and other site trash.

IV. Attachments

White paper on reasons and rationale for low-flow sampling.

V. Key Checks and Preventative Maintenance

- The drawdown in the well should be minimized as much as possible (preferably no more than 0.5-foot to 1 foot) so that natural groundwater-flow conditions are maintained as closely as possible.
- The highest purging rate should not exceed 1 liter per minute. This is to keep the drawdown minimized.
- Stirring up of sediment in the well should be avoided so that turbidity containing adsorbed chemicals is not suspended in the well and taken in by the pump.

- Overheating of the pump should be avoided to minimize the potential for losing VOCs through volatilization.
- Keep the working space clean with plastic sheeting and good housekeeping.
- Maintain field equipment in accordance with the manufacturer's recommendations. This will include, but is not limited to:
 - Inspect sampling pump regularly and replace as warranted
 - Inspect quick-connects regularly and replace as warranted
 - Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

Attachment to the SOP on Low-Flow Sampling Groundwater Sampling from Monitoring Wells

White Paper on Low-Flow Sampling

EPA recommends low-flow sampling as a means of collecting groundwater samples in a way that minimizes the disturbance to the natural groundwater flow system and minimizes the introduction of contamination into the samples from extraneous sources. The following are details about these issues.

When a pump removes groundwater from the well at the same rate that groundwater enters the well through the screen, the natural groundwater-flow system around the well experiences a minimum of disturbance. Some disturbance is bound to occur because you are causing groundwater to flow to the well in a radial fashion that otherwise would have flowed past it. However, the resulting low-flow sample provides the most-representative indication we can get of groundwater quality in the immediate vicinity of the well.

Normally, when a well is pumped at an excessive rate that drops the water level in the well below the water level in the aquifer, the water cascades down the inside of the well screen when it enters the well. The turbulence from this cascading causes gases such as oxygen and carbon dioxide to mix with the water in concentrations that are not representative of the native groundwater and are higher than expected. This causes geochemical changes in the nature of the water that can change the concentrations of some analytes, particularly metals, in the groundwater sample, not mention its effect on the dissolved oxygen levels that then will be measured in the flow-through cell. Such turbulence also may cause lower-than-expected concentrations of volatile organic compounds due to volatilization.

For wells in which the water level is above the top of the screen, the water up in the riser is out of the natural circulation of the groundwater and, therefore, can become stagnant. This stagnant water is no longer representative of natural groundwater quality because its pH, dissolved-oxygen content, and other geochemical characteristics change as it contacts the air in the riser. If we minimize the drawdown in the well when we pump, then we minimize the amount of this stagnant water that is brought down into the well screen and potentially into the pump. As a result, a more-representative sample is obtained.

Typically, wells contain some sediment in the bottom of the well, either as a residue from development that has settled out of the water column or that has sifted through the sand pack and screen since the well was installed. This sediment commonly has adsorbed on it such analytes as metals, SVOCs, and dioxins that normally would not be dissolved in the groundwater. If these sediments are picked up in the groundwater when the well is disturbed by excessive pumping, they can:

- Make filtering the samples for metals analysis more difficult
- Add unreasonably to the measured concentration of SVOCs and other organic compounds

The SOP for low-flow sampling has been modified recently and should be consulted for additional information about low-flow sampling and ways of dealing with wells in which the water level cannot be maintained at a constant level.

Mini RAE Photoionization Detector (PID)

I. Purpose

The purpose of this SOP is to provide general reference information for using the Mini RAE PID in the field. Calibration and operation, along with field maintenance, will be included in this SOP.

II. Scope

This procedure provides information on the field operation and general maintenance of the Mini RAE PID. Review of the information contained herein will ensure that this type of field monitoring equipment will be properly utilized. Review of the owner's instruction manuals is a necessity for more detailed descriptions.

III. Definitions

Volatile Organic Compound (VOC) - Expresses the VOC concentration in ppm
ppm - parts per million: parts of vapor or gas per million parts of air by volume.

IV. Procedures

The Mini RAE utilizes the principle of a detecting sensor. The PID operates on the principle that most organic compounds and some inorganic compounds are ionized when they are bombarded by high-energy ultraviolet light. These compounds absorb the energy of the light, which excites the molecules and results in a loss of electron and the formation of a positively charged ion. The number of ions formed and the ion current produced is directly proportional to mass and concentration. The amount of energy required to displace an electron is called photo ionization potential (PIP). The air sample is drawn into a UV lamp using a pump or a fan. The energy of the lamp determines whether a particular chemical will be ionized. Each chemical compound has a unique ionizing potential. When the UV light energy is greater than the ionization potential of the chemical, ionization will occur. When the sample is ionized, the electrical signal is displayed on an analog or digital output. Although the output does not distinguish between chemicals, it does detect an increase in the ion current. If only one chemical is present in the air, it is possible to use PIDs quantitatively. Chemical structure and lamp intensity affects the sensitivity of the instrument to a given contaminant. All PID readings are relative to the calibration gas, usually isobutylene. It is important to calibrate the PID in the same temperature and elevation that the equipment will be used, and to determine the background concentrations in the field before taking measurements. For environments where background readings are high, factory zero calibration gas should be used.

Note: For volatile and semi-volatile compounds, knowing the PIP is critical in determining the appropriate instrument to use when organic vapor screening. Consult the QAPP and manufacturer's manual to determine that the proper instrument has been selected for the contaminate vapors of interest. If an expected compound at a site has a PIP less than 11.7 eV, it is possible to use a PID. If the ionization potential is greater than 11.7eV, an FID is required.

The following subsections will discuss Mini RAE calibration, operation, and maintenance. These sections, however, do not take the place of the instruction manual.

A. Calibration

Start up Instrument

- Press **Mode** button
- Observe displays:

On!.....

Version X.XX

Model Number
SN XXXX

Date Time
Temp

- After the monitor is turned on and it runs through the startup menus, the display will read "Ready". Press the [Y/+] key to start the pump.
- The pump will start, the seconds will count down to zero, and the instrument will be ready for use

Calibration Check and Adjustment

Allow instrument to warm up for 15 minutes.

- Depress the [N/-] key first, then while depressing the [N/-], depress the [Mode] key also and depress both keys for 5 seconds.

- Display will read:

Calibrate
Monitor?

- Press the [Y/+] key

- Display will read:

Fresh Air
Calibration?

- Perform the Fresh Air Calibration in an area free of any detectable vapor near your work zone.

- Press the [Y/+] key

- Display will read:

Zero....
In progress...

Wait...

Update data...

Zeroed...

Reading = X.X ppm

- Press any key and the display will go back to:

Fresh Air
Calibration?

- Press the [N/+] key

- Display will read:

Span/Cal?

- Press the [Y/+] key

- Display will read:

Isobutylene = 100 ppm

Apply Gas Now!

- Press the [Y/+] key

- Apply calibration gas - use either HAZCO Services Part Number R-SGRAE4 or Rae Systems Part Number 008-3002 - using a .5 LPM regulator and direct tubing.

Wait...30

- The display will count down showing the number of remaining seconds:

Reading = 100

Update data, span cal done.
Turn off gas!

- Calibration readings between 99 and 102 ppm are within the acceptable range.
- Display will read:

Span/Cal?

- **CALIBRATION IS COMPLETE!**
- Press any key to return to operational mode.

B. Operation

Due to the Mini RAE having many functions in terms of operation, it is recommended that you follow the operational procedures as outlined in the instruction manual from pages 2-5 to 2-14.

C. Site Maintenance

After each use, the meter should be recharged and the outside of the instruments should be wiped clean with a soft cloth.

D. Scheduled Maintenance

<u>Function</u>	<u>Frequency</u>
Check alarm and settings	Monthly/before each use
Clean screens and gaskets around sensors	Monthly
Replace sensors	Biannually or when calibration is unsuccessful

V. Quality Assurance Records

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the field logbook.

- Identification - Site name, date, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc), serial number, time, resulting concentration, comments and identity of air monitoring personnel.
- Field observations - Appearance of sampled media (if definable).
- Additional remarks (e.g, Mini RAE had wide range fluctuations during air monitoring activities.)

VI. References

Mini RAE 2000 Portable VOC PGM-7600, RAE Systems, Revision E, May 2005.

MiniRAE 2000

Portable VOC Monitor
PGM-7600



OPERATION AND MAINTENANCE MANUAL

(Document No.: 011-4001-000)
Revision E, May 2005



ATTENTION!

For European Applications

- A. CE 0575 II 1G/2G
DEMKO 03 ATEX 0204759X
Eex ia IIC T4**
- B. Recharge batteries only in non-hazardous locations.**
- C. Do not connect external cable to serial interface jack in hazardous locations.**
- D. Use RAE Systems Adapter P/N 500-0072 for connection to communication port and charging jack only in a non-hazardous area.**

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 **WARNING** 

- Do NOT proceed before reading -

This manual must be carefully read by all individuals who have or will have the responsibility for using, maintaining, or servicing this product.

The product will perform as designed only if it is used, maintained, and serviced in accordance with the manufacturer's instructions.

CAUTION!!

To reduce the risk of electric shock, turn off power before removing the monitor cover. Disconnect the battery before removing sensor module for service. Never operate the monitor while the cover is removed. Remove monitor cover and sensor module only in an area known to be non-hazardous.

The model PGM-7600 equipment is classified as to intrinsic safety for use in class I, division 1, groups A, B, C, D, or non-hazardous locations only.

Special Notes

-1-

When the MiniRAE 2000 Monitor is taken out from the transport case and turned on for the first time, there may be some residual organic or inorganic vapor trapped inside the detector chamber. The initial PID sensor reading may indicate a few ppm. Enter an area known to be free of any organic vapor and turn on the monitor. After running for several minutes, the residual vapor in the detector chamber will be cleared and the reading should return to zero.

-2-

The battery of the MiniRAE 2000 monitor will discharge slowly even if it is turned off. If the monitor has not been charged for 5-7 days, the battery voltage will be low. Therefore, it is a good practice to always charge the monitor before using it. It is also recommended to fully charge the monitor FOR AT LEAST 10 HOURS before first use. See Section 7 for more information on battery charging and replacement.

WARNINGS

STATIC HAZARD: Clean only with damp cloth.

For safety reasons this equipment must be operated and serviced by qualified personnel only. Read and understand instruction manual completely before operating or servicing.

Use only RAE Systems battery packs, part nos. 012-3050, 012-3051 or 012-3052. This instrument has not been tested in an explosive gas/air atmosphere having an oxygen concentration greater than 21%. Substitution of components may impair intrinsic safety. Recharge batteries only in non-hazardous locations.

The calibration of all newly purchased RAE Systems instruments should be tested by exposing the sensor(s) to known concentration calibration gas before the instrument is put into service.

For maximum safety, the accuracy of the MiniRAE 2000 should be checked by exposing it to a known concentration calibration gas before each day's use.

AVERTISSEMENTS

**DANGER RISQUE D'ORIGINE ELECTROSTATIQUE:
Nettoyer uniquement avec un chiffon humide.**

Pour des raisons de sécurité, cet équipement doit être utilisé, entretenu et réparé uniquement par un personnel qualifié. Étudier le manuel d'instructions en entier avant d'utiliser, d'entretenir ou de réparer l'équipement.

Utiliser seulement l'ensemble de batterie RAE Systems, la référence 012-3050, 012-3051 au 012-3052. Cet instrument n'a pas été essayé dans une atmosphère de gaz/air explosive ayant une concentration d'oxygène plus élevée que 21%. La substitution de composants peut compromettre la sécurité intrinsèque. Ne charger les batteries que dans emplacements désignés non-dangereuse.

La calibration de toute instruments de RAE Systems doivent être testé en exposant l'instrument a une concentration de gaz connue par une procédure diétalonnage avant de mettre en service l'instrument pour la première fois.

Pour une securite maximale, la sensibilité du MiniRAE 2000 doit être verifier en exposant l'instrument a une concentration de gaz connue par une procédure diétalonnage avant chaque utilisation journalière.

1. GENERAL INFORMATION

MiniRAE 2000 Portable VOC Monitor (Model PGM 7600) is a compact monitor designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. It monitors Volatile Organic Compounds (VOC) using a Photo-Ionization Detector (PID) with a 9.8 eV, 10.6 eV, or 11.7 eV gas discharge lamp. Features are:

- **Lightweight and Compact**
 - Compact, light weight (19 oz.) and rugged design
 - Built-in sample draw pump
- **Dependable and Accurate**
 - Up to 10 hours of continuous monitoring with rechargeable battery pack
 - Designed to continuously monitor VOC vapor at ppm levels
- **User Friendly**
 - Preset alarm thresholds for STEL, TWA, low and high level peak values. Audio buzzer and flashing LED display are activated when the limits are exceeded.
- **Datalogging Capabilities**
 - 15,000 point datalogging storage capacity for data download to PC

MiniRAE 2000 consists of a PID with associated microcomputer and electronic circuit. The unit is housed in a rugged ABS + PC case with a backlit 1 line by 8 character dot matrix LCD and 3 keys to provide easy user interface.

GENERAL INFORMATION

1.1 General Specifications

Table 1.1

Portable VOC Monitor Specification	
Size:	8.2"L x 3.0"W x 2.0"H
Weight:	19.5 oz with battery pack
Detector:	Photo-ionization sensor with 9.8, 10.6, or 11.7 eV UV lamp
Battery:	A 4.8V /1250 mAH Rechargeable Nickel Metal Hydride battery pack (snap in, field replaceable)
Battery Charging:	10 hours charge through built-in charger
Operating Hours:	Up to 10 hours continuous operation
Display:	1 line by 8 characters 5x7 dot matrix LCD (0.4" character height) with LED back light automatically in dim light
Range, Resolution & Response time (t ₉₀):	
	Isobutylene (calibration gas)
	0-99 ppm 0.1 ppm 2 sec
	100-1,999 ppm 1.0 ppm 2 sec
	2000-10,000 ppm 1.0 ppm 2 sec
Measurement Accuracy (Isobutylene):	
	0 – 2000 ppm: ± 2 ppm or 10% of reading.
	> 2000 ppm: ± 20% of reading
PID Detector:	Easy access to lamp and sensor for cleaning and replacement
Correction Factors:	Built-in 102 VOC gases
Calibration:	Two-point field calibration of zero and standard reference gas
Calibration Memory:	
	Store up to 8 separate calibration, alarm limits and span value
Inlet Probe:	Flexible 5" tubing
Keypad:	1 operation key and 2 programming keys

GENERAL INFORMATION

Direct Readout:	Instantaneous, average, STEL and peak value, battery voltage and elapsed time
Intrinsic Safety:	UL & cUL Class 1, Division I, Group A,B,C,D, Temperature Code T3C (US & Canada); CE 0575 II II 1G DEMKO 02 ATEX 0204759 Eex ia IIC T4 (Europe)
EM Interference:	No effect when exposed to 0.43 W/cm ² RF interference (5 watt transmitter at 12 inches)
Alarm Setting:	Separate alarm limit settings for Low, High, STEL and TWA alarm
Operating Mode:	Survey or Hygiene mode
Alarm:	90 dB buzzer and flashing red LEDs to indicate exceeded preset limits, low battery voltage, or sensor failure.
External Alarm:	Optional plug-in pen-size vibration alarm or remote alarm
Alarm Mode:	Latching or automatic reset
Real-time Clock:	Automatic date and time stamps on data logged information
Datalogging:	15,000 points with time stamp, serial number, user ID, site ID, etc.
Communication:	Upload data to PC and download instrument setup from PC through RS-232 port
Sampling Pump:	Internally integrated. Flow rate: 450-550 cc/min.
Temperature:	0° to 45°C (32° to 113°F)
Humidity:	0 % to 95 % relative humidity (non-condensing)
Housing:	ABS + PC, conductive coating, splash and dust proof, will withstand 1 meter drop test with rubber boot
Attachment:	Wrist strap, rubber boot and belt clip

2. OPERATION OF MINIRAE 2000

The MiniRAE 2000 Portable VOC Monitor is a compact Monitor designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. It gives real time measurements and activates alarm signals whenever the exposure exceeds preset limits. Prior to factory shipment the MiniRAE 2000 is preset with default alarm limits and the sensor is pre-calibrated with standard calibration gas. However, the user should test the instrument and verify the calibration before the first use. After the monitor is fully charged and calibrated, it is ready for immediate operation.

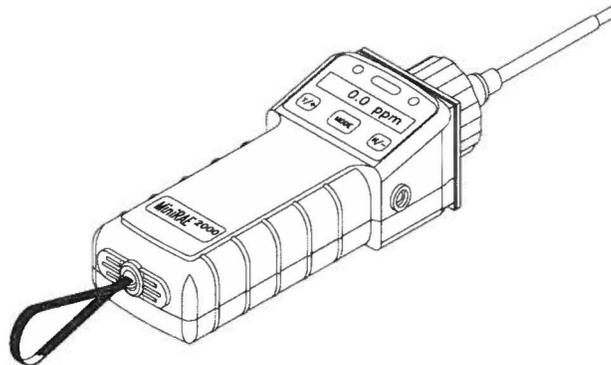


Figure 2-1 MiniRAE 2000

2.1 Physical Description

The main components of the MiniRAE 2000 Portable VOC monitor include:

- Three keys for user to interact with the monitor: 1 operation key and 2 programming keys for normal operation or programming of the monitor
- LCD display with back light for direct readout and calculated measurements
- Buzzer and red LED's for alarm signaling whenever the exposures exceed preset limits
- Wrist strap
- Charge contact for plugging directly to the charging station
- Gas entry and exit ports
- Serial communication port for PC interface
- External alarm and analog output port
- Protective rubber cover

2.2 Keys and Display

Figure 2.2 shows the LCD display and the keypad on the front panel of the monitor. The function of the 3 keys during normal operation are summarized below:

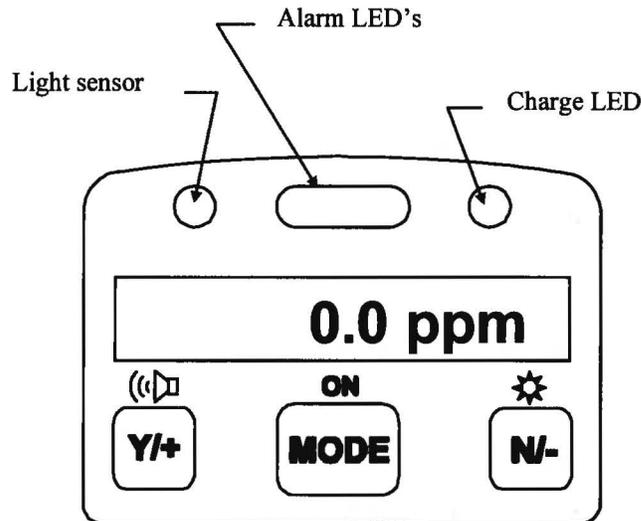


Figure 2-2 LCD Display and Keypad

Key Function in Normal Operation

[MODE] -Turn on/off the power* and step through menu items

[N/-] -Toggle on/off the back light, negative acknowledge, decrease value

[Y/+] -Start measurement, positive acknowledge, increase value

* Pressing and holding **[MODE]** key for 5 seconds turns off the power to the monitor. Monitor will beep once per second and display countdown timer during power-down sequence. Press **[MODE]** key momentarily to step through menu items. To save time, press any key during message scrolling to skip to the end of the message.

2.3 Power On/Off

To turn on the MiniRAE 2000 portable VOC monitor, press [MODE] key for one second and release. The audio buzzer will beep once and the air pump will turn on. The display will show "ON!.." and then "Ver n.nn" to indicate the unit's current firmware version number. Next displayed are the serial number, the model number, Operating mode, current date and time, unit internal temperature, gas selected, high low, STEL, TWA/AVG alarm limits, battery voltage, and shut off voltage. Also displayed are internal mode settings such as User mode, Alarm mode, datalog time remaining and log periods in the respective order.

To turn off the MiniRAE 2000 portable VOC monitor, press and hold the [MODE] key for 5 seconds. The monitor will beep once per second during the power-down sequence with a count down timer showing the number of remaining seconds. The message "Off!.." flashes on the LCD display and the display will go blank indicating that the monitor is turned off.

Data protection during power off

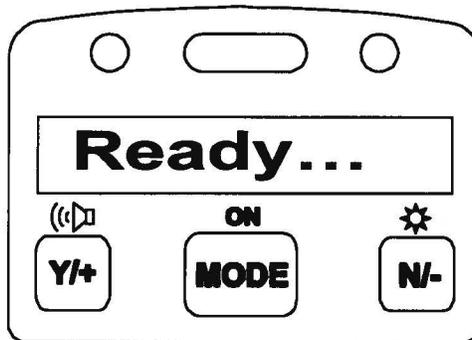
When the monitor is turned off, all the current real time data including last measured value are erased. However, the datalog data is preserved in non-volatile memory. Even if the battery is disconnected, the datalog data will not be lost. While the power is off, the real time clock will continue to operate until the battery is completely drained (usually in 4-5 days without any charging). If the battery is completely drained or is disconnected from the monitor for more than 30 minutes, the real time clock will be lost. In this case, the user needs to enter the real time clock information again, as described in Section 4, or send the PC clock during configuration through the PC communication.

2.4 Operation

The **MiniRAE 2000** VOC monitor has two operation modes: **Survey** and **Hygiene** mode. The **Survey mode** allows the user to manually start and stop the monitoring/measuring operation and display certain exposure values. In the **Hygiene mode**, the monitor runs continuously after the monitor is turned on. Refer to Section 4.7.1 for switching between the two modes.

2.4.1 Survey Mode

After the monitor is turned on, it runs through the start up menu. Then the message “**Ready...**” is displayed (see figure below).



At this point, the user has two options:

1. Step through the Main Menu.
2. Take a measurement.

Press the [MODE] button to step through the Main Menu. Press the [Y/+] button to proceed to take a measurement.

The Main Menu

Press the [MODE] button to enter the Main Menu. Press the [Y/+], [MODE] or [N/-] as indicated in the flow chart below to step through the Main Menu. The PID sensor and pump are turned off during this time.

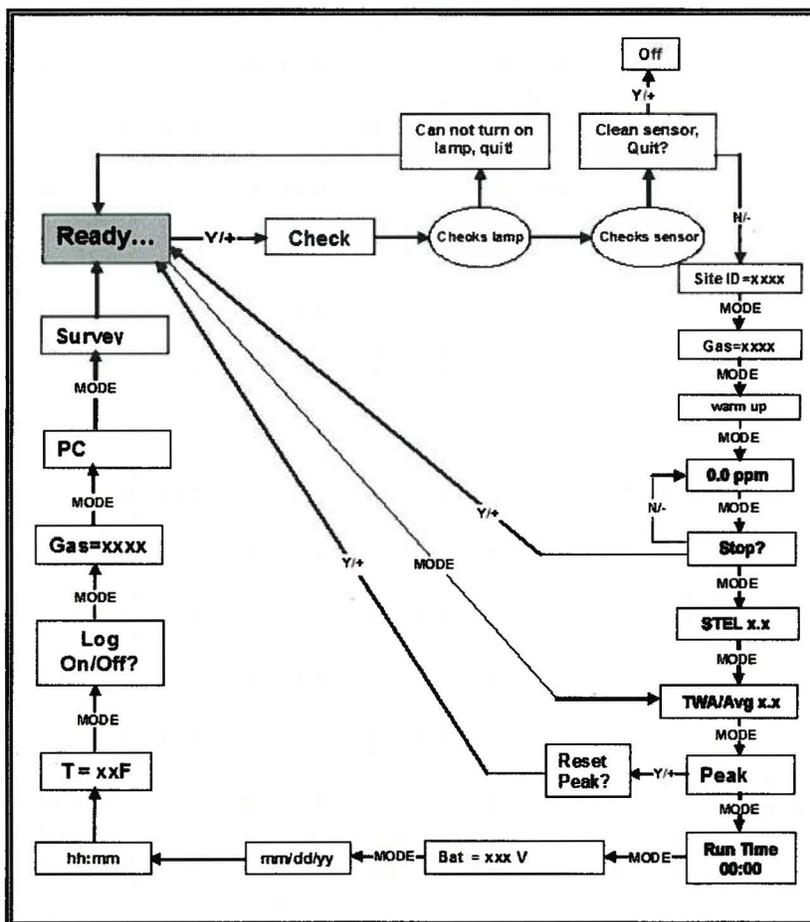
The Main Menu functions are:

- **Ready...**
- **Check**
- **Site ID = xxxx**
- **Gas = xxxx**
- **Warm up**
- **X.x ppm**
- **Stop?**
- **TWA/Avg x.x ppm**
- **STEL x.x ppm**
- **Peak x.x ppm**
- **Run time hh:mm**
- **Bat = X.XV**
- **Mm/dd/yy**
- **hh:mm**
- **T = xxxF [date, time and temperature (°C or °F)]**
- **Log On/Off?**
- **PC Comm?**
- **Survey**

OPERATION

These functions are arranged in a “round robin” order. To select a specific function, press the button as shown below until the desired function appears.

Main Menu



The Main Menu Functions

- **Ready...:** Indicates that the monitor is ready to take a measurement or to step through the Main Menu. Press the [Y/+] button to advance to taking a measurement (read “Taking a Measurement” on Page 2-12 for details).

Note: The **Ready...** screen is skipped if the menu is cycled through while a measurement is running.

- **Check...:** This message displays while the system is checking the lamp and the sensor. If the lamp test succeeds, the system will progress to checking the sensor. If the lamp test does not succeed, the display will read **Can not turn on lamp, quit!**

- **Can not turn on lamp, quit!:** This message displays when the lamp does not turn on. The system will automatically return to **Ready...** allowing the user to test the lamp again. If the lamp fails a second time, turn the monitor off and refer to Section 7.2 “**PID Sensor & Lamp Cleaning / Replacement**”.

- **Clean Sensor, Quit?:** This message displays when the sensor requires cleaning. Press the [Y/+] button to turn the monitor off and clean the sensor. Press the [N/-] button and the system will progress to the **Site ID = xx**

- **Site ID = xxxx:** This display shows the Site ID and indicates that the monitor is about to start taking measurements (read “Taking a Measurement” for details)

Note: This display appears only after a measurement has been started. It does not appear when the user is cycling through the Main Menu and the monitor is idling.

- **Gas = xxxx:** This display identifies the gas to be measured and indicates that the monitor is about to take a measurement (read “Taking a Measurement” for details)

OPERATION

Note: This display appears only after a measurement has been started. It does not appear when the user is cycling through the Main Menu and the monitor is idling.

- **x.x ppm:** (read “Taking a Measurement” for details)

Note: This display appears only after a measurement has been started. It does not appear when the user is cycling through the Main Menu and the monitor is idling.

- **TWA/Avg:** Displays (in ppm) the Time Weighted Average (TWA) or the Average since the start of the measurement. The average is recalculated every minute.
- **STEL:** Displays the Short Term Exposure Limit.
- **PEAK:** Displays (in ppm) the highest instantaneous reading since the start of the measurement. If [Y/+] is pressed while the peak reading is displayed, the unit will ask **Reset Peak?**. If [Y/+] is pressed again, the peak value will be cleared and the display will return to the **Ready...** message or instantaneous reading. The peak reading is automatically reset when a new measurement is started by pressing [Y/+] from the **Ready...** screen.
- **Run time hh:mm:** The duration of the current measurement period.
- **Bat = X.XV:** The current battery voltage.

Note: A fully charged battery pack should show 4.8 volts or higher. When the battery voltage falls below 4.4 volts, a flashing “**Bat**” will appear as a warning message. At that point, you have 20-30 minutes of run time remaining. When the battery voltage falls below 4.2 volts the monitor turns off automatically.
- **Mm/dd/yy:** The current date.
- **hh:mm:** The current time (24-hour format)

OPERATION

- **T = xxxF:** The internal unit temperature in degrees Fahrenheit. (see Section 4.7.13 to change temperature units)
- **Log on/Off?:** Allows the user to start datalogging of the current measurement. A superscript “L” flashes in the ppm measurement display when datalogging is on. This screen is not shown when datalogging is disabled or when the monitor is not operating in manual start/stop mode.
- **PC Comm?:** This function enables the user to upload data from the MiniRAE 2000 to a Personal Computer (PC) or send/receive configuration information between a PC and the MiniRAE 2000. Press [MODE] to return to **Ready...**

To communicate with a PC, connect the monitor to the serial port of a PC and start the MiniRAE 2000 application software. Press the [Y/+] button and the LCD displays “**pause monitor, ok?**” Press the [Y/+] button one more time, and the display shows “**Comm...**” The monitor is now ready to receive commands from the PC.

- **Survey:** This function displays the Current Operating Mode (**Survey** or **Hygiene**).

Taking a Measurement

There are two ways to start a measurement.

1. Operating in Hygiene mode.
2. Manually start and stop measurement in Survey mode.

To start a measurement in Hygiene mode, please refer to Section 4.7.1, “**Change Operation Mode**”. To start a measurement in Survey Mode, the MiniRAE 2000 monitor must first be in the “Ready...” mode. This is the mode to which the monitor normally powers up.

OPERATION

Measurement phases

1. Ready
2. Start measurement
3. Measurement display and datalogging
4. Stop measurement

Ready

The display reads **Ready...** indicating the unit is ready to start a measurement.

Start Measurement

Press the [Y/+] button to start the check cycle (see above), and then the measurement cycle.

After completing the **Check** cycle, the display will show the **Site ID** and then the **Gas** selected for measurement. The pump will start and the reading will be displayed. The **Peak** and **Average** values will be automatically reset to zero.

Measurement Display and Datalog

Instantaneous readings of the gas concentration in parts per million (ppm) are updated every second. A flashing superscript **L** is displayed when datalogging is on. Datalog information is saved only after one full datalog period is completed.

Stop Measurement

Press the [MODE] button and the display shows Stop? Press [N/-] to continue measurement and [Y/+] to stop the measurement and datalog event. The pump stops automatically when measurement is stopped. Peak and average values for the current measurement can be read in idle mode until a new measurement is started.

Automatic Increment of Site ID

Every time a measurement is taken, the site ID will be incremented by one automatically in Survey mode.

Variable Alarm Signal

In Survey Mode, if the measurement exceeds the low alarm limit, the buzzer and flashing alarm are activated and will beep/flash once per second. The alarms will increase in frequency as the gas concentration approaches the high alarm limit reaching 8 times per second when the high alarm has been exceeded.

Press [Y/+] key to clear if latching alarm.

2.4.2 Hygiene Mode

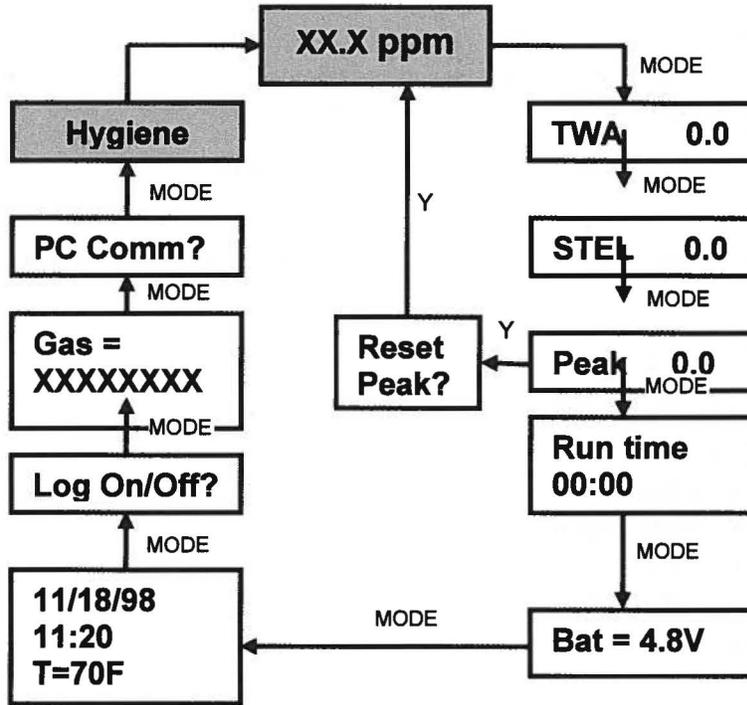
In Hygiene Mode, the unit will continuously taking measurements, once the power is turned on. After the initial start-up sequence displaying the current monitor settings, the LCD displays the instantaneous readings.

The Hygiene operation menu displays include:

- **Real time readings in ppm**
- **Current TWA/Avg, STEL and Peak values (see Section 4.6.6)**
- **Run time**
- **Current battery voltage**
- **Date, time and temperature**
- **Log on/off?**
- **Gas name**
- **PC communication?**
- **Hygiene**

Detailed description of most of these displays are the same as Section 2.4.1.

HYGIENE MODE MAIN MENU



To choose a specific display, press the [MODE] key one or more times until the desired display appears, or the [Y/+] key where indicated with a Y.

Note: To get back to instantaneous reading from any of the above display, press [MODE] key repeatedly until the "XX.X ppm" display appears.

2.5 Alarm Signals

During each measurement period, the gas concentration is compared with the programmed alarm limits (gas concentration alarm limit settings: Low, High, TWA and STEL). If the concentration exceeds any of the preset limits, the loud buzzer and red flashing LED are activated immediately to warn the user of the alarm condition.

In addition, the MiniRAE 2000 will alarm if one of the following conditions occurs: battery voltage falls below a pre-set voltage level (4.4 V), failure of UV lamp, pump stall, or when the datalog memory is full. When the low battery alarm occurs, there will be approximately 20-30 minutes of operating time remaining. When the battery voltage falls below 4.2 V, the monitor will turn off automatically.

OPERATION

Alarm Signal Summary:

Condition	Alarm Signal
Gas exceeds "High Alarm" limit	3 beeps/flashes per second
Gas exceeds "Low Alarm" limit	2 beeps/flashes per second
Gas exceeds "TWA" limit	1 Beeps/flashes per seconds
Gas exceeds "STEL" limit	1 Beeps/flashes per seconds
Pump failure	3 beeps/flashes per second plus "Pump" message on LCD
PID lamp failure	3 beeps/flashes per second plus "Lamp" message on LCD
Low battery	1 flash per second, 1 beep per minute plus "Bat" message on LCD
Memory full	1 flash per second plus "Mem" message on LCD

Alarm Signal Testing:

Under normal non-alarm conditions, it is possible to test the MiniRAE 2000 LED and buzzer in Special Diagnostic Mode (see Section 8 for details).

2.6 Preset Alarm Limits and Calibration

The MiniRAE 2000 portable VOC monitor is factory calibrated with standard calibration gas, and is programmed with default alarm limits. There are 102 gas settings stored in the library. Some examples of calibration and alarm limits are shown below. Refer to Section 4 on programming procedures for selecting a different gas, perform a calibration or set new alarm limits.

Factory Calibration and Preset Alarm Limits

Cal Gas	Cal Span	unit	Low	High	TWA	STEL
Isobutylene	100	ppm	50	100	100	250
Hexane, n-	100	ppm	500	750	500	750
Xylene, m-	100	ppm	100	150	100	150
Benzene	5	ppm	2	5	5	2
Styrene	50	ppm	20	40	20	40
Toluene	100	ppm	50	100	50	100
Vinyl Chloride	10	ppm	5	10	5	10
Custom	100	ppm	50	100	50	100

2.7 Integrated Sampling Pump

The MiniRAE 2000 portable VOC monitor includes an integrated sampling pump. This is a diaphragm type pump that provides a 500-600 cc per minute flow rate. Connecting a Teflon or metal tubing with 1/8 inch inside diameter to the gas inlet port of the MiniRAE 2000, this pump can pull in air samples from 200 feet away horizontally, or 90 feet vertically, at about 3 feet per second flow speed.

The pump turns on when a measurement is started, and turns off when the sample is manually stopped in Survey mode or when the unit is turned off from Hygiene Mode.

If liquid or other objects are pulled into the inlet port filter, the monitor will detect the obstruction and shut down the pump immediately. The alarm will be activated and a flashing error message "Pump" will be also displayed on the LCD display.

The user should acknowledge the pump shut off condition by clearing the obstruction and pressing the [Y/+] key to re-start the pump.

The pump stall threshold is set in the special Diagnostic Mode (Section 8).

2.8 Back Light

The LCD display is equipped with an LED back light to assist in reading the display under poor lighting conditions. Pressing and holding the [N/-] key for one second in normal operation can turn on the backlight. The backlight can be turned off by pressing [N/-] a second time. If the [N/-] key is not pressed, the back light will be turned off automatically after a pre-programmed time-out period to save power.

In addition, the ambient light is sensed and the back light will be turned on automatically if the ambient light is below a threshold level. The back light is turned off automatically when the ambient light exceeds the threshold level.

See Section 8 for instructions on how to set the light threshold level.

Note: The LED backlight consumes about 20-30% of the total average current, when the instrument is idle or not taking a measurement.

2.9 Datalogging

During datalogging, the MiniRAE 2000 Portable VOC monitor flashes a superscript “L”, on the display to indicate that datalogging is enabled. The monitor stores the time stamp, sample number, and measured gas concentration at the end of every sample period (when data logging is enabled). In addition, the following information are stored: user ID, site ID, serial number, last calibration date, and alarm limits. All data are retained (even after the unit is turned off) in non-volatile memory so that it can be down loaded at a later time to a PC.

Datalogging event

When Datalogging is enabled, measurement readings are being saved. These data are stored in “groups” or “events. A new event is created and stored each time the monitor is turned on, or a configuration parameter is changed, or datalogging is interrupted (e.g. Communication with PC during Hygiene mode). Information, such as start time, user ID, site ID, gas name, serial number, last calibration date, and alarm limits will be recorded.

Datalogging sample

After an event is recorded, the unit records a shorter form of the data. This data contains: the sample number, time (hour/minute) and gas concentration.

3. OPERATION OF ACCESSORIES

The accessories for the MiniRAE 2000 include:

- An AC Adapter (Battery Charger)
- Alkaline battery holder
- Water Trap Filter

Optional Accessories:

- Dilution Fitting
- Calibration adapter
- Calibration regulator and Flow controller
- Organic Vapor Zeroing kit

3.1 Standard Kit and Accessories

1) AC Adapter (Battery Charger)

WARNING

To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. Remove and replace battery only in area known to be non-hazardous.

Ne charger les batteries que dans emplacements designés non-dangereuses.

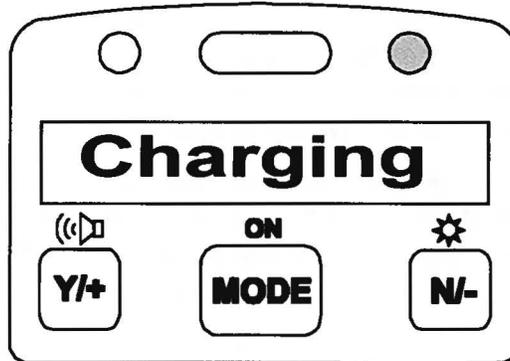
A **battery charging circuit** is built into the MiniRAE 2000 monitor. It only needs a regular AC to 12 V DC adapter (wall mount transformer) to charge the monitor.

To charge the battery inside the MiniRAE 2000 monitor:

1. Power off the Monitor.
2. Connect the AC adapter (or the optional automotive charging adapter) to the DC jack on the MiniRAE 2000 monitor. If the unit was off, it will automatically turn on.
3. The first message displayed will be "Deep discharge?" The unit will ask this question for three times. If the user wants to discharge the battery pack, affirm this query with the [Y/+]
key, otherwise the unit will move on to the charge mode directly.

OPERATION OF ACCESSORIES

4. While charging, the display message will alternate between “Charging” and “Bat=x.xV” (x.x is the present battery voltage). The LED should be red in color when charging.



5. When the battery is fully charged, the LED will change from red to green and the message “Fully charged” will appear on the display. After the battery is fully charged, the unit will enter the “trickle charge” mode. In which, the red LED will turn on for several seconds every minute, to maintain the full charge.

A completely discharged MiniRAE 2000 monitor will be charged to full capacity within 10 hours. The battery will be drained slowly even if the monitor is turned off. If the monitor has not been charged for 7-10 days, the battery voltage will be low.

The factory-supplied battery is designed to last for 10 hours of normal operation (no alarm, no back light condition), for a new battery under the best condition. As the battery becomes older or is subject to adverse conditions (such as cold ambient temperature), the battery capacity will be reduced significantly.

2) Alkaline Battery Holder

An alkaline battery holder is supplied with each MiniRAE 2000. It accepts four AA size alkaline batteries and can be used in place of the Ni-MH or Ni-Cd battery pack to provide approximately 12-14 hours of operation. The adapter is intended to be used in emergency situations when there is no time to charge the Ni-Cd or Ni-MH battery pack.

To install the adapter, remove the cover of the battery compartment. Remove the Ni-Cd or Ni-MH battery pack from the battery compartment and replace with the alkaline battery adapter. Replace the battery compartment cover.

The internal charging circuit is designed to prevent damage to alkaline batteries and the charging circuit when alkaline batteries are installed inside the monitor.

Note: The AA Alkaline battery adapter supplied by RAE Systems Inc. is intrinsically safe!

3) Water Trap Filter

The water trap filter is made of PTFE (Teflon[®]) membrane with a 0.45 micron pore size to prevent water from being sucked into the sensor manifold, which would cause extensive damage to the monitor. It will also remove any dust and other particles from entering the monitor and prolong the operating life of the sensor. To install the water trap, simply insert it to the front of the inlet tube of the MiniRAE 2000 monitor.

3.2 Optional Accessories

1) Dilution Fitting

The user may wish to install a dilution fitting on the inlet to dilute the gas samples. One application for a dilution fitting is to measure organic gas when the concentration exceeds the upper limit of the sensor range.

Make sure to set the dilution ratio in the programming mode (see Section 4.7.9) so that the correct gas reading will be displayed when the dilution fitting is used.

WARNING: To use a dilution fitting, the user must have the monitor located in a clean atmosphere outside the confined space and use a remote access probe or Tygon tubing to measure the gas concentration inside the confined space.

2) Calibration Adapter

The calibration adapter for the MiniRAE 2000 is a simple 6-inch Tygon tubing with a metal adapter on one end. During calibration, simply insert the metal adapter into the regular gas inlet probe of the MiniRAE 2000 and the tubing to the gas regulator on the gas bottle.

OPERATION OF ACCESSORIES

3) Calibration Regulator and Flow Controller

The Calibration Regulator and Flow controller is used in the calibration process. It regulates the gas flow rate from the Span gas cylinder into the gas inlet of the MiniRAE 2000 monitor during calibration process. The maximum flow rate allowed by the flow controller is about 0.5L/min (500 cc per min.). Alternatively, a Demand-flow Regulator or a Tedlar gas bag may be used to match the pump flow precisely.

4) Organic Vapor Zeroing kit (Charcoal filter)

The Organic Vapor Zeroing Kit is used for filtering organic air contaminants that may affect the zero calibration reading. To use the Organic Vapor Zeroing Kit, simply connect the filter to the inlet port of the MiniRAE 2000.

4. PROGRAMMING OF MINIRAE 2000

The MiniRAE 2000 Monitor is built with a microcomputer to provide programming flexibility. Authorized users can recalibrate the monitor, change the alarm limits, change site ID, user ID, lamp type, and real time clock, etc.

Programming is menu-driven to provide intuitive end-user operation. The display shows the menu options and the key pad used for menu selection and data entry.

4.1 Programming Mode

The programming mode allows the users to change the setups in the monitor, calibrate the monitor, modify the sensor configuration and enter user information, etc. The programming mode has four menu items. Each menu item includes several sub-menus to perform additional programming functions. Appendix A shows a more detailed menu tree structure.

Programming Menu

Calibrate/Select Gas?

Change Alarm Limits?

Change Datalog?

Change Monitor Setup?

Once inside the programming mode, the LCD will display the first menu. Each subsequent menu item can be viewed by pressing the [N/-] repeatedly until the desired menu is displayed. To enter the sub-menu of a particular menu, press [Y/+] key, the sub-menu will be displayed.

Return to Operation mode: To exit the programming mode and return to operation, press the [MODE] key once at any of the programming menu displays.

4.2 Keys for Programming Mode

The three keys perform a different set of functions during the programming mode as summarized below.

Key	Function in Programming Mode
[MODE]:	Exit menu when pressed momentarily or exit data entry mode when pressed and held for 1 second
[Y/+]:	Increase alphanumerical value for data entry or confirm (yes) for a question
[N/-]:	Decrease alphanumerical value for data entry or deny (no) for a question

4.3 Entering into Programming Mode

1. Turn on the MiniRAE 2000 monitor and wait for the “**Ready..**” message or the instantaneous reading display “**0.0 ppm**” message displayed.
2. Press and hold down both [N/-] and [MODE] keys for three seconds to enter programming mode. This delay is to prevent the user from entering programming mode by accident.
3. The first menu item “Calibrate/select Gas?” will be displayed.
4. Release both [MODE] and [N/-] keys simultaneously to start the programming mode
5. Press [N/-] key to scroll to the next menu item of the programming menu. Press [Y/+] key to select the displayed menu item.

The following Sections 4.4 - 4.7 describe the details of each menu options.

4.4 Calibrate and Select Gas

WARNINGS

The calibration of all newly purchased RAE Systems instruments should be tested by exposing the sensor(s) to known concentration calibration gas before the instrument is put into service for the first time.

For maximum safety, the accuracy of the MiniRAE 2000 should be checked by exposing it to known concentration calibration gas before each day's use.

In the first menu of the programming mode, the user can perform functions such as calibration of the MiniRAE 2000 Monitor, select default cal memories, and modify cal memories (see Table 4.4).

Table 4.4

Calibrate/Select Gas Sub-Menu
Fresh Air Cal?
Span Cal?
Select Cal Memory?
Change Span Value?
Modify Cal Memory?
Change Correction Factor?

Calibrating the MiniRAE 2000 monitor is a two-point process using “fresh air “ and the standard reference gas (also known as span gas). First a “Fresh air” calibration, which contains no detectable VOC (0.0 ppm), is used to set the zero point for the sensor. Then a standard reference gas that contains a known concentration of a given gas is used to set the second point of reference.

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Note: The span value must be set prior to calibrating for fresh air or span.

The user can store calibrations for up to 8 different measurement gases. The default gas selections are as follows:

Cal Memory #0.....Isobutylene

Cal Memory #1.....Hexane

Cal Memory #2.....Xylene

Cal Memory #3.....Benzene

Cal Memory #4.....Styrene

Cal Memory #5.....Toluene

Cal Memory #6.....Vinyl Chloride

Cal Memory #7.....Custom?

Memory #0 functions differently than the other 7 memories. For Memory #0, isobutylene is always the calibration gas. When the gas is changed in Memory #0 to one of 100 other preprogrammed chemicals or to a user-defined custom gas, a correction factor is applied to all the readings. During calibration, the unit requests isobutylene gas and displays the isobutylene concentration immediately following calibration, but when the unit is returned to the normal reading mode, it displays the selected gas and applies the correction factor.

The other 7 cal memories require the same calibration gas as the measurement gas. These memories may also be modified to a preprogrammed chemical or to a user-defined custom gas. In the gas library, only the gases that can be detected by the installed UV lamp will actually be displayed. Note that although the correction factor for the new gas will be displayed and can be modified, this factor is not applied when Memories #1-7 are

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used. Therefore the factor will not affect the readings in these memories.

Once each of the memories has been calibrated, the user can switch between the calibrated gases by changing the cal memory without the need to recalibrate. Or the user can switch the measurement gas in Memory #0 and the appropriate correction factor will automatically be applied without the need to recalibrate. If the gas is changed in Memories #1-7, it is necessary to recalibrate.

To change a default gas from the list above to a library or custom gas, first go to Select Cal Memory (Section 4.4.3) and then proceed to Modify Cal Memory (Section 4.4.5) to enter the desired gas. If the desired compound does not appear in the preprogrammed library, the user can use the Custom_VOC entry in the library, or the name and correction factor of any of the existing compounds can be changed as described in Section 4.4.5. A list of some 300 correction factors is given in Technical Note 106, available at the website www.raesystems.com.

4.4.1 Fresh Air Calibration

This procedure determines the zero point of the sensor calibration curve. To perform a fresh air calibration, use the calibration adapter to connect the MiniRAE 2000 to a “fresh” air source such as from a cylinder or Tedlar bag (option accessory). The “fresh” air is clean dry air without any organic impurities. If such an air cylinder is not available, any clean ambient air without detectable contaminant or a charcoal filter can be used.

1. The first sub-menu shows: “Fresh air Cal?”
2. Make sure that the MiniRAE 2000 is connected to one of the “fresh” air sources described above.
3. Press the [Y/+] key, the display shows “zero in progress” followed by “wait..” and a countdown timer.

After about 15 seconds pause, the display will show the message “update data...zeroed... reading = X.X ppm...” Press any key or wait about 20 seconds, the monitor will return back to “Fresh air Calibration?” submenu.

4.4.2 Span Calibration

This procedure determines the second point of the sensor calibration curve for the sensor. A cylinder of standard reference gas (span gas) fitted with a 500 cc/min. flow-limiting regulator or a flow-matching regulator is the simplest way to perform this procedure. Choose the 500 cc/min. regulator only if the flow rate matches or slightly exceeds the flow rate of the instrument pump. Alternatively, the span gas can first be filled into a Tedlar Bag, or delivered through a demand-flow regulator. Connect the calibration adapter to the inlet port of the MiniRAE 2000 Monitor, and connect the tubing to the regulator or Tedlar bag.

Another alternative is to use a regulator with >500 cc/min flow but allow the excess flow to escape through a T or an open tube. In the latter method, the span gas flows out through an open tube slightly wider than the probe, and the probe is inserted into the calibration tube.

Before executing a span calibration, make sure the span value has been set correctly (see next sub-menu).

1. Make sure the monitor is connected to one of the span gas sources described above.
2. Press the [Y/+] key at the "Span Cal?" to start the calibration. The display shows the gas name and the span value of the corresponding gas.
3. The display shows "Apply gas now!" Turn on the valve of the span gas supply.

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4. Display shows “wait.... 30” with a count down timer showing the number of remaining seconds while the monitor performs the calibration.
5. To abort the calibration, press any key during the count down. The display shows “Aborted!” and return to “Span Cal?” sub-menu.
6. When the count down timer reaches 0, the display shows the calibrated value.
Note: The reading should be very close to the span gas value.
7. During calibration, the monitor waits for an increased signal before starting the countdown timer. If a minimal response is not obtained after 35 seconds, the monitor displays “No Gas!” Check the span gas valve is on and for lamp or sensor failure before trying again.
8. The calibration can be started manually by pressing any key while the “Apply gas now!” is displayed.
9. After a span calibration is completed, the display will show the message “Update Data Span Cal Done! Turn Off Gas.”
10. Turn off the flow of gas. Disconnect the calibration adapter or Tedlar bag from the MiniRAE 2000 Monitor.
11. Press any key and it returns back to “Span Gas Cal?”

4.4.3 Select Cal Memory

This function allows the user to select one of eight different memories for gas calibration and measurement. For Memories #1-7, the calibration and measurement gas is the same and no correction factor is applied. For Memory #0, the calibration gas is always isobutylene and the measurement gas may be different, in which case the correction factor for that gas is automatically applied. The default gas selections are listed in Section 4.4

1. "Select Cal Memory?" is the third sub-menu item in the Calibration sub-menu. Pressing the [Y/+] key, the display will show "Gas =" gas name followed by "Mem # x?"
2. Press [N/-] to scroll through all the memory numbers and the gas selections respectively. Press [Y/+] to accept the displayed Cal Memory number.
3. After the [Y/+] key is pressed, the display shows "Save?" Press [Y/+] key to save and proceed. Press [N/-] to discard the entry and advance to the next sub-menu.
4. If the gas in a newly selected Cal Memory number is not calibrated, the display shows "CF= x.xx". A correction factor with the value "x.xx" will be applied.
5. If the gas of a newly selected cal memory number has been calibrated previously, the display shows "Last calibrated xx/xx/xx".

4.4.4 Change Span Value

This function allows the user to change the span values of the calibration gases.

1. "Change Span Value?" is the fourth sub-menu item in the Calibration sub-menu
2. Press [Y/+], display shows the gas name and the span value. A cursor will blink at the first digit of the Span value. To modify the span gas value, go to Step 3. Otherwise, press and hold the [MODE] key for 1 second to accept the previously stored span gas value and move to the next sub-menu.
3. Starting from the left-most digit of the span gas value, use the [Y/+] or [N/-] key to change the digit value and press [MODE] key momentarily to advance to next digit. Repeat this process until all digits are entered. Press and hold the [MODE] for 1 second to exit.
4. The display shows "Save?" To accept the new value, press the [Y/+] key. Press the [N/-] key or the [MODE] key to discard the change and move to the next sub-menu.

4.4.5 Modify Cal Memory

If the current cal memory number selected is not memory 0, users will be prompted whether to modify the settings of the selected cal memory. Press [Y/+] to modify the cal memory and [N/-] to go to the next sub-menu.

Once [Y/+] is pressed the LCD display will show the current memory number, current Gas selected and prompt user for acceptance of current gas selected.

1. Press [N/-] to modify the gas selection if desired. Or press [Y/+] key to skip the change of gas selection, and proceed to the next sub-menu.
2. After pressing [N/-], display shows “Copy gas from library?” Press [Y/+] to accept or [N/-] for the next sub-menu, “Enter Custom gas?”
3. In the “Copy gas from library” submenu, use [Y/+] and [N/-] keys to scroll through the selections in the library. Press [MODE] key momentarily to select the gas. The display shows ”Save?” Press [Y/+] to save or [N/-] to discard the changes and proceed to next sub-menu.
4. In the Custom gas sub-menu, the user can enter the gas name. Press the [Y/+] or [N/-] key to cycle through all 26 letters and 10 numerals. Press the [MODE] key momentarily to advance to the next digit. The flashing digit will move to the next digit to the right. Repeat this process until all digits (up to 8 digits) of the custom gas name is entered.

Press and hold the [MODE] key for 1 second to exit the name entry mode. The display will show “Save?” Press [Y/+] to save the entry, or [N/-] to discard the changes.

4.4.6 Change Correction Factor

This function allows the user to change the Correction Factor of the standard calibration gas (only for Cal Memory #0).

1. "Change Correction Factor?" is the sixth sub-menu in the Calibration sub-menu.
2. Press [Y/+] key. Display shows the gas name, then the correction factor.

A cursor blinks at the left-most digit of the correction factor. If user wants to modify the correction factor, go to Step 3. Otherwise, press and hold the [MODE] key for 1 second to accept the previously stored correction factor value and return to the first sub-menu of the calibrate/select gas menu.

3. Starting from the left-most digit of the correction factor, use [Y/+] or [N/-] key to change the digit value and press [MODE] key momentarily to advance to the next digit, the cursor will move to the next digit to the right. Repeat this process until all digits are entered. Press and hold the [MODE] for 1 second to exit.
4. The display shows "Save?" To confirm the new value, press [Y/+] to accept the change. Press [N/-] or [MODE] to discard the change and return to the first sub-menu, Calibrate and Select Gas.

4.5 Change Alarm Limits

In this menu, the user can change the high and low alarm limits, the STEL limit and the TWA limit (see Table 4.5 below). Press the [Y/+] key and the display shows the current gas selected followed by the first sub-menu item below.

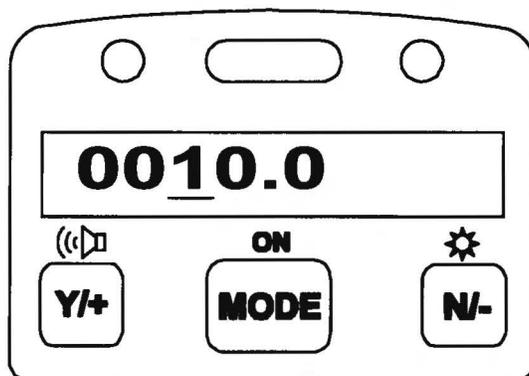
Table 4.5

Alarm Limit Sub-Menu
Change High Alarm limit?
Change Low Alarm limit?
Change STEL limit?
Change TWA limit?

1. Scroll through the Alarm Limit sub-menu using the [N/-] key until the display shows the desired limit to be changed, e.g., "High limit?", "STEL limit?", etc.

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2. Press the [Y/+] key to select the desired limit and the display shows a flashing cursor on the left-most digit of the previously stored alarm limit.



3. To modify this limit value, use the [Y/+] or [N/-] key to change the digit value and press the [MODE] key momentarily to advance to the next digit. The flashing digit will move to the next digit to its right. Repeat this process until the new limit value is entered. Press and hold the [MODE] key for 1 second to exit data entry mode.
4. If there is any change to the existing value, the display shows "Save?" Press [Y/+] to accept the new value and move to the next sub-menu. Press [N/-] to discard the changes and move to the next sub-menu.

4.5.1 Change Low Alarm Limit

The second sub-menu item in the Alarm Limit sub-menu allows the user to change the Low Alarm limit. The LCD displays “Low limit?” To change Low Alarm limit, press [Y/+] key, or Press [N/-] key advance to next sub-menu in Table 4.5.

1. Press [Y/+] and the display will show a flashing cursor on the left-most digit of the previously stored Low alarm limit.
2. To modify this limit value, use the [Y/+] or [N/-] key to change the digit value and press the [MODE] key momentarily to advance to the next digit. The flashing digit will move to the next digit to its right. Repeat this process until the new limit values is entered. Press and hold the [MODE] key for 1 second to exit data entry mode.
3. If there is any change to the existing value, the display shows “Save?” Press [Y/+] to accept the new value and move to the next sub-menu. Press [N/-] to discard the changes and move to the next sub-menu.

4.5.2 Change STEL Limit

This sub-menu item allows the user to change the STEL limit. The display shows “STEL limit?”

1. Press the [Y/+] key and the display will show a flashing cursor on the left-most digit of the previously stored STEL limit.
2. To modify this limit value, use the [Y/+] or [N/-] key to change the digit value and press the [MODE] key momentarily to advance to the next digit. The flashing digit will move on to next digit to its right. Repeat this process until the new limit values is entered. Press and hold the [MODE] key for 1 second to exit data entry mode.
3. If there is any change to the existing value, the display shows “Save?” Press [Y/+] to accept the new value and move to the next sub-menu. Press [N/-] to discard the changes and move to the next sub-menu.

4.5.3 Change TWA Limit

This sub-menu item allows the user to change the TWA limit. The LCD displays “TWA limit?”

1. Press **[Y/+]** and the display will show a flashing cursor on the left-most digit of the previously stored TWA limit.
2. To modify this limit value, use the **[Y/+]** or **[N/-]** key to change the digit value and press the **[MODE]** key momentarily to advance to the next digit. The flashing digit will move on to next digit to its right. Repeat this process until the new limit values is entered. Press and hold the **[MODE]** key for 1 second to exit data entry mode.
3. If there is any change to the existing value, the display shows “Save?” Press **[Y/+]** to accept the new value and move to the next sub-menu. Press **[N/-]** to discard the changes and move to the next sub-menu.

4.6 Change Datalog

The MiniRAE 2000 monitor calculates and stores the concentration and ID of each sample taken. In the datalog sub-menu, a user can perform the tasks and functions shown below.

Datalog Sub-Menu

Reset Peak/Minimum?

Clear Data?

Change Data Period?

Change Average Type?

4.6.1 Reset Peak

This function will reset the peak and minimum stored in the data memory. Note: this function will not clear the STEL or TWA data.

1. "Reset Peak?" is the first sub-menu item in the Datalog sub-menu (Table 4.6).
2. Press the [Y/+] key to reset the Peak/Minimum Values. The display shows "Are You Sure?"
3. Pressing the [Y/+] key again will reset the values. The display shows "Peak/Minimum Cleared" and moves to the next submenu.
4. Press the [N/-] or [MODE] key to exit without resetting the values and move to the next sub-menu.

4.6.2 Clear Data

This function will erase all data stored in the non-volatile datalog memory. Note: This function does not change STEL, TWA, Peak, Minimum and run time values, which are stored in the regular data memory.

1. "Clear Data?" is the third sub-menu item in the Datalog sub-menu.
2. Press the [Y/+] key to clear the datalog memory. The display shows "Are you sure?"
3. Press the [Y/+] key again to confirm erasure of all the datalog memory.
4. Press the [N/-] or [MODE] key to exit without clearing the datalog memory and move to the next datalog sub-menu.

4.6.3 Change Data Period

The datalog period can be programmed from 1 to 3,600 seconds (1 hour).

1. "Change Data Period?" is the fifth sub-menu item in the Datalog sub-menu.
2. Press the [Y/+] key and the display shows "Datalog Period = XXXX" with the left-most digit flashing, where "XXXX" is the previously stored data log period.
4. To modify this period, starting from the left-most digit, use the [Y/+] or [N/-] key to change the digit value and press the [MODE] key momentarily to advance to the next digit. The flashing digit will move to the next digit to the right. Repeat this process until all 4 digits of the new period are entered. Press and hold the [MODE] key for 1 second to exit data entry mode.
5. If there is any change to the existing value, the display will show "Save?" Press [Y/+] to accept the new value or [N/-] to discard the changes and move to the next sub-menu.

4.6.4 Change Average Type

The user can select either an 8-hour Time Weighted Average (TWA) or a running Average. The running average is simply the average of all instantaneous (1-second) readings since the measurement was started. This average may increase or decrease with time depending on the readings. The TWA is a cumulative value used to estimate the fraction of the 8-hour limit to which the user has been exposed since the start of the measurement. This value can only increase or remain constant, never decrease. Refer to Technical Note 119 for more information on how TWA is calculated.

1. "Change Average Type?" is the sixth sub-menu in the Datalog sub-menu.
2. Press the [Y/+] key to enter the function.
3. The display will show "Running Average?" or "Time Weighted Average?" depending on the current average type.
4. Press [N/-] key to toggle between the average types. Press [Y/+] key to select the displayed average type.
5. If there is any change to the existing setting, the display shows "Save?" Press [Y/+] to save the change. Press [N/-] or [MODE] to discard the change and return to the first sub-menu.

4.7 Change Monitor Setup

Several monitor specific variables can be changed in this menu. The following is a list of configuration data that can be modified by the user.

Monitor Setup Sub-Menu	Diagnostic Mode
Change Operation Mode?	“
Change Site ID?	Change Unit ID?
Change User ID?	Change Host ID?
Change Alarm Mode?	“
Change User Mode?	“
Change Date?	“
Change Time?	“
Change Lamp?	“
Change Pump Duty Cycle?	“
Change Unit?	“
Change Dilution Ratio?	“
Change Output?	“
Change DAC Range?	“
Set Temperature Unit?	“

4.7.1 Change Operation Mode

MiniRAE 2000 supports two operation modes: Survey and Hygiene mode.

Survey mode: Manual start/stop of measurements and display of certain exposure values.

Hygiene mode: Automatic measurements, running and datalogging continuously and calculates additional exposure values.

1. "Change Op Mode?" is the first sub-menu item in the Monitor Setup menu (Table 4.7).
2. Press the [Y/+] key and the display shows the current user mode: "Op Mode = *current mode*?"
3. Press the [Y/+] key to accept the currently displayed operation (Op) mode. Press [N/-] to toggle to the other operation mode. Press [MODE] to exit this sub-menu and move to the next monitor setup sub-menu.
4. When changing Op mode from Hygiene to Survey, the display shows the additional message "Warning! Exit Hygiene?" to prevent accidental exit from Hygiene mode. Press the [Y/+] key to acknowledge.
5. If there is any change to the existing setting, the display will show "Save?" Press the [Y/+] key to accept or the [N/-] key to discard and move to the next sub-menu.

Note: If a new Op Mode is saved, the display shows "Op Mode changed!!" when exiting the programming mode.

4.7.2 Change Site ID

The user can enter an 8-digit alphanumeric site ID in the programming mode. This site ID will be included in the datalog report.

1. "Change Site ID?" is the second sub-menu item in the Monitor Setup menu (Table 4.7).
2. Press the [Y/+] key and the display shows the current site ID: "Site ID = xxxxxxx" with the left most digit flashing.
3. Press the [Y/+] or [N/-] key to cycle through all 26 letters and 10 numerals. Press [MODE] momentarily to advance to the next digit. The flashing digit will move to the next digit to the right. Repeat this process until all 8 digits of the new site ID are entered.
4. Press and hold the [MODE] key for 1 second to exit the data entry mode.
5. If there is any change to the existing site ID, the display shows "Save?" Press the [Y/+] key to accept the new site ID. Press the [N/-] key to discard the change and move to the next sub-menu.

4.7.3 Change User ID

The user can enter an 8-digit alphanumeric user ID in the programming mode. This user ID will be included in the datalog report.

1. "Change User ID?" is the third sub-menu item the Monitor Setup menu.
2. Press the [Y/+] key and the display shows the current user ID: "User ID = xxxxxxxx" with the left most digit flashing.
3. Press the [Y/+] or [N/-] key to cycle through all 26 letters and 10 numerals. Press [MODE] momentarily to advance to the next digit. The flashing digit will move to the next digit to the right. Repeat this process until all 8 digits of the new user ID are entered.
4. Press and hold the [MODE] key for 1 second to exit the data entry mode.
5. If there is any change to the existing user ID, the display shows "Save?" Press the [Y/+] key to accept the new user ID. Or press the [N/-] key to discard the changes and move to the next sub-menu.

4.7.4 Change Alarm Mode?

There are two different alarm modes: **Latched** and **Automatic Reset** (Auto Reset) in the MiniRAE 2000 that can be selected from the programming menu.

1. "Change Alarm Mode?" is the fourth sub-menu item in the Monitor Setup menu.
2. Press the [Y/+] key; the display shows the current alarm mode.
3. Press the [Y/+] key to accept the currently displayed alarm mode. Press [N/-] key to toggle to the other alarm mode. Press [MODE] to exit this sub-menu and move to the next monitor setup sub-menu.
4. If there is any change to the existing setting, the display will show "Save?" Press [Y/+] to save the change. Press [N/-] or [MODE] to discard the change and move to the next sub-menu.

4.7.5 Change User Mode

There are two different user modes: **Display** and **Program** that can be selected from the programming menu.

1. “Change User Mode?” is the fifth sub-menu item in the Monitor Setup menu (Table 4.7).
2. Press the [Y/+] key; the display shows the current user mode selected.
3. Press the [Y/+] key to accept the currently displayed user mode. Press [N/-] key to toggle to the alternate user modes. Press [MODE] to exit this sub-menu and move to the next monitor setup sub-menu.
4. If there is any change to the existing selection, the display shows messages “Program change” and “Are you sure?” Press [Y/+] to confirm the change or press [N/-] or [MODE] to discard the changes and move to the next sub-menu.

CAUTION: If the user mode is changed to **Display** mode, the user can no longer enter the programming mode. Therefore, the user can not change the user mode back to **Program** mode in normal mode.

To restore the user mode back to **Program** mode, turn the unit off and back on in Diagnostic Mode. Next enter Program mode by holding the [MODE] and [N/-] keys for three seconds. Enter the password at the prompt (the default is 0000). Once program mode is entered, go to the “Change Monitor Setup” / “Change User Mode” and change the mode back to **Program**.

An alternative way to change Display mode back to Program mode is through the PC and the ProRAE-Suite software.

4.7.6 Change Date

The MiniRAE 2000 monitor is equipped with a real time clock (RTC). The user can enter the correct date and time (see 4.7.7) for the real time clock.

1. "Change Date?" is the sixth sub-menu item in the Monitor Setup menu.
2. Press [Y/+] and the display shows the current date "mm / dd / yy" with the left most digit of the date flashing.
5. To modify this value, use the [Y/+] or [N/-] key to change the digit value and press the [MODE] key momentarily to advance to the next digit. The flashing digit will move on to next digit to its right. Repeat this process until the new date and time values are entered. Press and hold the [MODE] key for 1 second to exit data entry mode.
4. If there is any change to the existing value, the display shows "Save?" Press [Y/+] to confirm the new value or press [N/-] or [MODE] to discard the changes and move to the next sub-menu.

4.7.7 Change Time

To change the time in the RTC of the MiniRAE 2000:

1. “Change Time?” is the seventh sub-menu item in the Monitor Setup menu.
2. Press [Y/+] and the display shows the current time in the 24-hour format “hh : mm” with the left most digit of the time flashing.
3. To modify this value, use the [Y/+] or [N/-] key to change the digit value and press the [MODE] key momentarily to advance to the next digit. The flashing digit will move on to next digit to its right. Repeat this process until the new date and time values are entered. Press and hold the [MODE] key for 1 second to exit data entry mode.
4. If there is any change to the existing value, the display shows “Save?” Press [Y/+] to confirm the new value or press [N/-] or [MODE] to discard the changes and move to the next sub-menu.

4.7.8 Change Lamp

There are three UV lamps with different photon energies available for the PID sensor: **9.8 eV**, **10.6 eV** and **11.7 eV**. The user can select any one of the lamps from the programming mode.

1. "Change Lamp Type?" is the eighth sub-menu item in the Monitor Setup menu (Table 4.7).
2. Press the [Y/+] key; the display shows the current PID lamp selection.
3. Press the [Y/+] key to accept the currently displayed lamp. Press [N/-] key to scroll through the sub-menu for other lamp selections. Press [MODE] to exit this sub-menu and return to the next sub-menu in Table 4.7.
4. If there is any change to the existing selection, the display will show "Save?" Press [Y/+] to save the new selection or press [N/-] or [MODE] to discard the change and return to the next sub-menu in Table 4.7.

4.7.9 Change Unit

User can change the display and datalog unit from parts per million (ppm) to milli-gram per cubic meter (mg/m^3).

1. "Change Unit?" is the ninth sub-menu item in the Monitor Setup sub-menu.
2. Press the [Y/+] key, the display should show the current unit "Display Unit = ppm?" or "Display Unit = mg?"
3. Press [Y/+] key to accept the currently displayed unit. Press [N/-] key to toggle to the other unit. Press [MODE] key to exit this sub-menu.
4. If there is any change to the existing selection, press [Y/+] to confirm the new selection or press [N/-] or [MODE] to discard the changes and move to the next sub-menu.

Caution:

1. **The correction factor in the gas library is calculated based on "ppm" unit. If "mg" unit is selected, the built-in correction factor library is not valid.**
2. **No automatic conversion between "ppm" and " mg/m^3 " reading is performed by the monitor.**
3. **When the unit name is changed from "ppm" to "mg", the unit must be recalibrated with the span gas concentration entered in mg/m^3 . The converse rule applies when the unit is changed from "mg" to "ppm".**

4.7.10 Change Dilution Ratio

If a dilution system is used upstream of the MiniRAE 2000 inlet port, the user can enter the dilution ratio (from 1 to 10) to compensate the readings. The unit will then display the actual concentration of the gas before dilution. The dilution ratio should be 1 in normal operation where no dilution gas is applied to the sample gas. Dilution improves accuracy and linearity when the concentrations are above a few thousand ppm.

1. "Change Dilution Ratio?" is the tenth sub-menu item in the Monitor Setup menu.
2. Press the [Y/+] key; the display shows the current dilution ratio: "Dilution Ratio = xx" with the left most digit flashing.
3. Press the [Y/+] or [N/-] key to increase or decrease the value of the digit. Press [MODE] momentarily to advance to the next digit. The flashing digit will move to the next digit to the right. Repeat this process until both digits of the new dilution ratio are entered.
4. Press and hold the [MODE] key for 1 second to exit the data entry mode and move to the next sub-menu.
5. If there is any change to the existing dilution ratio, the display shows "Save?" Press [Y/+] to confirm the new value or press [N/-] or [MODE] to discard the changes and move to the next sub-menu.

4.7.11 Change Output?

There are two different external output options: DAC (Analog output) and Alarm in the MiniRAE 2000 that can be selected from the programming menu. The alarm output can be used to connect to the optional vibration alarm (vibrator) only. The analog output, which is proportional to the gas concentration, can be connected a chart recorder or can be queried by a computer to download data in real time (see Technical Note 141).

1. "Change External Output?" is the eleventh sub-menu item in the Monitor Setup menu.
2. Press the [Y/+] key and the display shows the current output option selection: "Output = DAC?"
3. Press the [Y/+] key to accept the currently displayed output option. Press [N/-] to change to the other external option: "Output = Alarm?" Press [MODE] to exit this sub-menu and move to the next monitor setup sub-menu.
4. If there is any change to the existing selection the display will show "Save?" Then, press [Y/+] to save the change, press [N/-] to go back to Step 2, or press [MODE] to exit this sub-menu and move to the next monitor setup sub-menu.

4.7.12 Change DAC Range?

There are four different DAC (Digital-to-Analog Conversion) range values available in the **MiniRAE 2000: 20, 200, 2000 and 10K ppm**. The maximum 2.5V DC analog signal output from the unit will represent the range value chosen. (See for analog signal output connection.)

1. “Change DAC Range?” is the twelfth sub-menu item in the Monitor Setup menu.
2. Press the **[Y/+]** key, the display shows the current DAC Range value: “DAC Range = 2000 ppm?”
3. Press the **[Y/+]** key to accept the currently displayed value. Press **[N/-]** to scroll through the sub-menu for other range values. Press **[MODE]** to exit this sub-menu and return to the first sub-menu in Table 4.7.
4. If there is any change to the existing selection, press the **[Y/+]** key and the display will show “Save?” Press the **[Y/+]** key to save the change or press the **[N/-]** key to discard and return to the first sub-menu in Table 4.7.

4.7.13 Set Temperature Unit?

The temperature display can be switched between Fahrenheit and Celsius units.

1. "Set Temperature Unit?" is the thirteenth sub-menu item in the Monitor Setup menu.
2. Press the [Y/+] key, and the display shows the current setting: "Temperature Unit = Fahrenheit?"
3. Press the [Y/+] key to accept the currently displayed value. Press [N/-] to select the sub-menu "Temperature Unit = Celsius?" Press [MODE] to exit this sub-menu and return to the first sub-menu in Table 4.7.
4. If there is any change to the existing selection, press the [Y/+] key and the display will show "Save?" Press the [Y/+] key to save the change and return to the first sub-menu in Table 4.7 or press the [N/-] key to discard and return to Step 3..

4.8 Exit Programming Mode

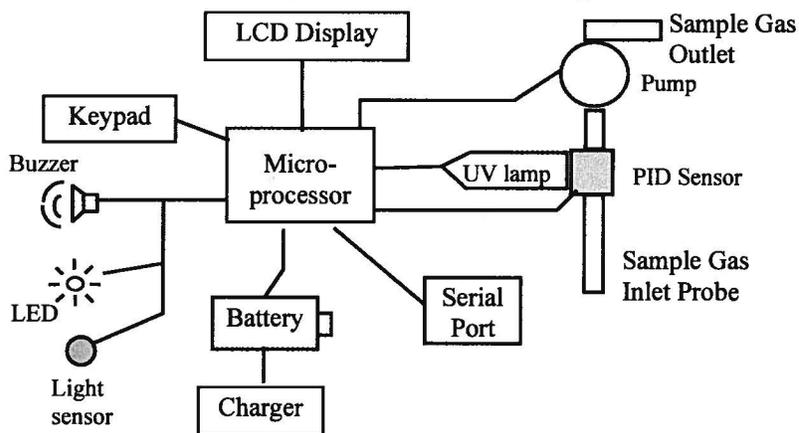
1. To exit programming mode from the first tier menu level, press the **[MODE]** key once.
2. To exit programming mode from 2nd tier sub-menu, press the **[MODE]** key twice.
3. To return to programming mode, press and hold down both the **[MODE]** and **[N/-]** keys for 3 seconds.

5. THEORY OF OPERATION

The MiniRAE 2000 monitor uses a newly developed electrodeless discharge UV lamp as the high-energy photon source for the PID. As organic vapors pass by the lamp, they are photo-ionized and the ejected electrons are detected as a current. The PID sensor with a standard 10.6 eV lamp detects a broad range of organic vapors. A lamp with high photon energy (e.g. 11.7 eV) will measure the more kinds of compounds, whereas low photon energies (e.g. 9.8 eV) are selective for easily ionizable compounds such as aromatics. In principle, any compound with an ionization energy lower than that of the lamp photons can be measured.

The PID sensor for the MiniRAE 2000 monitor is constructed as a small cavity in front of the UV lamp. A diaphragm pump draws the gas sample into the sensor and then pumps it out through the side of the instrument.

Figure 5-1 MiniRAE 2000 Block Diagram



THEORY OF OPERATION

A single chip microcomputer is used to control the operation of the alarm buzzer, LED, pump and light sensor. It measures the sensor readings and calculates the gas concentrations based on calibration to known standard gases. The data are stored in non-volatile memory so that they can be sent to a PC for record keeping. RS-232 transceivers provide a serial interface between the monitor and the serial port of a PC. An LCD display consisting of a single row of eight alpha/numeric characters is used to display the readings. The user interacts with the monitor through three keys on the front panel keypad.

A rechargeable NiMH, NiCd battery, or an alkaline battery pack powers the monitor.

6. MAINTENANCE

The major maintenance items of the MiniRAE 2000 are:

- Battery pack
- Sensor module
- PID lamp
- Sampling pump
- Inlet connectors and filters

Note: Maintenance should be performed by qualified personnel only.

NOTE: The printed circuit board of the monitor is connected to the battery pack even if the power is turned off. Therefore, it is very important to disconnect the battery pack before servicing or replacing any components inside the monitor. Severe damage to the printed circuit board or battery may occur if the battery pack is not disconnected before servicing the unit.

6.1 Battery Charging and Replacement

When the display shows a flashing message “Bat”, the battery requires recharging (see Section 3.1 for Battery charging). It is recommended to recharge the MiniRAE 2000 monitor upon returning from fieldwork. A fully charged battery runs a MiniRAE 2000 monitor for 10 hours continuously. The charging time is less than 10 hours for a fully discharged battery. The built-in charging circuit is controlled by the micro-controller to prevent over-charging. The battery may be replaced in the field (in area known to be non-hazardous) if required.

WARNING

To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. Remove and replace battery only in area known to be non-hazardous.

Replacing Battery Pack

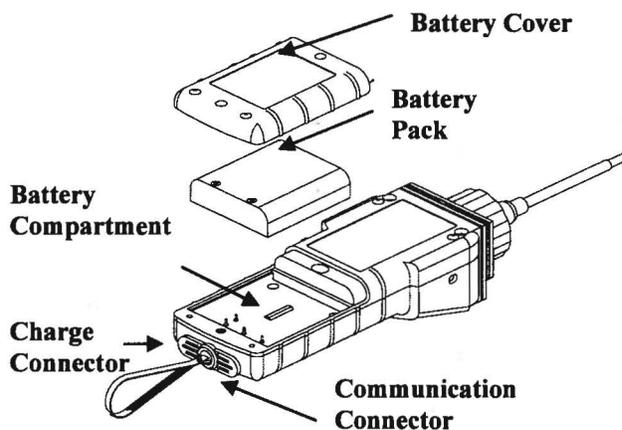


Figure 6-1 Battery Replacement

1.

MAINTENANCE

Turn off the power of the MiniRAE 2000.

2. Unscrew the two battery compartment screws, located on the bottom of the monitor, and remove the cover.
3. Remove the battery pack from the battery compartment.
4. Replace a fully charged spare battery pack inside the battery compartment. Make sure the battery pack is oriented properly inside the compartment
5. Close the battery cover and tighten the two screws.

Replacing Alkaline Battery Adapter

1. Insert four fresh AA size alkaline batteries into the alkaline battery holder. Make sure that the polarity of the batteries is correct.
2. Follow the same procedure as described above to replace the battery holder.

Note: The internal charging circuit is designed to prevent charging to alkaline batteries.

6.2 PID Sensor & Lamp Cleaning/Replacement

The sensor module is made of several components and is attached to the lamp-housing unit as shown in Figure 7-2.

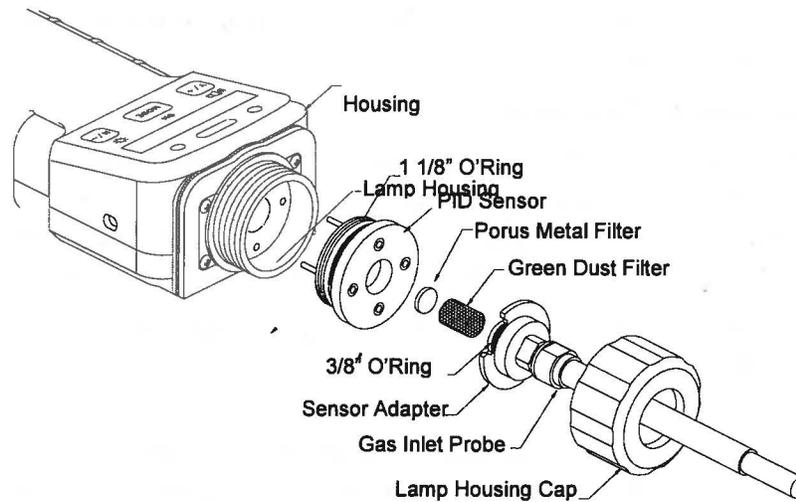


Figure 7-2 Sensor Components

Note: Normally the cleaning procedure is not needed. Clean the PID sensor module, the lamp and the lamp housing only when one of the following happened:

1. The reading is inaccurate even after calibration.
2. The reading is very sensitive to air moisture.
3. A chemical liquid has been sucked into the unit and damaged the unit.

Use of the water trap filter will help prevent contamination and accidentally drawing liquid into the sensor.

MAINTENANCE

To access the sensor components and lamp, gently unscrew the lamp-housing cap, remove the sensor adapter with the gas inlet probe and the metal filter all together. Then hold the PID sensor and pull straight out to avoid bending the electrical pins on the sensor (see Figure 7-2). A slight, gentle rocking motion helps release the sensor.

To clean the PID sensor:

Place the entire PID sensor module into GC grade methanol. It is highly recommended that an ultrasound bath to be used to clean the sensor for at least 15 minutes. Then dry the sensor thoroughly. Never touch the electrodes of the sensor by hand.

Also use a methanol-soaked cotton swab to wipe off the lamp housing where it contacts the sensor when the sensor is installed.

Turn over the sensor so that the pins point up and the sensor cavity is visible. Examine the sensor electrodes for any corrosion, damage, or bending out of alignment. The metal sensor electrode “fingers” should be flat and straight. If necessary, carefully bend the sensor fingers to ensure that they do not touch the Teflon portions and that they are parallel to each other. Make sure that the nuts on the sensor pins are snug but not overtight. If the sensor is corroded or otherwise damaged, it should be replaced.

MAINTENANCE

To clean lamp housing or change the lamp:

To clean lamp housing or change the lamp:

If the lamp does not turn on, the monitor will display an error message to indicate replacement of the lamp may be required.

1. If the lamp is operational, clean the lamp window surface and the lamp housing by wiping it with GC grade methanol using a cotton swab using moderate pressure. After cleaning, hold the lamp up to the light at an angle to detect any remaining film. Repeat the process until the lamp window is clean. Never use water solutions to clean the lamp. Dry the lamp and the lamp housing thoroughly after cleaning.

CAUTION: Never touch the window surface with the fingers or anything else that may leave a film. Never use acetone or aqueous solutions.

2. If the lamp does not turn on, remove the lamp from the lamp housing. Place the lamp O-ring onto the new lamp. Insert the new lamp, avoiding contact with the flat window surface.
3. Reinstall the PID sensor module.
4. Tighten the Lamp Housing Cap.
5. If the lamp type has been changed, adjust the lamp type setting in the programming mode (Section 4.7.8).

6.3 Sampling Pump

When approaching the end of the specified lifetime of the pump, it will consume higher amount of energy and reduce its sample draw capability significantly. When this occurs, it is necessary to replace or rebuild the pump. When checking the pump flow, make sure that the inlet connector is tight and the inlet tubing is in good condition. Connect a flow meter to the gas inlet probe. The flow rate should be above 450 cc/min when there is no air leakage.

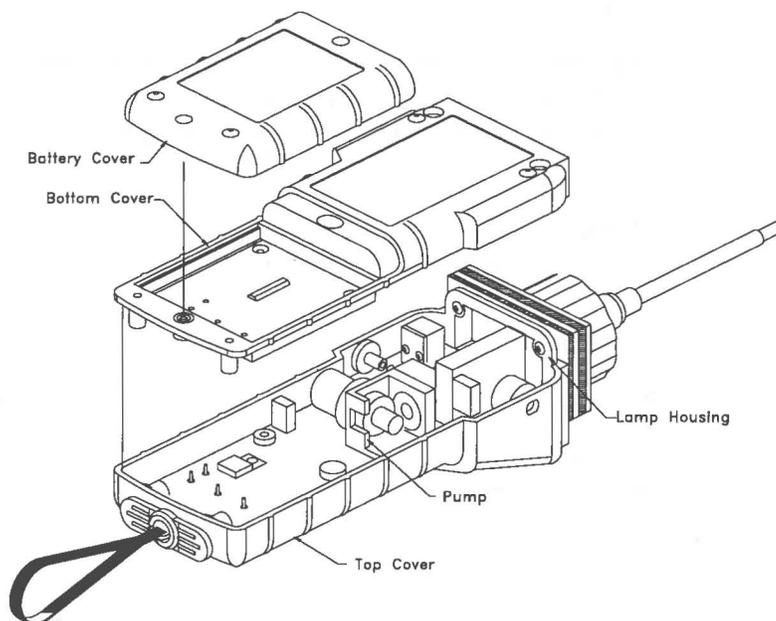


Figure 7-3 Sampling Pump

MAINTENANCE

Pump Replacement

1. Turn off the MiniRAE 2000 power.
2. Open the battery cover, remove the battery pack, and carefully unscrew the six screws to open the bottom cover.
3. Unplug the pump from the PCB. Unscrew the two screws that hold the pump assembly to the PCB. Disconnect the Tygon tubing that connects the pump to the gas inlet port and gas outlet port.
4. Insert a new pump assembly. Connect the Tygon tubing to the gas inlet port. Plug the pump connector back into the PCB and screw down the pump assembly to the board.
5. Replace the bottom cover and tighten the six screws. Reconnect the battery pack. Replace the battery pack and its cover.

6.4 Turning on the UV Lamp

The UV lamp is made of a glass envelope and a UV window (salt crystal) on one end of the envelope. The inside of the lamp is filled with low pressure gases. To turn on the lamp, a high voltage electric field is applied from the outside of the glass envelope. The molecules inside the lamp are ionized and produce a glow discharge that generates the UV light. The MiniRAE 2000 has a built-in sensing mechanism to monitor the status of the UV lamp and display a “Lamp” error message if it is not on.

If the UV lamp has not been used for a long period of time (> 1 month) or is cold, it may become slightly harder to turn on. If such a condition occurs, the “Lamp” message will appear in the monitor display during the power on sequence. This phenomenon is more significant in 0.25” UV lamps used in ToxiRAE and MultiRAE Plus products, because of the relatively small lamp size. To solve this problem, simply turn on and off the monitor a few times and the lamp should turn on. After the UV lamp is turned on for the first time, it should be easier to turn on the UV lamp next time.

It is possible that the UV lamp is actually on when the lamp error message appears. This is because when the lamp becomes old, the internal threshold level to detect lamp failure may have shifted and cause a false alarm. To eliminate such possibility, simply check to see the UV lamp is actually on. This can be done easily by removing the sensor cap and observing the glow light of the UV lamp in a dark place. The user can also feed the monitor with calibration gas and observe if the sensor reading changes. If the reading changes significantly with the gas, the UV lamp is actually on.

A possible failure mechanism for the UV lamp is a leak developed along the seal of the glass envelope. When such condition occurs, the lamp will become very hard or impossible to turn on and will need to be replaced.

7. TROUBLESHOOTING

To aid the user in diagnosing the monitor, a special diagnostic mode can be used displays critical, low level parameters. Section 7.1 describes the operation of the diagnostic mode. Section 7.2 summarizes the frequently encountered problems and suggested solutions. By turning on the MiniRAE 2000 monitor in diagnostic mode and by using the troubleshooting table in Section 7.2, the user can usually correct the problem without having to return the monitor for repair.

WARNING

This function should be used by qualified personnel only! The diagnostic mode allows the user to set several low-level parameters that are very critical to the operation of the monitor. Extra care should be taken when setting these parameters. If the user is not familiar with the function of these parameters and sets them incorrectly, it may cause the monitor to shut down or malfunction.

TROUBLESHOOTING

7.1 Troubleshooting Table

Problem	Possible Reasons & Solutions
Cannot turn on power after charging the battery	<p>Reasons: Discharged battery. Defective battery. Microcomputer hang-up.</p> <p>Solutions: Charge or replace battery. Disconnect, then connect battery to reset computer.</p>
No LCD back light	<p>Reasons: Trigger level too low, the current mode is not user mode, and the mode does not support automatic turn on back light.</p> <p>Solutions: Adjust trigger level. Verify the back light can be turned on in user mode. Call authorized service center.</p>
Lost password	<p>Solutions: Call Technical Support at +1.408 .752 .0723 or +1. 888 .723 .4800</p>
Reading abnormally High	<p>Reasons: Dirty sensor module. Dirty water trap filter. Excessive moisture and water condensation.</p> <p>Solutions: Clean sensor module and lamp housing. Replace water trap filter. Blow dry the sensor module.</p>
Buzzer Inoperative	<p>Reasons: Bad buzzer.</p> <p>Solutions: Call authorized service center.</p>

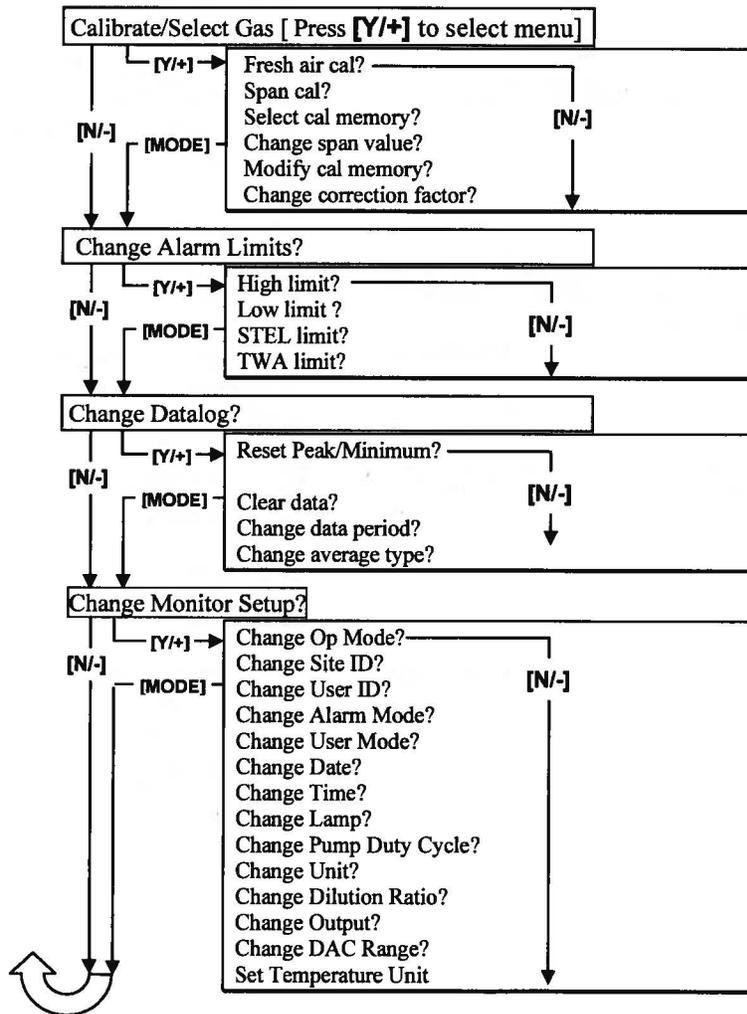
TROUBLESHOOTING

<p>Inlet flow too low</p>	<p>Reasons: Pump diaphragm damaged or has debris. Flow path leaks.</p> <p>Solutions: Check flow path for leaks; sensor module O-ring, tube connectors, Teflon tube compression fitting. Replace pump or diaphragm.</p>
<p>“Lamp” message during operation</p>	<p>Reasons: Lamp drive circuit. Weak or defective PID lamp, defective.</p> <p>Solutions: Turn the unit off and back on Replace UV lamp</p>
<p>Full scale measurement in humid environment</p>	<p>Reasons: Dirty or wet sensor.</p> <p>Solutions: Clean and dry sensor and lamp housing. Adjust sensor fingers to ensure not touching Teflon. Use water trap filter.</p>
<p>Reading abnormally low</p>	<p>Reasons: Incorrect calibration. Low sensitivity to the specific gas. Weak or dirty lamp. Air leakage.</p> <p>Solutions: Calibrate the monitor. Replace sensor. Clean or replace lamp. Check air leakage.</p>

APPENDIX A. QUICK REFERENCE GUIDE

Press [N/-] and [MODE], simultaneously, for 3 seconds, to enter Programming Mode. Press [MODE] to return to Survey Mode.

PROGRAMMING MODE



RAE Systems, Inc. Contact Information

Main Office: 3775 N. First St.
San Jose, CA 95134-1708
USA

Telephone: 408-952-8200

Fax: 408-952-8480

Instrument Sales: 877-723-2878

Email: RaeSales@raesystems.com

Website: www.raesystems.com

Technical Service: 888-723-4800
Tech@raesystems.com

Special Note

If the monitor needs to be serviced, contact either:

1. The RAE Systems distributor from whom the monitor was purchased; they will return the monitor on your behalf.
2. The RAE Systems Technical Service Department. Before returning the monitor for service or repair, obtain a Returned Material Authorization (RMA) number for proper tracking of your equipment. This number needs to be on all documentation and posted on the outside of the box in which the monitor is returned for service or upgrade. Packages without RMA Numbers will be refused at the factory.

MultiRAE Plus

PGM-50/4, PGM-50/4P, PGM-50/5P
Multiple-Gas Monitor



USER MANUAL

008-4022-000, Revision B1, November 2003

Equipment List

NUMBER	PART	PART NUMBER
	Monitor Only	
(not shown)*	Shipping case	008-3040-000
2	Monitor with wrist strap	<i>as specified</i>
2	Sensors	<i>as specified</i>
2	Rubber boot with belt clip	008-3042-000
2	Rechargeable Li-Ion battery	500-0037-100
3	Alkaline battery adapter	500-0029-000
4	120-230 V AC/DC wall adapter	<i>as specified</i>
5	Calibration adapter	008-3016-000
5	External filters	008-3022-003
5	Inlet probe	008-3012-001
5	Charcoal filters	008-3006-005
6	Training CD	008-4013-000
7	User manual	008-4022-000
	Monitor with Accessories Kit	
1	Hard transport case	002-3009-000
8	Remote sampling probe with coiled Teflon tubing	008-3015-200
9	Tool kit	081-0005-000
	Optional Calibration Kit	008-3001-000
10	Calibration gas	<i>as specified</i>
11	Regulators with tubing (male)	007-3021-000
11	Regulators with tubing (female)	002-3011-000
	Datalogging Upgrade Option	008-001-000
6	ProRAE Suite software package, for Microsoft® Windows™ 95, 98, 2000, NT, ME & XP	000-5001-000
12	Computer interface cable	008-3003-000

*Different shipping cases are used for monitor-only and single calibration gas kits.

This is a complete kit, which includes the accessories and calibration kits with a MultiRAE Plus monitor that is datalog-enabled.



Read Before Operating

This manual must be carefully read by all individuals who have or will have the responsibility of using, maintaining, or servicing this product. The product will perform as designed only if it is used, maintained, and serviced in accordance with the manufacturer's instructions.



Caution!

To reduce the risk of electric shock, turn off power before removing the monitor cover. Disconnect the battery before removing sensor modules for service. Never operate this monitor while the cover is removed. Remove monitor cover and sensor modules only in an area known to be non-hazardous.



Special Note

When the MultiRAE Plus monitor is taken out of the transport case and is turned on for the first time, there may be some residual vapors trapped inside the monitor and the initial toxic gas sensors may indicate a few ppm. After running the monitor for several minutes in clean air, the residual vapors should clear and readings should return to near zero.



Attention! For European Applications

- A. CE 0575  II 2G
DEMKO 03 ATEX 0308256X, EEx ia d IIC T3/T4
- B. Recharge batteries in non-hazardous locations.
- C. Do not connect external cable to serial interface jack in hazardous locations.
- D. Use RAE Systems Adapter P/N 500-0072 for connection to communication port and charging jack only in a non hazardous area.

Protected by U.S. Patents 5,393,979 , 5,561,344 ,
5,773,833 , 6,225,633 , 6,313,638 , 6,333,632 , 6,320,388

Warnings

For safety reasons this equipment must be operated and serviced by qualified personnel only. Read and understand the instruction manual completely before operating or servicing.

Battery Pack

Use only RAE Systems battery packs, part number 500-0029 or 500-0037. This instrument has not been tested in an explosive gas/air atmosphere having an oxygen concentration greater than 21%. Substitution of components may impair intrinsic safety. Recharge batteries only in non-hazardous atmospheres.

Computer Interface

Do not transfer data by means of the computer interface cable in hazardous atmospheres.

Static Hazard

Clean only with a damp cloth.

Calibration

The calibration of any newly purchased RAE Systems Instrument should be tested by exposing it to known concentration calibration gases before the instrument is put into service for the first time. For safety, check the accuracy of the monitor by exposing the sensors to known concentration calibration gas(es) before each day's use.

Readings

Any rapid up-scale reading followed by a declining or erratic reading may indicate a gas concentration beyond upper scale limit, which may be hazardous.

Avertissements

Pour des raisons de sécurité, cet équipement doit être utilisé, entretenu et réparé uniquement par un personnel qualifié. Étudier le manuel d'instructions en entier avant d'utiliser, d'entretenir ou de réparer l'équipement.

Ensemble de Batterie

Utiliser seulement l'ensemble de batterie RAE Systems avec numéro de série 500-0029 ou 500-0037. Cet instrument n'a pas été essayé dans une atmosphère de gaz/air explosive ayant une concentration d'oxygène plus élevée que 21%. La substitution de composants peut compromettre la sécurité intrinsèque. Ne charger les batteries que dans l'emplacement désigné non dangereux.

Câble de Computer

Connecter pas le câble externe que dans environnements non dangereux.

Danger Risque D'origine Electrostatique

Nettoyer uniquement avec un chiffon humide.

La Calibration

La calibration de toute instruments de RAE Systems doit être testé en exposant l'instrument à une concentration de gaz connue par une procédure de talonnage avant de mettre en service l'instrument pour la première fois. Pour une sécurité maximale, la sensibilité du MultiRAE Plus doit être vérifié en exposant l'instrument à une concentration de gaz connue par une procédure de talonnage avant chaque utilisation journalière.

Les Lectures

Toute lecture rapide et positive, suivie d'une baisse subite au erratique de la valeur, peut indiquer une concentration de gaz hors gamme de détection qui peut être dangereuse.

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General Information

The MultiRAE Plus is a programmable multiple-gas monitor designed to provide continuous exposure monitoring of toxic organic and inorganic gases, oxygen and combustible gases for workers in hazardous environments.

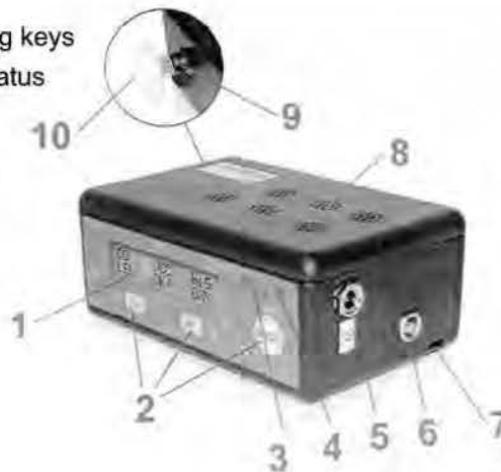
The MultiRAE Plus is an extremely flexible one-to-five sensor instrument for use in confined space, emergency response, industrial hygiene, and many other monitoring applications. The MultiRAE Plus is the only instrument available on the market today that can offer protection using both standard gas detection sensors for the detection of oxygen, combustible gas, and specific toxic gases, as well as an integrated Photoionization Detector (PID) for the ultimate broad-range toxic gas detection. The MultiRAE Plus is easily reconfigured and upgraded to meet your changing needs. Its versatility replaces a wide range of monitors, saving training, and maintenance costs. The MultiRAE Plus transitions quickly and easily from a sophisticated technician instrument to a simple text or display only monitor. The same monitor can be used as a personal monitor, a hand-held sniffer, or as a continuous operational area monitor.

Datalogging-Enabled Monitors

Datalog monitors are capable of storing datalog data in the instrument's non-volatile memory. When the version number appears during the power-on sequence, the "D" indicates a Datalog monitor. Call the factory to learn how to upgrade the instrument to a Datalog monitor.

Physical Description

1. Display
2. Operation/programming keys
3. Visual alarm/charge status
4. Light sensor
5. Power jack
6. RS-232 port
7. Wrist strap holder
8. Buzzer and gas outlet
9. Gas inlet
10. External filter



Operating the MultiRAE Plus

 The external filter must always be used with the monitor.

Turning the Monitor On and Off

To turn on, press . The monitor will beep once and go through a 90-second warm-up sequence as follows:

On! – English, PGM-50

Multi-Gas Monitor, Software Version

RAE Systems, Inc. (customizable using ProRAE Suite software)

Monitor Type, Serial Number

Date, Time, Temperature

Checking Sensor ID's (As the MultiRAE Plus checks each sensor, it displays the date it was last calibrated and its warranty expiration date. If a new sensor is installed, it will ask for it to be calibrated.)

Alarm Limits (for High, Low, STEL, TWA)

Instrument Calibration (The last calibration date must be within the last 30 days for safe operation.)

Battery Shut Off Voltage

User Mode

Alarm Mode

Datalog Memory

Datalog Time Left

Datalog Mode

Datalog Period

To turn off after the warm-up is complete, press and hold  for 5 seconds. The monitor beeps each second during the count-down sequence. Release when "Off!" flashes on the LCD. Plug the 110 VAC/12 VDC transformer into the monitor when not in use; the "Charging,...." message appears on the screen.

User Modes

The MultiRAE Plus has three user modes: **Text**, **Display**, and **Advanced**. Each mode provides a different level of access to the monitor's features. Text mode is the simplest mode, Advanced mode is the most complex.

The table shows the features in the order in which they appear. Regardless of which user mode the monitor is in, press **MODE** to advance to the next available feature.

Features	Text Mode	Display Mode	Advanced Mode
Sensor Names & Instantaneous Readings - instantaneous readings are the actual gas concentrations for the following sensors: TOX1 (toxic gas) – parts-per-million (ppm) TOX2 (toxic gas) – ppm VOC (volatile organic compound) – ppm LEL (lower explosive limit) – percentage OXY (oxygen) - percentage	yes (with “OK” on LCD)	yes	yes
PEAK - the highest reading for each gas concentration since the monitor was turned on; updated every second.	no	yes	yes
MIN - the lowest reading for each gas concentration since the monitor was turned on; updated every second.	no	yes	yes
STEL - the Short Term Exposure Limit for VOC and toxic gases only; the average reading of the gas concentration for the last 15 minutes, which is updated every minute. NOTE: “*****” will appear for the first fifteen minutes.	no	yes	yes
TWA - the Time Weighted Average for VOC and toxic gases only; the accumulated reading of the gas concentration, divided by 8 hours, since the monitor was turned on. Updated every minute.	no	yes	yes

Battery Voltage - the current battery voltage, measured in volts. Shut off - A fully charged battery will be 4.8 V or greater. When the battery voltage falls below 4.4 V, the "Bat" warning message appears and only 20-30 minutes of run time remain before the instrument will automatically shut down (at 4.2 V).	yes	yes	yes
Date & Time, Run-Time and Temp - the runtime is how long the instrument has been on in hours and minutes.	no	no	yes
Start/Stop Datalog - turns manual datalogging on/off.	no	no	yes
LEL Gas - monitor measures LEL in units of specified target gas. NOTE: Correction factor may only be changed in Program Mode.	no	no	yes
VOC Gas - monitor measures VOC in units of specified target gas. NOTE: Correction factor may only be changed in Program Mode.	no	no	yes
Print Reading - capable of printing out the gas concentration readings if a serial printer is connected to the instrument. NOTE: This feature can be turn on using ProRAE Suite.	no	yes	yes
PC Communication - capable of uploading data from the monitor to a computer or downloading configuration information from a computer to the monitor via a serial port.	yes	yes	yes

Calibrating the Monitor

⚠ While all instruments are calibrated prior to leaving the factory, temperature extremes and/or shocks during shipment can cause sensor drift. Therefore, the accuracy of any newly purchased RAE Systems monitor should be tested by exposing the sensor(s) to known concentration calibration gas before the monitor is used or put into service. For maximum safety, the accuracy of the monitor should be checked by exposing the sensor(s) to known concentration calibration gas before each day's use.

When should you calibrate the monitor?

The monitor should be calibrated no less than every 30 days, or if it does not pass a fresh air reading, or if it does not pass a field verification.

Calibration

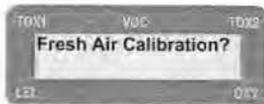
The sensors are calibrated in a two-step process using fresh air and span gas (a span gas contains a known concentration of a given gas). Some sensors may show sensitivity to other gases - this is called "cross sensitivity". Therefore, it is important to choose the gas mixture carefully. We recommend the standard RAE Systems MultiRAE Plus 4-gas calibration mix (50% LEL methane, 20.9% oxygen, 25 ppm H₂S, 50 ppm CO in a single gas cylinder) to calibrate the LEL, H₂S and CO sensors, and isobutylene (100 ppm) for the PID. You will also need a calibration adapter in order to connect the monitor (with external filter!) to the outlet of the gas cylinder. For the calibration of other toxic sensors, you will need the specific gas for that sensor.

Getting Started

To calibrate the monitor, the instrument must be in Program Mode. To enter Program Mode, press and hold **MODE** and **N/-** for 5 seconds.

If the monitor is in Text or Display Mode, you will be prompted for a password. Use **Y/+** to change the number. Use **MODE** to move on to the next digit. The default password is "0000". Press and hold **MODE** to submit the password.





Fresh Air Calibration

The first step of calibration is a Fresh Air Calibration:

Calibrate Monitor?

Press **Y/+** .

Fresh Air Calibration?

Press **Y/+** .

The monitor will cycle through each sensor. When the process is complete, the display will read, "Zero Cal Complete!".

Zero Organic Filters for Zeroing PID

Use an optional external zero organic filter (P/N 008-3024-000, 3-pack) when the ambient air may be contaminated with hydrocarbons.

Attach the filter to the MultiRAE Plus during fresh air calibration. The filter can be used up to 20 times before disposing. This filter removes most heavier organic and inorganic compounds, but may not completely remove lighter compounds such as methane, propane, and CO.

Span Gas Calibration

To complete step two of calibration, a Span Gas Calibration must be performed for each sensor.

The instructions below are for a standard confined space entry instrument utilizing CO, H₂S, LEL, Oxygen sensors.

For this calibration you will need the standard RAE Systems MultiRAE Plus 4-gas calibration mix (50% LEL methane, 20.9% oxygen, 25 ppm H₂S, 50 ppm CO in a single gas cylinder). For the calibration of other toxic sensors, or to calibrate a single sensor, please go to the Program Mode section of this manual.

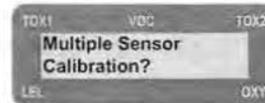
Multiple Sensor Calibration

Press **Y/+**.

The monitor will assume you want to calibrate the CO, H₂S, LEL and Oxygen sensors.

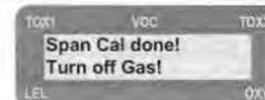
Press **Y/+**.

Apply the RAE Systems 4-gas span gas mixture and start the gas flow.



The 60-second countdown timer appears.

"Span Cal Done! Turn Off Gas" message appears. The readings should be very close to the span gas values shown on the gas cylinder.



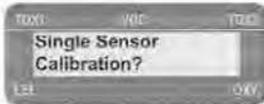
Turn off the gas flow and disconnect the calibration adapter from the monitor. If calibration fails, an error message appears instead. Refer to *Troubleshooting: "Calibration Error Message"* on page 38.

NOTE: If calibration is accidentally started and gas has run out or has been disconnected, press **MODE** repeatedly. Calibration will stop and revert back to the previous calibration values.

Calibrating the PID Sensor

The single sensor method used to calibrate the PID can also be used to calibrate single toxic sensors. For the PID, use isobutylene (100ppm) span gas. For other toxic sensors, use the appropriate gas, e.g., ammonia sensor - use ammonia gas, etc.

Single Sensor Calibration



Press **Y/+**.

When the installed sensors appear on the display use **MODE** to move from sensor to sensor.

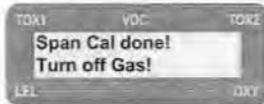


Press **Y/+** to select the highlighted sensor and start calibration.

Apply span gas mixture and start gas flow.

The 60-second countdown timer appears.

NOTE: Some sensors (Cl_2 , PH_3 , NH_3 , HCN) require a special "presoak" period prior to starting calibration. Turn the gas on to the MultiRAE Plus for this time period. **Refer to Range, Resolution and Response Time chart on page 41 BEFORE starting the calibration procedure.** When calibration has started and if the MultiRAE Plus displays "No gas flow..." apply gas or hit any key to start. Press **Y/+** to start calibration.



Calibration is complete when the sensor name and its span value appear, confirmed by a "Span Cal Done! Turn Off Gas" message. If no gas has reached a sensor after sixty seconds, calibration will abort. The readings should be relatively close to the span gas values.

Turn off the gas flow and disconnect the calibration adapter from the monitor. If calibration fails, an error message appears instead. *Refer to Troubleshooting: "Calibration Error Message" on page 38.*

Calibration Time Stamp

A time stamp is created and stored each time a sensor calibration is performed, which is included in the datalog report.

Press **MODE** twice to exit calibration mode and return to the main display.

NOTE: Residual gas may linger on the sensors for up to 60 seconds.

If the sensors do not return to zero, repeat fresh air calibration.

MultiRAE Plus Usage Overview

Storage

Always keep the MultiRAE Plus on charge in a dry indoor area when not in use.

⚠ If the MultiRAE Plus is to be stored more than 2 weeks off the charger, it is recommended to remove the Li-ion battery. Upon reinstalling the battery, it will need a complete charge and some sensors (like NO and NH₃) may require time to warm up, anywhere from 20 minutes to 24 hours. Refer to *Technical Note-114 Sensor Specifications and Cross Sensitivities*. The clock will also need to be reset.

Confined Space Pre-Entry Test

Test the atmosphere in the confined space by sampling air at 3 levels (Top, Middle and Bottom) in the Confined Space. Give the instrument time to sample the gas at each level - the correct sampling time is 60 seconds plus 1 second per every foot of hose.

Alarms

If there are any gas **ALARMS** at any level in the confined space it is not safe. **DO NOT ENTER!**

Identify the alarm condition and then start your preventive actions according to your company's Confined Space Entry procedures.

No Alarms

If there are no alarms, the Confined Space may be safe for entry. Disconnect the hose before carrying the MultiRAE Plus into the Confined Space. If monitoring is to be done by a Confined Space attendant, they should continue to monitor while you enter the area.

If the unit alarms and "BAT" is displayed, the battery needs to be charged. There is 15 minutes or less of run time remaining. **Leave the Confined Space immediately!** See the *Applications and Technical Notes Guide* for more information regarding Confined Space Entry and other applications.

After Usage

Turn the MultiRAE Plus off by pressing and holding . The buzzer will beep and count down 5-4-3-2-1 and read "OFF". Return the MultiRAE Plus to the dry, indoor storage area and connect the charger to the MultiRAE Plus.

Alarm Signals

When an alarm condition occurs, the monitor will provide audible and visual alarms to alert users of unsafe conditions. *Refer to the Alarm Signals table on page 11 for a complete list of alarm conditions.*

 **The alarm signals are disabled while in the following modes: Communicate with PC, Print Reading, Calibrate Monitor. To reduce the risk of exposure to hazardous atmospheres, use these modes only in an area known to be non-hazardous.**

The alarm system can be set up in one of two ways:

Auto Reset Alarm (default): The alarm signals automatically reset when the alarm condition is no longer present. **NOTE:** Not all alarm conditions have this option.

Latched Alarm: The alarm signal remains on even when the alarm condition is no longer present; press  to acknowledge and reset alarm signals.

Testing Alarm Signals

Press . If functional, the buzzer will beep once and the backlight will flash once.

Alarm Condition	Alarm Signal			Screen Message	Reset Alarm
	beep/sec	flash/sec	vibration*		
Gas concentration exceeds High Alarm	3	3	yes	sensor name "HIGH"	move away from gas
Gas concentration exceeds Low Alarm	2	2	yes	sensor name "LOW"	move away from gas
Gas concentration exceeds STEL	1	1	yes	sensor name "STEL"	move away from gas & wait 15 minutes
Gas concentration exceeds TWA	1	1	yes	sensor name "TWA"	move away from gas & turn unit OFF/ON
Gas concentration exceeds sensor range	3	3	yes	sensor name "OVR"	move away from gas
Unit short circuits or Reading over max range	3	3	yes	sensor name "MAX"	indicates possible sensor failure. calibrate sensor to verify performance
Excessive sensor negative drift	1	1	yes	sensor name "NEG"	perform zero calibration
Blocked inlet or Pump failure	3	3	yes	"PUMP"	unblock inlet; press  to restart pump
PID lamp fails to light	3	3	yes	"LAMP"	turn off/on or wait; lamp may turn on by itself
Excessive LEL gas or LEL sensor is OFF	3	3	yes	sensor name "OFF"	move away from gas & turn LEL sensor ON (press )
Low battery	1/min	1 min	no	"Bat"	charge battery
Datalog memory full	1	1	yes	"Mem"	clear datalog memory or turn on "wrap-around"
Datalog memory write error	1	1	yes	"EEem"	turn unit OFF/ON

*The external vibration alarm is an optional feature.

Preset Alarm Limits and Calibration

The monitor is factory calibrated with standard calibration gas and is programmed with default alarm limits as listed:

Gas	Cal Gas/Balance	Unit	TWA	STEL	Low	High
CO	50/Air	ppm	35	100	35	200
H ₂ S	25/N ₂	ppm	10	15	10	20
SO ₂	5/N ₂	ppm	2	5	2	10
NO	25/N ₂	ppm	25	25	25	50
NO ₂	5/Air	ppm	1	1	1	10
Cl ₂	10/N ₂	ppm	0.5	1	0.5	5
O ₂	20.9/N ₂	%Vol	-	-	19.5	23.5
CH ₄	50/Air	%LEL	-	-	10	20
HCN	10/N ₂	ppm	5	5	5	50
NH ₃	50/N ₂	ppm	25	35	25	50
PH ₃	5/N ₂	ppm	0.3	1	1	2
VOC*	100/Air	ppm	10.0	25.0	50.0	100

*Note: 100 ppm isobutylene gas is used for VOC gas calibration

Back Light

The backlight assists reading the LCD in poor lighting conditions and automatically turns on anytime the MultiRAE Plus is in alarm.

To manually turn on, press , and it will automatically turn off after 60 seconds. The backlight can also be set to automatically turn on in low lighting conditions, and likewise turn off in adequate lighting conditions.

NOTE: The backlight can shorten the operating time by 20-30%.

Sampling Pump

The integrated sampling pump automatically turns on when the monitor is turned on and remains on during normal operation. The pump speed is adjustable between the default low setting (~200 cc/min) and the high setting (~300 cc/min). Use the low setting to save battery and filter life. Use the high setting for reactive gases and remote sampling in applications like Wingtank entry and HazMat.

The monitor can detect any obstructions in the external filter that causes a pump stall. The alarm will activate and a "Pump" error message will appear. To acknowledge the pump stall, press **Y/+** to start the pump again.

Refer to Pump Stall on page 29 for details on how to adjust the pump stall threshold for either the high or low settings.

Datalogging

A small "L" at the center of the screen means the monitor is datalogging. Datalogging-enabled monitors can calculate and store hours of gas readings based on the time-interval and type of gas measurement specified. The time-interval can be set to between 1 and 3600 seconds in 1-second increments. The average and peak gas concentrations are the two types of gas measurements that can be stored for each sensor. **NOTE:** STEL and TWA values will only be logged if average is selected. All data is stored in non-volatile memory that can be downloaded to a computer. Users may select one of two types of memory storage: wrap-around or stop. Refer to Select Memory Full Type on page 23.

NOTE: Datalogging pauses upon entering Program Mode or PC Communication Standby Mode. Upon exiting Program Mode datalogging will resume. Upon exiting PC Communication Standby Mode, datalogging will resume only if datalogging mode was set to "Automatic".

Maximum Datalog Time for 5 Sensors

Log Interval	1 sec	60 sec	300 sec (5 min)
Tmax	80 minutes	80 hours	400 hours

Datalog Options

Automatic: Datalogging automatically starts/stops when the monitor is turned on/off.

Manual: If the MultiRAE Plus is in Advanced mode, press **Y/+** at the "Start Datalog" screen. Set a timer to specify the maximum datalogging time using ProRAE Suite software.

Periodic: Set a daily start/stop time to datalog using ProRAE Suite.

Scheduled: Set a monthly start/stop time to datalog using ProRAE Suite.

Charging the Battery Pack

To charge the battery pack plug the transformer supplied with the monitor into the power jack on the monitor.

When a Li-Ion battery pack is installed, charging automatically begins. The LED appears red during charging, and once the battery is fully charged, the LED turns green. The display also indicates the charge status. A completely drained battery pack charges to full capacity in less than 10 hours. When the "Bat" message appears on the LCD, the battery pack needs to be recharged.

NOTE: A fully charged battery pack will switch to trickle charge to maintain battery life. Repeatedly turning the power to the transformer on and off will reset the charge and possibly burn out the battery.

To change the battery pack or to use the alkaline battery adapter, refer to *Replacing the Battery Pack or Emergency Alkaline Battery Adapter* on page 32.

 **If the MultiRAE Plus is to be stored more than 2 weeks off the charger, it is recommended to remove the Li-ion battery.**

Accessories

External Filters

The external filter is a PTFE (Teflon®) membrane with a 0.2 micron pore that reduces the amount of liquid and dust that can contaminate the sensor. Using the external filter prolongs sensor and pump life.

Change the external filter whenever it becomes discolored, clogged with particles, or draws in liquid.

NOTE: Do not use the external filter when calibrating reactive gases. Instead, use the High Pump Speed setting and a short Teflon® tube. Although this shortens battery life, it provides a faster response.

Remote Sampling Probe

When searching in hard-to-reach areas, use the standard remote sampling probe (P/N 008-3015-200) with a telescoping handle and 6 feet of Teflon tubing. For longer distances, attach a length of Teflon tubing. The monitor is capable of drawing samples from over 100 feet.



Optional Dilution Fitting

When gas samples have less than 10% oxygen, the dilution fitting (P/N 008-3025/3026) will increase the oxygen concentration. The dilution fitting can also measure combustible, VOC or toxic gases when the concentration exceeds the upper limit of the sensor range. In Program Mode, set the dilution ratio to obtain the correct gas reading when the dilution fitting is used. The dilution fitting attaches directly to the meter and the sample tubing attaches to the dilution fitting. *Refer to Technical Note-167 Proper Use of Dilution Fittings on Pumped Monitors for more information.*

⚠ The monitor and the dilution air inlet must be located in a clean atmosphere outside the confined space. Use either a remote sampling probe or Tygon tube test gas samples.

Calibration Adapter

The calibration adapter is a 6-inch Tygon tube with a male Luer connector on the end. During calibration, connect one end of the tube to the external filter (on the monitor) and the other end to the calibration gas.



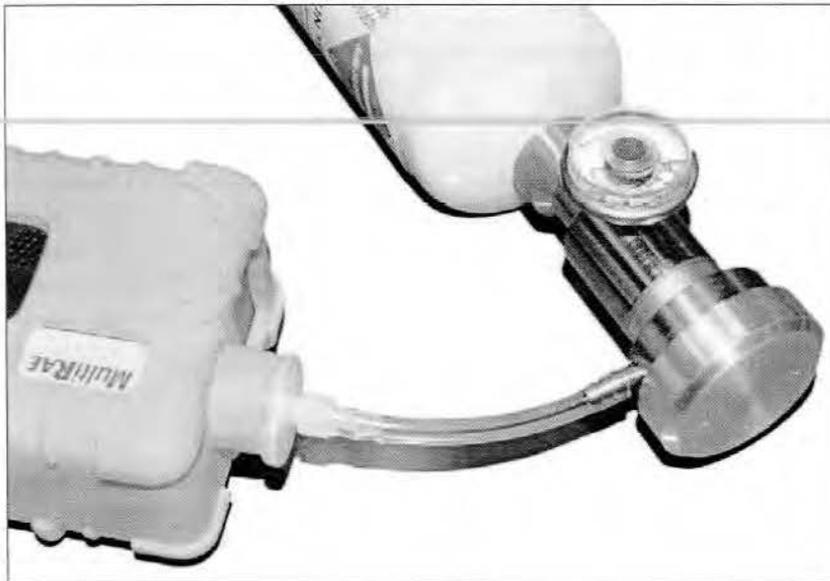
Alternatively, the calibration gas can be sampled from:
an optional **Tedlar gas bag** (P/N 500-0003-000) filled with calibration gas,



an optional **open cup** (P/N 007-3002-000) with calibration gas flow exceeding the pump demand,



or an optional **demand flow regulator** (P/N 002-3051-000, female or P/N 008-3052-000, male) directly from the gas cylinder.

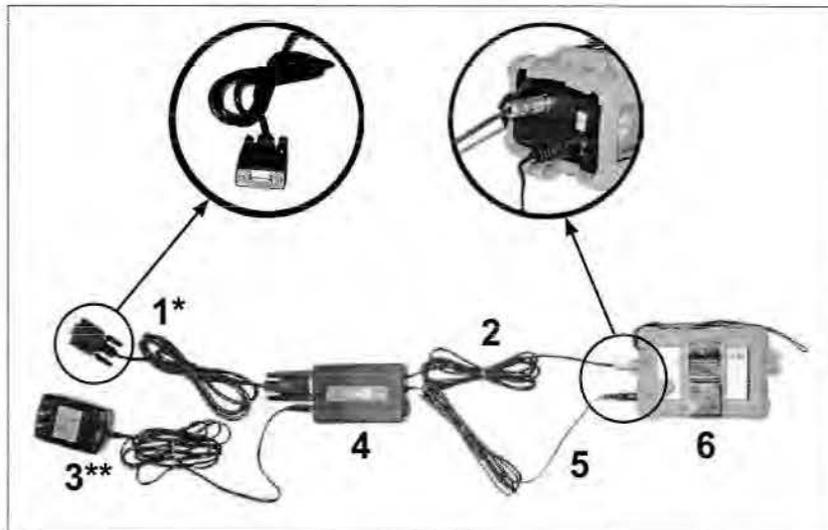


Using the Intrinsically Safe Barrier Box

⚠ This does NOT ship with UL/cUL-approved monitors. The barrier box is only for ATEX European approved MultiRAE monitors.

To conform to ATEX European safety standard, the barrier box **must be used** when utilizing an RS-232 cable and/or transformer.

1. RS-232 cable (detachable)*
2. Computer interface cable
3. Transformer (detachable)**
4. Intrinsically safe barrier
5. Power cable
6. MultiRAE Plus monitor



Communicating with a Computer

* This connection is not necessary during normal charging.

Connect the RS-232 cable from the barrier box to the monitor.

Connect the computer interface cable to the barrier box.

Plug the computer interface cable into a computer.

Charging the Monitor

** Connection is optional during computer communication.

Connect the power cable from the barrier box to the monitor.

Connect the transformer to the barrier box.

Plug the transformer into an appropriate outlet.

Programming Mode

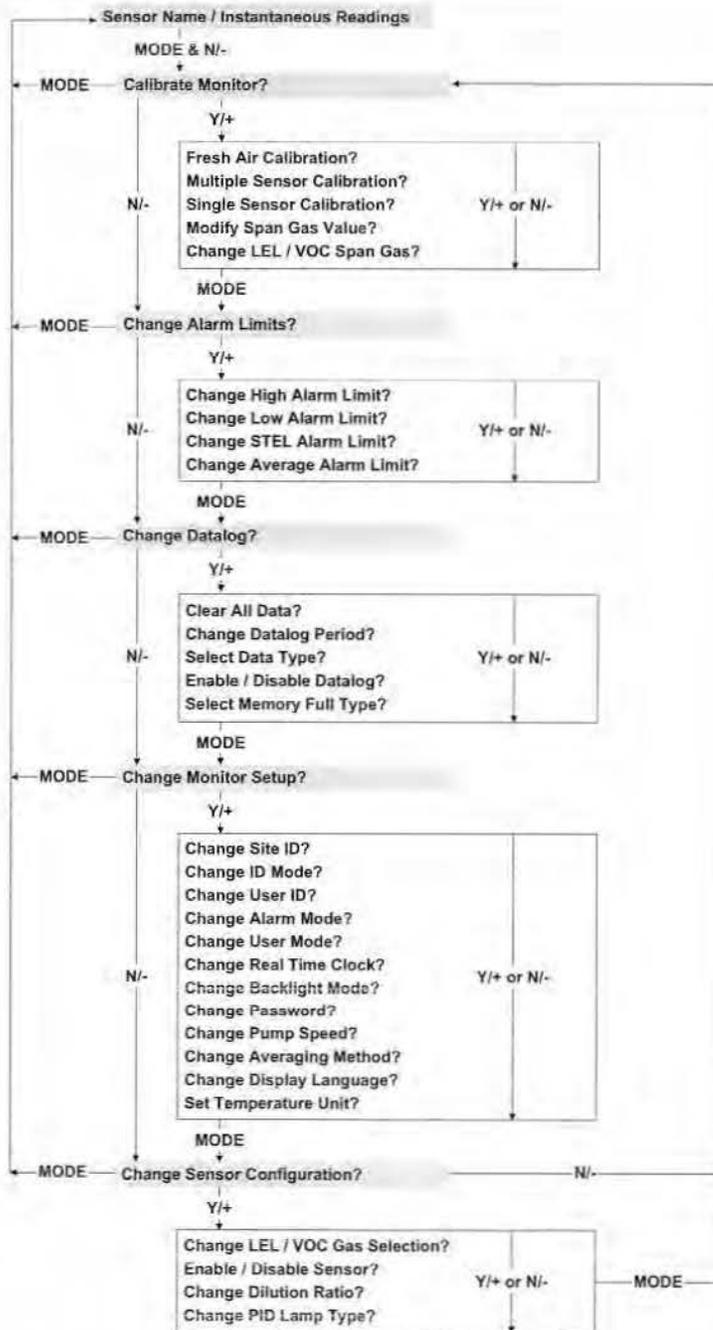
In addition to calibration, authorized users may change the monitor settings to their requirements using the Programming Mode.

NOTE: Monitoring gas concentrations continues during Programming Mode, but pauses during Calibration. Datalogging also pauses during Programming Mode, but resumes when programming is finished.

Press 	for desired menu to answer "no" to decrease a digit
Press 	for desired submenu to answer "yes" to increase a digit
Press 	to return to the sensor name/ instantaneous reading display to exit a submenu to advance digits

To enter the Program Mode, press  and  together until the first program menu appears: "Calibrate Monitor?" Refer to *Getting Started on page 5*. The figure on the following page summarizes the programming menus and how to navigate through them.

Programming Menus



Security Levels

Security levels are setup via computer using ProRAE Suite. The default password is: 0000. **NOTE:** For security purposes "0000" always appears instead of actual password.

No changes will be saved unless the user is in the correct mode with the correct security level.

User Mode Security Level	Text			Display			Advanced		
	0	1	2	0	1	2	0	1	2
Calibrate Monitor?									
Fresh Air Calibration?	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓*	✓
Multiple Sensor Calibration?	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓*	✓
Single Sensor Calibration?	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓*	✓
Modify Span Gas Value?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change LEL/VOC Span Gas?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change Alarm?									
Change High Alarm Limit?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change Low Alarm Limit?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change STEL Alarm Limit?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change Average Alarm Limit?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change Datalog?									
Clear All Data?	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓*	✓
Change Datalog Period?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Select Data Type?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Enable/Disable Datalog?	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓*	✓
Select Memory Full Type?	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓*	✓
Change Monitor Setup?									
Change Site ID?	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓*	✓
Change ID Mode?	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓*	✓
Change User ID?	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓*	✓
Change Alarm Mode?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change Alarm Mode?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change User Mode?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change Real Time Clock?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change Backlight Mode?	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓*	✓
Change Password?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change Pump Speed?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change Averaging Method?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change Display Language?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Set Temperature Unit?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change Sensor Configuration?									
Change LEL/VOC Gas Selection?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Enable/Disable Sensor?	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓*	✓
Change Dilution Ratio?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓
Change PID Lamp Type?	✓**	✓*	✓*	✓**	✓*	✓*	✓*	✓*	✓

* Need password

** No change allowed

Calibrate Monitor

Fresh Air Calibration? Refer to *Calibrating the Monitor* on page 5.

Multiple Sensor Calibration? Refer to *Calibrating the Monitor*.

Single Sensor Calibration? Refer to *Calibrating the Monitor*.

Oxygen Sensor Calibration: The oxygen sensor calibration is slightly different from other sensors; span calibration at 20.9% O₂ is performed during fresh air calibration. During single sensor calibration, the oxygen sensor can be calibrated to 0% O₂ with pure nitrogen gas, by pressing **Y/+** when asked "0%? Oxygen?" To calibrate at a different concentration specified in Modify Span Gas Value, press **N/-**.

NOTE: After a single sensor oxygen calibration, perform fresh air calibration to ensure the oxygen sensor is calibrated correctly.

Modify Span Gas Value?

The span gas is the second point of reference for calibration. Users may modify the span values of the standard calibration gases to use other calibration gases. However, DO NOT modify the span values when using the RAE Systems calibration gas supplied with the monitor.

Change LEL/VOC Span Gas?

Change the type of calibration gas from methane (LEL) and isobutylene (VOC) to be used as the span gas during LEL or VOC gas calibration. However, DO NOT modify the span gases when using the RAE Systems calibration gas supplied with the monitor.

Change Alarm Limits

Users may change the alarm limits for each sensor. Use **N/-** to cycle through the submenu options. Press **Y/+** to enter a submenu. To modify the limit, use **Y/+** and **N/-** to change the value. Use **MODE** to move from character to character.

To escape the submenu without saving changes, press **MODE**. To save, press **MODE** until "Save?" appears. Press **Y/+** to save changes, otherwise press **N/-** to discard changes.

Change High Alarm Limit?

Change Low Alarm Limit?

Change STEL Alarm Limit? (Short Term Exposure Limit)

Change Average Alarm Limit? (TWA – Time Weighted Average)

Change Datalog Setting

The monitor calculates and stores the gas readings at specified intervals, which can be reviewed by the user. Users may also program additional datalog options for the monitor through the computer.

Clear All Data?

Erase all data stored in the non-volatile memory, but does not delete the PEAK, MIN, STEL, TWA displayed values, which are stored separately.

Change Datalog Period?

Program the datalog period from 1 second to an hour (3,600 seconds).

Select Data Type?

Store either the average (TWA) or peak value for each datalog interval. If peak values are selected, average values like STEL and TWA will not be selected.

Enable/Disable Datalog?

Enable or disable the datalogging function for each sensor. If a * is displayed next to a sensor name, data will be recorded. Use **MODE** to move from sensor to sensor. An asterisk (*) means the sensor is enabled; no asterisk means the sensor is disabled. Press **Y/+** to select or press **N/-** to deselect. To save changes, press **MODE** until "Save?" appears. Then press **Y/+** to accept. Otherwise, hold **MODE** to escape and cancel changes.

Select Memory Full Type?

The instrument's memory can store about 3 days' worth of data, as a result of continuous monitoring at 1-minute intervals. Users may select one of two types of memory storage:

Wrap-around: after the memory becomes full, the latest data overwrites the oldest data. e.g. the most recent 3 days' worth of data is stored.

Stop: halts datalogging when the memory is full, and the "MEM" alarm sounds. e.g. the first 3 days' worth of data is stored.

Change Monitor Setup

Change the monitor setup or enter user information for the monitor. Use **MODE** to move the cursor from character to character. Use **Y/*** and **N/-** to toggle up and down the alphabet and numbers. To save, press **MODE** until "Save?" appears. Press **Y/*** to save changes, otherwise, press **N/-** to discard changes. To escape this menu without saving changes, press and hold **MODE**.

Change Site ID?

Enter an eight-character alphanumeric site identification, which is included in datalog reports.

Change ID Mode?

Set up an identification code to use during start-up or to access a previously saved customized ID.

Change User ID?

Enter an eight-character alphanumeric user identification, which is included in datalog reports.

Change Alarm Mode?

Choose either latched or automatic reset. The user must manually acknowledge a latched alarm by pressing **Y/***.

Change User Mode?

The three different user modes are: Text, Display and Advanced.

Change Real Time Clock?

Change or update the real time clock and calendar.

Change Back Light Mode?

Automatic – the monitor turns the back light on/off when ambient light falls below/above the threshold or **Manual** – press **N/-** to turn the back light on/off.

Change Password?

Modify the password.

Change Pump Speed?

Low – (default) use when operating conditions are slow to change; prolongs pump motor life, LEL sensor life and battery run time.

High – use for long lengths of tubing or when rapid changes in input conditions are expected, such as HazMat response or when used for measuring heavy, low vapor pressure compounds like jet fuel.

Change Averaging Method?

Choose: **TWA** (default) – an eight-hour Time Weighted Average or **AVG** – the running average

Change Display Language?

Choose English or Spanish.

Set Temperature Unit?

Choose Celsius or Fahrenheit to measure temperature.

Change Sensor Configuration

Change LEL/VOC Gas Selection?

Choose an LEL or VOC gas listed in the monitor to calculate its correction factor relative to the LEL or VOC calibration gas. *Refer to Correction Factors on page 26.* The correction factor allows the unit to display the equivalent concentration of the selected LEL or VOC gas. To create a custom factor for a specific gas or mixture of gases, modify the relative correction factor to increase or decrease the gas reading.

Enable/Disable Sensor?

Enable or disable sensor(s); a disabled sensor will not measure or display the gas concentration. Use if a sensor has failed or is providing erroneous readings. Use  to move from sensor to sensor. An asterisk (*) means the sensor is enabled; likewise, no (*) means the sensor is disabled. Press  to select or press  to deselect. To save changes, press  until "Save?" appears. Then press  to accept. Otherwise, hold  to escape and cancel changes.

Change Dilution Ratio?

Attach an optional dilution fitting on the gas inlet port to dilute the gas sample. Enter a dilution ratio (from 1 to 10) to compensate the reading for the actual gas concentration.

Change PID Lamp Type?

This only applies to PID monitors. The PID sensor can utilize either a 10.6 eV or an 11.7eV UV. Since each lamp type has a different correction factor table, it is important to select the correct lamp type.

Correction Factors

VOC and LEL sensors respond to a broad range of gases and show a different sensitivity to different gases; correction factors allow measurement of a specific gas (the measurement gas) while using a different gas for calibration (the calibration gas). The correction factor (CF) for a measurement gas is defined as:

$$\text{CF} = \text{Sensitivity to a Calibration Gas} \div \text{Sensitivity to a Measurement Gas}$$

To convert the monitor reading of the calibration gas to the true concentration of a measurement gas, use the following equation:

$$\text{True Concentration (ppm)} = \text{CF} \times \text{Monitor Reading (ppm)}$$

The monitor has three sets of correction factors, one for the LEL and two for the VOC (10.6 eV and 11.7 eV) Each set consists of 20 to 40 different gases. Specify the PID lamp type (e.g. 10.6 eV or 11.7 eV) to access the proper VOC correction factor.

To set up a correction factor, first choose a calibration gas in the Calibrate Monitor program menu and then choose a measurement gas in the Change Sensor Configuration menu. If the calibration gas is different from methane for LEL or isobutylene for PID, then the new CF is calculated and the displayed value will be different from the values in Technical Notes 106 or 156.

NOTE: Correction factors provide an estimate of the measurement gas concentration. For greatest accuracy, it is necessary to calibrate the LEL or VOC sensor directly with the measurement gas.

Refer to Technical Note-106 Correction Factors and/or Technical Note-156 LEL Correction Factors.

Diagnostic Mode

The monitor is equipped with a diagnostic mode that can display critical, low level parameters to help users identify problems. *Refer to Troubleshooting on page 38.*

 **The diagnostic mode allows the user to set several low level parameters which are very critical to the operation of the monitor. Extra care should be taken when setting these low level parameters. If the user is unfamiliar with these parameters and sets them incorrectly, it may cause the monitor to shut down or malfunction. The diagnostic mode should only be used by qualified personnel.**

To switch the monitor to diagnostic mode, turn the monitor off.

Press and hold  and  together; release both keys when the unit beeps. The monitor is now in diagnostic mode.

Press  until the desired diagnostic parameter appears:

Sensor Name and Raw Sensor Readings

If a sensor is programmed and is properly installed, the sensor name should appear. If the sensor name does not appear, then the sensor may be improperly programmed or defective. The raw sensor reading is the uncalibrated output for each sensor. When fresh air is applied, the raw sensor readings should be 200 to 700 for toxic gas and VOC sensors; 100 to 1300 for the LEL sensor; and 1200 to 2300 for the oxygen sensor. When calibration gas is applied, the raw sensor readings should increase or decrease by the amounts listed in Technical Note - 123 Special Diagnostic Modes. If the raw sensor readings are outside the normal range or do not change when gas is applied, the sensor or monitor may be defective.

RF Test (Radio Frequency)

This feature applies when the monitor is used with the RAELink Remote package. The RF test shows the successful rate of communication.

Adjust Lamp Failure Threshold

If the lamp physically appears fine, but the "Lamp" error message appears during normal operation, the lamp failure threshold may be set too high.

To adjust the level:

Turn the monitor on in diagnostic mode and go to the "Lamp = xxx, Fail = yyy +/-" display. ("xxx" is the lamp current reading; "yyy" is the value of the lamp failure threshold.)

Decrease the "yyy" value until it is about 10 counts below the "xxx" value. Press **MODE** to exit.

Then press **Y/+** to save changes, or press **N/-** to discard changes.

Battery Type and Bias

The type of battery (Lithium-Ion battery pack or alkaline battery adapter) used to charge the monitor is displayed. Some toxic gas sensors require a bias voltage of a few hundred millivolts for the sensor to function properly. These include NO and NH₃ sensors.

To manually switch the bias voltage supply on, refer to *Special Bias Voltage for Toxic Sensors* on page 35.

Install a biased sensor in the TOX1 socket. If the bias voltage is switched on, the bias reading should be below 182, otherwise it may be defective.

Show x1 and x10 Range of PID Sensor (PID detectors only)

The PID sensor is connected to two amplifiers with two different gains: unity gain and gain of ten; these are the raw outputs of both amplifiers. When fresh air is applied, both amplifier outputs should be 200 to 500. When a VOC gas is applied, both amplifier outputs should increase; the amount of increase for the unity gain (x1) should be 1/10 of the increase for the gain of ten (x10). If the increase does not agree with the expected value, then the gain switch of the amplifier may be defective.

Display Contrast

Press **Y/+** to increase the contrast and **N/-** to decrease the contrast. The LCD contrast bar indicates the current setting. If the display appears to have dark lines, press **Y/+** a few times to see the display more clearly. **NOTE:** In extreme temperatures, the display may fade or bleed out.

LEL Power

The top line indicates the instantaneous reading of raw counts from the LEL sensor. The bottom line shows if the LEL sensor is on or off. Press **N/-** to turn the power off, and press **Y/+** to turn the power on.

Clock, Time, Battery, and Temperature

This display shows the real time clock, the date, the battery voltage in raw count and temperature sensor reading.

Sensor Expiration Date

The expiration date (month and year) for each installed sensor is based on the manufacturing date and expected life of each sensor. If the current date exceeds the expiration date for any sensor, the performance of the given sensor cannot be guaranteed. It is strongly recommended to replace the sensor immediately to ensure proper operation.

Pump Stall

The "Pump = 20/20" reading is the minimum and maximum pump raw count (RC), and "Stall = 40 +/-" is the pump stall threshold. The pump stalls if the maximum raw count reaches the pump stall threshold, which causes the pump to shut off. To determine the pump stall threshold:

$$[(\text{max RC when pump is free} + \text{max RC when pump is blocked})] \div 2$$

To adjust the pump stall threshold, press **[Y/+]** to increase or **[N/-]** to decrease the numerical value.

Back Light Threshold

Adjust the threshold for the LCD backlight to automatically turn on/off; verify the threshold is 100, which is suitable for most situations.

Serial Number and Pump

Displays the monitor's serial number and the pump status. If a pump is installed and a pump speed control circuit is available, toggle the display "Pump=Low/High" by pressing **[N/-]**. **NOTE:** Changes made are only for testing the pump condition and are not saved to the nonvolatile memory. *Refer to Change Pump Speed on page 25.*

Battery Duration Time

Use to test battery life and displays the last run time before the unit turned itself off due to low battery.

Communicate with PC

Connect monitor to a personal computer to upload a configuration file or download stored data.

Maintenance

⚠ Power from the battery is flowing to the printed circuit board (PCB) and sensors even when the power is off. Therefore, It is very important to disconnect the battery pack before servicing or replacing sensors or any components inside the monitor. Severe damage to the PCB may occur if the battery pack is not disconnected before servicing the unit.



Li-Ion Battery Pack

The factory supplied Li-Ion battery pack is designed to last for 10 hours of normal operation (without alarm or backlight conditions). The rechargeable batteries have a 1-year warranty. Age, ambient temperature, and heavy useage may impact battery life. Battery packs will slowly drain even if the monitor is turned off. If the battery packs have not been charged for 10 days, the battery voltage will be low. It is recommended to fully charge the battery packs before going into the field, and recharge the battery pack upon returning from the field.

- ⚠ To reduce the risk of ignition of hazardous atmospheres, recharge battery only in areas known to be non-hazardous. Remove and replace battery only in areas known to be non-hazardous. Ne charger les batteries que dans emplacements désignés non dangereux.**

Replacing the Battery Pack

- ⚠ To reduce the risk of ignition of hazardous atmospheres, recharge battery only in areas known to be non-hazardous. Remove and replace battery only in areas known to be non-hazardous. Ne charger les batteries que dans emplacements désignés non dangereux.**

Remove the monitor cover by loosening the two case screws, and then unplug the battery pack from the battery jack.

Place a fully charged spare battery pack into the monitor.

Make sure the battery plug is connected securely.

Reattach the cover and tighten the screws.



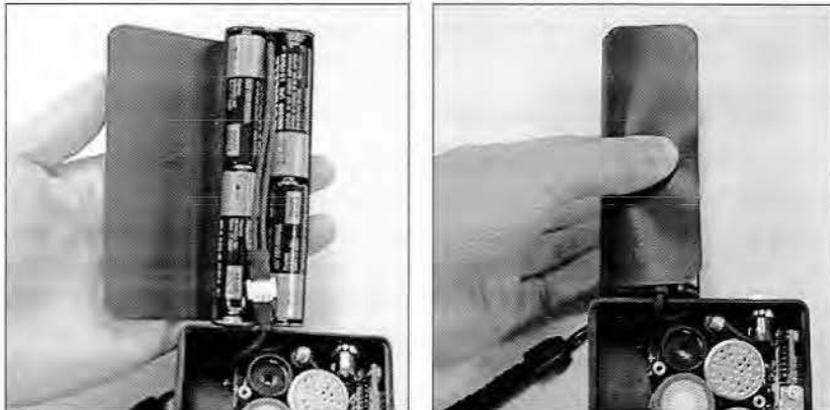
Emergency Alkaline Battery Adapter

⚠ The alkaline battery adapter supplied by RAE Systems is intrinsically safe. The adapter is intended to be used in emergency situations when there is no time to recharge the Li-Ion battery pack. The adapter accepts 4-AA alkaline batteries to provide approximately 12-14 hours of operation.

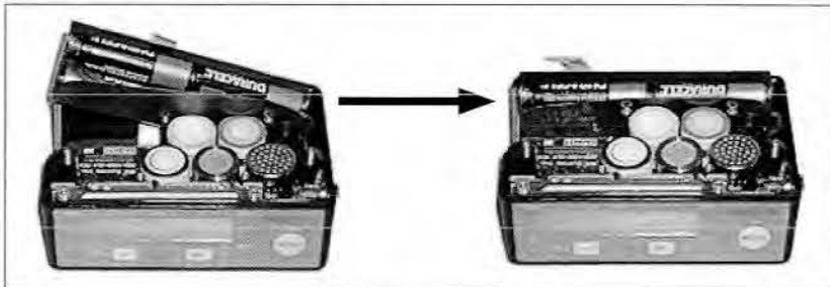
To install the adapter, remove the monitor cover. Remove the Li-Ion battery pack from the monitor by carefully disconnecting the wires.

Install four AA alkaline batteries into the battery adapter, making sure the battery polarity is correct.

Connect the battery adapter to the monitor. Make sure the wires are placed inside the adapter, running between the batteries. Close the flap over.



Install the battery adapter in the monitor.



The monitor automatically detects the alkaline batteries and will run for 8-10 hours. Use the monitor once the alkaline battery adapter is installed. Replace the alkaline batteries when spent.

Sensor Replacement

Under normal operating conditions, most sensors will lose their original sensitivity after the expected operating life and eventually need to be replaced. Each sensor has a non-volatile memory that has the manufacturing and expiration dates, which appear during the warm-up period or can be looked up in the diagnostic mode.

Warranties: Oxygen (O₂), combustible gas (LEL), hydrogen sulfide (H₂S) and carbon monoxide (CO) sensors all have a 2-year warranty. All other toxic sensors have a 1-year warranty.

NOTE: The Oxygen and the LEL sensors have assigned sockets. These are identified on the PCB. High bias toxic sensors should be installed in socket 1/A. Refer to *Special Bias Voltage for Toxic Sensors on page 35*. Any toxic sensor can be installed in socket 2/B.

Replace the sensor when it fails to calibrate.

To replace sensor(s), turn the monitor off and remove the cover.

Using the sensor puller, remove the sensor to be replaced by carefully pulling straight out.

Plug a new sensor into the empty socket. Make sure the sensor pins are aligned with the socket holes before firmly pushing the sensor all the way down.

Replace the monitor cover.

Turn on the power of the monitor and the newly installed sensors should be recognized. Let the monitor run for 15 minutes before calibration.

Some sensors, like NO and NH₃, require up to 24 hours on-bias in the monitor prior to calibration and use. Refer to *Technical Note 114 Sensor Specifications and Cross Sensitivities*.

NOTE: Calibrate all sensors prior to use!

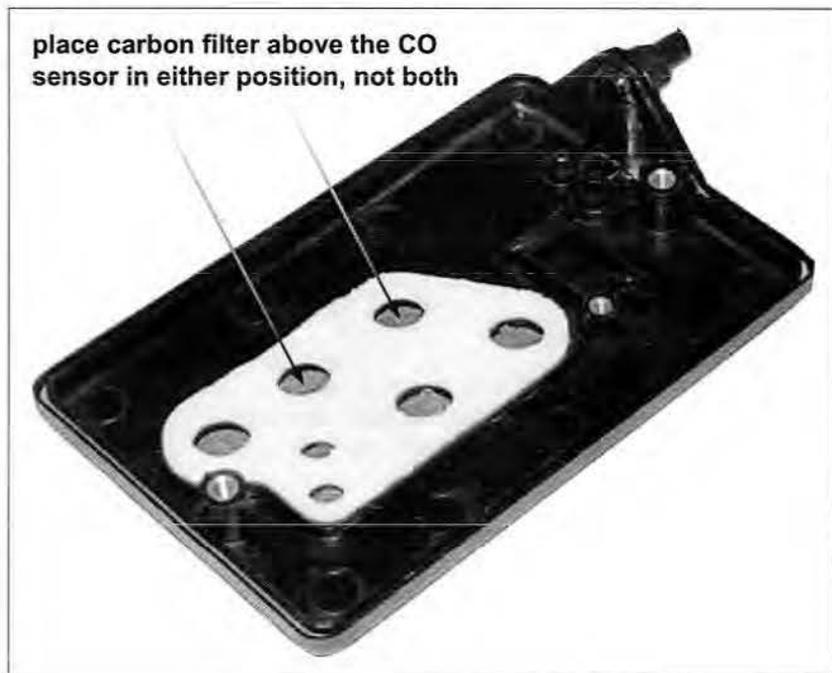


CO Sensor Charcoal Filters

CO sensors can be sensitive to hydrocarbons. To reduce or eliminate this cross sensitivity, a charcoal filter is installed in the gas plate above the CO sensor. The charcoal filter removes organic vapor cross-sensitivity and will last 4-6 weeks under normal operation conditions before it needs to be replaced. However, if the monitor is exposed to high concentrations of VOC gases, the carbon filter needs to be replaced more frequently. (P/N 008-3006-005, 5-pack; keep unused filters sealed during storage.)

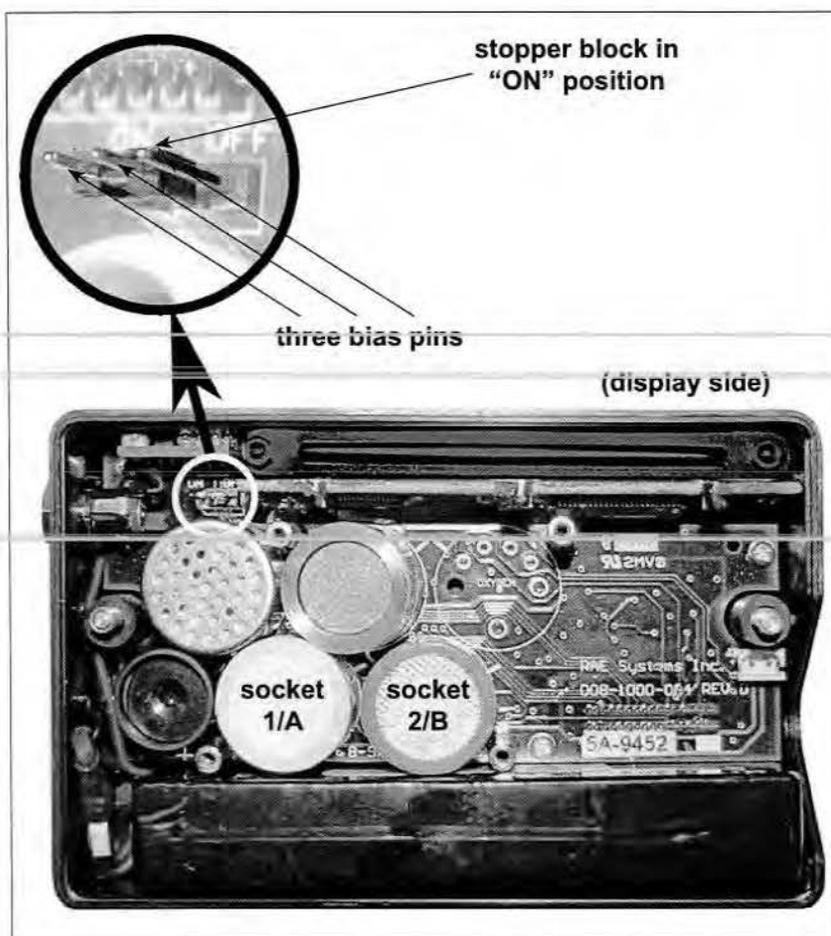
Refer to Technical Note-121 CO Sensor Cross-Sensitivity and Removal with Charcoal Filter for cross-sensitivity data.

- ⚠ The carbon filter used for CO sensors may lower the reading if used on other sensors. Remove the filter if another sensor is replacing a CO sensor in the monitor.**



Special Bias Voltage for Toxic Gas Sensors

NO and some NH₃ sensors require a special high bias. The bias pins are located next to the PID sensor socket. Using the sensor puller, move the stopper block from the "OFF" pins to the "ON" pins. The sensor ID and bias voltage will be checked during the power on sequence. An error message appears if the sensors are plugged into the wrong socket, or if the bias voltage is disabled. Biased sensors require 24 hours on bias before calibration.



PID Sensor Cleaning/Replacement

During the course of normal operation, a film of gas vapor may build up inside the PID sensor module and the lamp; the rate of build-up depends on the type and concentration being sampled. As a guide, it is recommended to clean the PID sensor module and lamp only when the PID is malfunctioning:

Periodically cleaning the lamp window also removes film deposits and restores lamp sensitivity. Exercise with care when cleaning the window surface to avoid damage.

Turn the monitor off and remove the cover.

Remove the stainless steel shielding cap for the PID sensor. Using the sensor puller, remove the PID sensor by carefully pulling straight out.

Dip the entire PID sensor into RAE Systems' lamp cleaning solution (supplied in the Lamp Cleaning Kit, P/N 081-0002-000).

- ⚠ **DO NOT store the methanol from the lamp cleaning kit in the same case as the MultiRae Plus, as long-term exposure to methanol can damage electrochemical sensors.**

It is highly recommended to use an ultrasound bath for at least three minutes. Then thoroughly air-dry the sensor.

- ⚠ **DO NOT use heat to dry sensors.**
- DO NOT disassemble PID sensor.**

If the lamp is operational, use a cotton swab or lens tissue to clean the flat window surface with GC grade methanol. If the lamp does not turn on replace with a new lamp. Avoid contact with the flat window surface.

Reinstall the PID sensor. Install the shielding cap. Replace the monitor cover.



Taking Care of the Lamp

- ⚠ **Never touch the window surface with fingers or anything which may leave a film. Water will degrade window surfaces, especially the 11.7 eV lamp window.**

The 10.6 eV PID lamp has a 1-year warranty. The "Lamp" error is an indication of a problem with the lamp current. A dirty or contaminated sensor often causes high readings of the VOC sensor. A weak or inoperative lamp often causes low readings or no response to test gas. If the UV lamp is on while the error message persists, then it is necessary to adjust the lamp threshold. *Refer to Adjust Lamp Failure Threshold on page 27.*

Sampling Pump Replacement

The sampling pump is a positive displacement piston pump, which needs to be replaced as it approaches the end of its life span. The pump's draw capability reduces significantly as it consumes a greater amount of energy to keep running. The sampling pump has a 1-year warranty. **To replace** the pump:

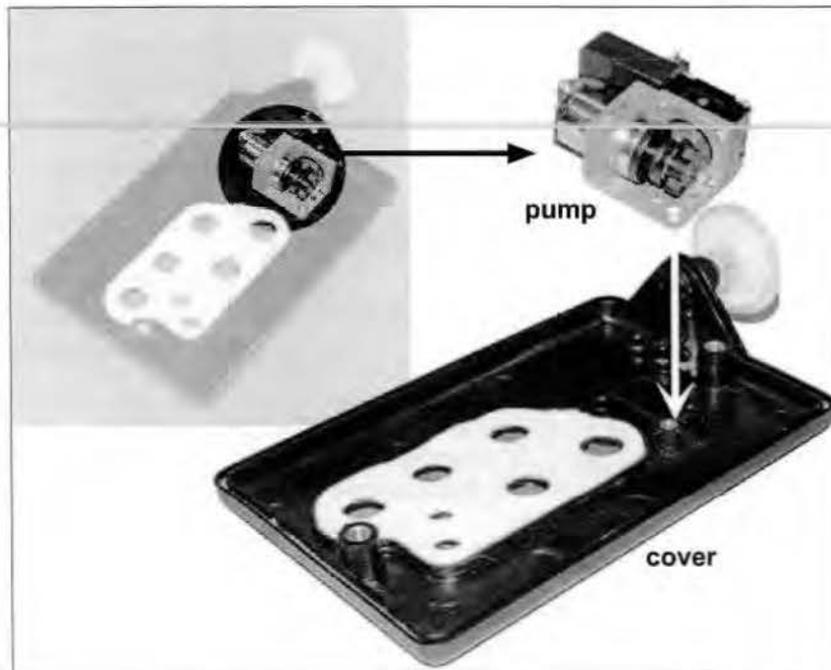
Turn the monitor OFF and remove the cover.

The sampling pump is attached to the cover.

Remove the single screw holding the pump to the cover.

Gently pull the pump assembly off the cover.

Replace with a new pump assembly and reassemble.



Troubleshooting

Technical Service: 1.888.723.4800 or email: Tech@raesystems.com

Problem	Possible Reason(s)	Possible Solution(s)
Cannot turn on after charging battery.	Defective battery. Microprocessor hang-up.	Charge or replace battery. Disconnect then reconnect battery to reset computer. Otherwise, install alkaline battery pack. If that still does not work, then call Service.
"Incorrect Year - Check Clock!" error message.	Battery has died and there is a mismatch between the date code on the sensors and its internal clock.	Press (Y/+) and reset clock.
Cannot turn off. Corrupted characters.	Microprocessor hang-up.	Disconnect and reconnect battery to reset computer. Reload firmware.
No LED or LCD backlight.	Defective LED or LCD backlight.	Check if backlight is in manual mode. Otherwise, call service center.
Lost password.	Forgot.	Use ProRAE Suite to reset password.
Buzzer inoperative.	Bad buzzer. Setting could be in special run silent mode.	Call authorized service center.
Calibration error message.	No calibration gas input. Low sensitivity to calibration gas.	Check standard gas flow path or cylinder pressure. Change calibration gas or sensor.
"Voltage too high" error message, while charging.	Battery fuse blown. Wrong AC adapter. AC adapter not fully plugged in.	Check battery and adapter.
"Bat" error message.	Battery low.	Recharge battery.

High pump noise. No inlet suction.	Leaky inlet path. Defective pump.	Check inlet connection. Clean or replace pump.
Abnormally low reading.	Bad calibration. Low sensitivity to calibration gas. Wrong span value. Bad sensor. Low flow.	Recalibrate. Use stronger span gas. Check span value. Replace sensor. Replace filters. Check flow.
Abnormally high reading.	Bad calibration. Wrong span value. Dirty PID sensor. Dirty filters. Excessive moisture.	Recalibrate. Check span value. Clean PID sensor in methanol in ultrasound bath. Replace filters. Dry PID sensor.
Reading jumping around.	Incorrect calibration gas. Wrong span value.	Calibrate the sensors. Use different calibration gas. Change sensor.
Read a small background value.	Small background gas level present. Sensor zero drift or newly installed.	Run fresh air calibration. Wait for newly installed sensor to stabilize.
"Lamp" error message.	Wrong threshold. Weak lamp. Dirty Sensor.	Adjust threshold. Clean or replace lamp. Clean PID sensor.
VOC reading plateaus at certain level.	Weak PID lamp. Dirty PID sensor.	Replace lamp. Clean lamp & PID sensor. Replace filters.
Full scale measurement in humid environment.	Dirty or wet sensor.	Clean and dry sensor. Replace external filter.

Specifications

Size	4.65"L x 3.0"W x 1.9"H (11.8 x 7.6 x 4.8 cm)
Weight	16 oz with battery (454g)
Sensors	Up to 5 sensors including: <ul style="list-style-type: none">• Photo-ionization detector for VOCs, 10.6 eV lamp standard• Protected catalytic bead for combustible gases• Interchangeable electrochemical sensors for oxygen and toxic gases (2)
Battery	<ul style="list-style-type: none">• Interchangeable Li-Ion and alkaline battery packs• Rechargeable units include lithium-ion battery pack with internal smart charging, 120V AC/DC wall adapter, and spare alkaline battery pack
Operating Hours	<ul style="list-style-type: none">• 14 hours continuous with Li-Ion (typical)• Unit will run and charge simultaneously
Display	2 line, 16 digit LCD with LED backlighting automatically in dim light or alarm condition
Keypads	1 operation and 2 programming keys
Direct Readout	Instantaneous (up to 5) values: <ul style="list-style-type: none">• Oxygen as percentage by volume• Combustible gas as percentage of lower explosive level (LEL)• Toxic gases and VOCs as parts per million by volume (VOC scaleable using correction factors)• High and low values for all gases• STEL and TWA values of toxic gases and VOCs• Battery and shut down voltage• Date, time, elapsed time, temperature
Alarms	90 dB buzzer and flashing red LED to indicate exceeded preset limits: <ul style="list-style-type: none">• High: 3 beeps and flashes per second• Low: 2 beeps and flashes per second• STEL and TWA: 1 beep and flash per second• Automatic reset or latching with manual override• Additional diagnostic alarms and display messages for low battery and pump stall
Datalogging	20,000 points (80 hours, 5 channels at one minute intervals) download to PC with serial number of unit, user ID, site number, and calibration date

Calibration	Two-point field calibration for zero and span gas
Sampling Pump	Internal two-speed pump. Flow rates: • Low: ~200 cc/min • High: ~300 cc/min
Low Flow Alarm	Auto shut-off pump at low flow condition
Temperature	-4° to 113°F (-20° to 45°C)
Humidity	0% to 95% relative humidity (non-condensing)
Attachment	Wrist strap and high-visibility rubber boot
Warranty	Lifetime on non-consuming components (per RAE Standard Warranty). 2 years for O ₂ , LEL, CO, and H ₂ S sensors. 1 year all other sensors. 1 year pump, 1 year battery, 1 year for 10.6eV PID lamp.
EMI Immunity	No effect when exposed to 0.43 mW/cm RF interference (5 watts at 12 inches)
Intrinsic Safety	U.S.A. and Canada: UL & cUL Class I, Division I, Groups A, B, C, D, hazardous locations, Temperature Code T3C Europe: DEMKO 03 ATEX 0308256X; EEx ia d IIC T4 (w/ Battery P/N 500-0029); EEx ia d IIC T3 (w/ Battery P/N 500-0037)

Range, Resolution & Response Time

(t₉₀ for pump-equipped instruments)

Sensor	Range	Resolution	t ₉₀ (sec)	Presoak Time for 60-sec Cal
LEL	0-100% LEL	1%	15	None
VOC	0-200 ppm	0.1 ppm	10	None
VOC	200-2000 ppm	1 ppm	10	None
O ₂	0-30%	0.1%	15	None
CO	0-500 ppm	1.0 ppm	40	None
H ₂ S	0-100 ppm	1.0 ppm	35	None
SO ₂	0-20 ppm	0.1 ppm	35	None
NO	0-250 ppm	1.0 ppm	30	None
NO ₂	0-20 ppm	0.1 ppm	25	None
Cl ₂	0-50 ppm	0.1 ppm	60	60 sec
PH ₃	0-5 ppm	0.1 ppm	60	60 sec
NH ₃	0-50 ppm	1.0 ppm	150	90 sec
HCN	0-100 ppm	1.0 ppm	200	170 sec

Notes



RAE Systems World Headquarters

3775 N. First St.
San Jose, CA 95134-1708 USA
Phone: 408.952.8200
Fax: 408.952.8480

E-mail: customerserv@raesystems.com

Web Site: www.raesystems.com

RAE Systems Technical Support

Monday through Friday, 7:00AM to 5:00PM Pacific Time
+1.888.723.4800 (toll-free)
email: tech@raesystems.com

RAE Systems Tubes: 888.RAE.TUBE (888.723.8823)

RAE Systems Europe ApS

Orestads Boulevard 69
DK-2300 Copenhagen, DENMARK
Phone: +45.8652.5155
Fax: +45.8652.5177

RAE Systems (Hong Kong) Ltd.

Room 8, 6/F, Hong Leong Plaza
33 Lok Yip Road
Fanling, N.T. HONG KONG
Phone: +852.2669.0828
Fax: +852.2669.0803

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General Guidance for Monitoring Well Installation

I. Purpose

To provide site personnel with a review of the well installation procedures that will be performed. These procedures are to be considered general guidelines only and are in no way intended to supplement or replace the contractual specifications in the driller's subcontract.

II. Scope

Monitoring well installations are planned for shallow and/or deep unconsolidated aquifers and/or for bedrock aquifers. The SOPs *Installation of Shallow Monitoring Wells*, *Installation of Surface-Cased Monitoring Wells*, *Installation of Bedrock Monitoring Wells*, and *Installation of Monitoring Wells Using Sonic Drilling* provide more specifics.

III. Equipment and Materials

1. Drilling rig (hollow stem auger, sonic, air hammer, air rotary, or mud rotary)
2. Well-construction materials (i.e., surface casing, screens, riser, casing, caps, bottom plugs, centering guides, sand, bentonite, grout, and surface-finish materials)
3. Development equipment

IV. Procedures and Guidelines

1. Wells will be installed in accordance with standard EPA procedures. Note that USEPA Region III requires any well penetrating a confining layer to be double-cased.
2. The threaded connections will be water-tight.
3. Well screens generally will be constructed of 10-slot or 20-slot Schedule 40 PVC and will be 5 to 10 feet in length depending on saturated thickness of unconsolidated sediments. The exact slot size and length will be determined by the field team supervisor. Stainless steel may be required under certain contaminant conditions.
4. Stick-up wells will be surrounded by four concrete-filled guard posts at least 2 inches in diameter.

5. A record of the finished well construction will be compiled.
6. All soils and liquids generated during well installations will be drummed for proper disposal.

Monitoring Well Installation

- 2" monitoring wells in unconsolidated materials will be installed in at least 6-inch-diameter boreholes to accommodate well completion materials in designated locations.
- All monitoring wells penetrating a confining layer will be surface-cased from the ground surface to approximately 5 feet into the confining layer. Exceptions to this may be allowed under certain circumstances (e.g., evidence of significant natural gaps in the confining layer).
- Monitoring wells in unconsolidated materials will be constructed of 2-inch-diameter, factory manufactured, flush-jointed, Schedule 40 PVC (or stainless steel) screen with threaded bottom plug and riser.
- Screens will be filter packed with a properly sized and graded, thoroughly washed, sound, durable, well-rounded basalt or siliceous sand. When using hollow-stem augers, the filter pack will be installed by slowly pouring the sand into the annular space while simultaneously raising the augers and using a weighted tape to sound for the sand surface. For rotary-drilled wells, the height of the sand pack also will be sounded with a weighted tape.
- The primary filter sand pack (typically Morie #00 or DSI #1 for a 10-slot screen) will extend from 1 to 2 feet below the base to 2 feet above the top of the screen; filter pack will be allowed to settle before final measurement is taken. For wells deeper than 30 feet, the filter pack will be placed using a tremie pipe and flowing water.
- A secondary filter sand pack (typically a fine sand seal) 1-foot thick may be placed above the primary sand pack.
- Annular well seals will consist of 2 feet of pelletized, chip, or granular bentonite clay placed above the filter pack. If necessary the pellets will be hydrated using potable water. For wells installed using hollow-stem augers, the bentonite will be poured into the annular space while slowly raising the augers and sounding for the top of the bentonite with a weighted tape. A high-solids bentonite slurry using powdered bentonite introduced with a side-discharging tremie pipe will be used for the bentonite seals in wells greater than 30 feet deep. For rotary-drilled wells, the height of the well seal also will be sounded with a weighted tape. High-solids slurries will have solids content of at least 20 percent.
- The top of the annular seal will be measured after the bentonite seal has been allowed to hydrate and before the grout is applied. The seal will be allowed to hydrate for at least 30 minutes before work in the well continues.

- The annular space above the bentonite seal will be filled to grade with a bentonite-cement slurry grout mixture.
- The grout mixture consists of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage.
- The grout mix will be carefully applied to avoid disturbing the bentonite seal; the method of grout placement must force grout from the top of the bentonite seal to ground surface.
- After allowing the grout to settle and set up overnight, additional grout will be added to maintain grade.
- A protective steel casing equipped with keyed alike locking caps will be grouted in place for each new well; the casing will extend at least 2 feet above grade and 3 feet below grade, and will be painted a bright color.

Well Development

- New monitoring wells will be developed after the well has been completely installed and the grout has hardened (at least 24 hours)
- The well will be developed by surging and pumping.
- Equipment placed in the well will be decontaminated before use.
- If information is available, begin developing in the least-contaminated well first.
- Development will include surging the well by either abruptly stopping flow and allowing water in the well column to fall back into the well or through the use of a surge block that is slightly smaller in diameter than the well casing inner diameter.
- Pipes and pumps must not be fitted with foot valves or other devices that might inhibit the return flow of water to the well.
- Surging should continue throughout the development process.
- The air-lift method may be used to pump materials out of the well. The air compressor will be fitted with filters to remove all oil and the air lift hose used will be made of inert materials.
- Well development will continue until the water produced is free of turbidity, sand, and silt. A Horiba-U22 meter, YSI meter with separate Hanna turbidity meter, or equivalent should be used to determine when the turbidity is low and parameters have stabilized.
- Development water will be considered hazardous and placed in sealed 55-gallon U.S. DOT approved steel drums. CH2M HILL will label and date the drums as pending analysis, and transport the drums to a designated site for storage.

V. Attachments

None.

VI. Key Check and Items

- Ensure that all equipment is properly decontaminated as needed.
- Only new, sealed materials (e.g., screens, risers, and sand) will be used in constructing the well.
- Care shall be taken when making downhole measurements to ensure that proper heights of sand, seal, and grout are achieved.

Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCL, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart (e.g., Munsell)
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification (attached)

III. Procedures and Guidelines

This section covers several aspects of soil characterization: instructions for completing the CH2M HILL soil boring log Form D1586 (attached), field classification of soil, and standard penetration test procedures.

A. Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books or on separate soil boring log sheets. Information collected will be consistent with that required for Form D1586 (attached), a standard CH2M HILL form (attached), or an equivalent form that supplies the same information.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both jar lids and labels and on the log sheets.

B. Heading Information

Boring/Well Number. Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.

Location. If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities through a survey.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first and last name.

C. Technical Data

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1-foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record soil recovery in feet.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A

partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons. Samples may be collected using direct push sampling equipment. However, blow counts will not be available. A pocket penetrometer may be used instead to determine relative soil density of fine grained materials (silts and clays).

Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below.

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

D. Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils (attached).

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). In addition, some elements of a complete soil

description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."
2. Group symbol, in parentheses, for example, "(SP)."
3. Color, using Munsell color designation
4. Moisture content
5. Relative density or consistency
6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488.

E. Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as “Interlayered Sand and Silt,” should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

F. Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

G. Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

H. Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 2.

I. Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586 [attached]). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 3 and 4.

J. Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

K. Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586. The split-barrel sampler should measure 2-inch or 3-inch O.D., and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch O.D.). A stiffer rod, such as an "N" rod (2-5/8-inch O.D.), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

Soil Boring Log (Sample Soil Boring Log.xls)

CH2M HILL Form D1586 and a completed example (Soil_Log_Examp.pdf)

ASTM D 2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)* (ASTM D2488.pdf)

ASTM 1586 *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586.pdf)

Tables 1 through 4 (Tables 1-4.pdf)

V. Key Checks and Preventive Maintenance

- Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later.
- Check that sample numbers and intervals are properly specified.
- Check that drilling and sampling equipment is decontaminated using the procedures defined in *SOP Decontamination of Drilling Rigs and Equipment*.

Sediment Sampling

I. Purpose

These general outlines describe the collection and handling of sediment samples during field operations.

II. Scope

The sediment sampling procedures generally describe the equipment and techniques needed to collect representative sediment samples. Operators manual, if available, should be consulted for specific details

III. Equipment and Materials

- Sample collection device (hand corer, scoop, dredge, grab sampler, or other suitable device)
- Stainless steel spoon or spatula or plastic disposable scoop for media transfer
- Measuring tape
- Log book
- Personal protection equipment (rubber or latex gloves, boots, hip waders, etc.)
- Materials for classifying soils, particularly the percentage of fines
- Sample jars, including jars for Total Organic Carbon and pH, as appropriate

IV. Procedures and Guidelines

1. Field personnel will start downstream and work upstream to prevent contamination of unsampled areas. In surface water bodies that are tidally influenced, sampling will be performed at low tide and under low flow conditions to minimize the dilution of possible contaminants. Sediment sampling activities will not occur immediately after periods of heavy rainfall.
2. Make a sketch of the sample area that shows important nearby river features and permanent structures that can be used to locate the sample points on a map. Whenever possible, include measured distances from such identifying features. Also include depth and width of waterway, rate of flow, type and consistency of sediment, and point and depth of sample removal (along shore, mid-channel, etc).

3. Note in the field book any possible outside sources of contamination; for example, the outlet to a drainage culvert in the water body near your sampling location.
4. Transfer sample into appropriate sample jars with a stainless steel utensil or plastic disposable scoop. Be especially careful to avoid the loss of the very fine clay/silt particles when collecting the sample. The fine particles have a higher adsorption capacity than larger particles. Minimize the amount of water that is collected within the sample matrix. Decant the water off of the sample slowly and carefully to maximize retention of the very fine particles. The sampler's fingers should never touch the sediment since gloves may introduce organic interference into the sample. Classify the soil type of the sample using the Unified Soil Classification System, noting particularly the percentage of silt and clay.
5. Samples for volatile organics should immediately be placed in jars. Rocks and other debris should be removed before placement in jars.
6. For channel sampling, be on the alert for submerged hazards (rocks, tree roots, drop-offs, loss silt and muck) which can make wading difficult.
7. Sample sediment for TOC and pH also, to give context to organic and inorganic data during the risk assessment.
8. Follow the site safety plan designed for the specific nature of the site's sampling activities and locations.
9. Decontaminate all sampling implements and protective clothing according to prescribed procedures.

V. Attachments

None.

VI. Key Checks and Items

- Start downstream, work upstream.
- Log exact locations using permanent features.
- Beware of hidden hazards.

Seep Groundwater Sample Collection

I. Purpose

To provide a general guideline for the collection of groundwater samples from seeps, which have either limited flow or are manifested simply by damp areas on the surface of the ground.

II. Scope

The SOP covers sampling seeps with drive points, similar to the equipment used in direct-push groundwater sampling. The assumption is that, even if there is a small amount of flow at the surface, a representative sample of the groundwater discharging at the seep must be taken from below the ground surface with a drive point rather than from the water at the surface. This avoids chemical changes to the groundwater, such as volatilization of organic compounds that may occur when the groundwater comes in contact with the atmosphere.

III. Equipment and Materials

- Stainless steel or PVC drive points and extra drive rods (if needed)
- Slide hammer or sledge hammer
- Peristaltic pump with dedicated polyethylene sampling tubing or small bailer
- Pre-cleaned sample containers
- Personal Protective Equipment as specified by the Health and Safety Plan.

IV. Procedures and Guidelines

1. Decontaminate the drive point and any other non-dedicated downhole equipment (e.g., extra drive rods) in accordance with the *Decontamination of Personnel and Equipment* SOP.
2. Drive the slotted interval of the drive point to the desired sampling depth using the drive hammer or sledge hammer. The desired depth is that at which there is sufficient groundwater in the drive point to obtain a sample. It should be recognized that the recharge to the small-diameter (1 to 1.25 inch ID) drive point may be slow.
3. In cases where the drive point must be pumped, insert the polyethylene sampling tubing into the drive point. Alternatively, a small-diameter bailer may be used.

4. In cases where the drive point is emplaced in a near-horizontal orientation, such as it may have when it is driven into a seepage area in the bank of a stream, be prepared for groundwater to flow from the drive point under the force of gravity. In this situation, the screen interval of the drive point must be fully embedded in the ground for groundwater to flow from the top of the drive point.
5. Fill all sample containers, beginning with the containers for VOC analysis.
6. Remove polyethylene sampling tubing, if used, from the drive point.
7. Decontaminate all non-dedicated downhole equipment in accordance with the *Decontamination of Personnel and Equipment SOP*.
8. Abandon drive point hole (as necessary) per project specifications.

V. Key Checks and Items

1. Verify that the drive points and any extra drive rods are clean.
2. When the drive point is emplaced in a near-horizontal orientation, be sure that the screen interval is completely embedded in the ground so that groundwater will flow through the embedded screen instead of through the exposed upper screen interval.

Packaging and Shipping Procedures for Low-Concentration Samples

I. Purpose and Scope

The purpose of this guideline is to describe the packaging and shipping of low-concentration samples of various media to a laboratory for analysis.

II. Scope

The guideline only discusses the packaging and shipping of samples that are anticipated to have low concentrations of chemical constituents. Whether or not samples should be classified as low-concentration or otherwise will depend upon the site history, observation of the samples in the field, odor, and photoionization-detector readings.

If the site is known to have produced high-concentration samples in the past or the sampler suspects that high concentrations of contaminants might be present in the samples, then the sampler should conservatively assume that the samples cannot be classified as low-concentration. Samples that are anticipated to have medium to high concentrations of constituents should be packaged and shipped accordingly.

If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result only employees who are trained under CH2M HILL Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated CH2M HILL HazMat advisor with questions.

III. Equipment and Materials

- Coolers
- Clear tape
- "This Side Up" labels
- "Fragile" labels
- Vermiculite
- Ziplock bags or bubble wrap
- Ice
- Chain-of-Custody form (completed)
- Custody seals

IV. Procedures and Guidelines

Low-Concentration Samples

- A. Prepare coolers for shipment:
 - Tape drains shut.
 - Affix "This Side Up" labels on all four sides and "Fragile" labels on at least two sides of each cooler.
 - Place mailing label with laboratory address on top of coolers.
 - Fill bottom of coolers with about 3 inches of vermiculite or absorbent pads.
- B. Arrange decontaminated sample containers in groups by sample number. Consolidate VOC samples into one cooler to minimize the need for trip blanks.
- C. Affix appropriate adhesive sample labels to each container. Protect with clear label protection tape.
- D. Seal each sample bottle within a separate ziplock plastic bag or bubble wrap, if available. Tape the bag around bottle. Sample label should be visible through the bag.
- E. Arrange sample bottles in coolers so that they do not touch.
- F. If ice is required to preserve the samples, cubes should be repackaged in zip-lock bags and placed on and around the containers.
- G. Fill remaining spaces with vermiculite or absorbent pads.
- H. Complete and sign chain-of-custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or the courier.
- J. Close lid and latch.
- K. Carefully peel custody seals from backings and place intact over lid openings (right front and left back). Cover seals with clear protection tape.
- L. Tape cooler shut on both ends, making several complete revolutions with strapping tape. Cover custody seals with tape to avoid seals being able to be peeled from the cooler.
- M. Relinquish to Federal Express or to a courier arranged with the laboratory. Place airbill receipt inside the mailing envelope and send to the sample documentation coordinator along with the other documentation.

Medium- and High-Concentration Samples:

Medium- and high-concentration samples are packaged using the same techniques used to package low-concentration samples, with potential additional restrictions. If applicable, the sample handler must refer to instructions associated with the shipping of dangerous goods for the necessary procedures for shipping by Federal Express or other overnight carrier. If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result only employees who are trained under CH2M HILL Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated CH2M HILL HazMat advisor with questions.

V. Attachments

None.

VI. Key Checks and Items

- Be sure laboratory address is correct on the mailing label
- Pack sample bottles carefully, with adequate vermiculite or other packaging and without allowing bottles to touch
- Be sure there is adequate ice
- Include chain-of-custody form
- Include custody seals

Soil Sampling

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for obtaining samples of surface and subsurface soils using hand and drilling-rig mounted equipment.

II. Equipment and Materials

- Stainless-steel trowel, shovel, scoop, coring device, hand auger, or other appropriate hand tool
- Stainless-steel, split-spoon samplers
- Thin-walled sampling tubes
- Drilling rig or soil-coring rig
- Stainless-steel pan/bowl or disposable sealable bags
- Sample bottles

III. Procedures and Guidelines

Before sampling begins, equipment will be decontaminated using the procedures described in SOP *Decontamination of Drilling Rigs and Equipment*. The sampling point is located and recorded in the field logbook. Debris should be cleared from the sampling location.

A. Surface and Shallow Subsurface Sampling

A shovel, post-hole digger, or other tool can be used to remove soil to a point just above the interval to be sampled. A decontaminated sampling tool will be used to collect the sample when the desired sampling depth has been reached. Soil for semivolatile organic and inorganic analyses is placed in the bowl and mixed; soil for volatile organic analysis is not mixed or composited but is placed directly into the appropriate sample bottles. A stainless-steel or dedicated wooden tongue depressor is used to transfer the sample from the bowl to the container.

The soils removed from the borehole should be visually described in the field log book, including approximated depths.

When sampling is completed, photo-ionization device (PID) readings should be taken directly above the hole, and the hole is then backfilled.

More details are provided in the SOP *Shallow Soil Sampling*.

B. Split-Spoon Sampling

Using a drilling rig, a hole is advanced to the desired depth. For split-spoon sampling, the samples are then collected following the ASTM D 1586 standard (attached). The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically this is 24 inches. The sampler is driven in 6-inch increments using a 140-pound weight (“hammer”) dropped from a height of 30 inches. The number of hammer blows for each 6-inch interval is counted and recorded. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch ID sampler may be required. Blow counts obtained with a 3-inch ID spoon would not conform to ASTM D 1586 and would therefore not be used for geotechnical evaluations.

Once retrieved from the hole, the sampler is carefully split open. Care should be taken not to allow material in the sampler to fall out of the open end of the sampler. To collect the sample, the surface of the sample should be removed with a clean tool and disposed of. Samples collected for volatiles analysis should be placed directly into the sample containers from the desired depth in the split spoon. Material for samples for all other parameters should be removed to a decontaminated stainless steel tray or disposable sealable bag. The sample for semivolatile organic and inorganic analyses should be homogenized in the field by breaking the sample into small pieces and removing gravel. The homogenized sample should be placed in the sample containers. If sample volume requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the sample and compositing the sample for non-volatile parameters only.

Split-spoon samples also will be collected using a tripod rig. When using a tripod rig the soil samples are collected using an assembly similar to that used by the drilling rig.

C. Thin-Walled Tube Sampling

Undisturbed fine grained samples may be collected for analysis for geotechnical parameters such as vertical hydraulic conductivity. These samples will be collected using thin-walled sampling tubes (sometimes called Shelby tubes) according to ASTM D 1587 (attached). Tubes will be 24- to 36 inches long and 3- to 4-inches in diameter, depending upon the quantity of sample required. Undisturbed samples will be obtained by smoothly pressing the sampling tube through the interval to be sampled using the weight of the drilling rig. Jerking the sample should be avoided. Once the sample is brought to the surface, the ends will be sealed with bees wax and then sealed with end caps and heavy tape. The sample designation, data and time of sampling, and the up direction will be noted on the sampling tube. The tube shall be kept upright as much as possible and will be protected from freezing, which could disrupt the undisturbed nature of the sample. Samples for geochemical analysis normally are not collected from thin-walled tube samples.

IV. Attachments

ASTM D 1586 Standard Penetration Test Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586.pdf)

ASTM D 1587 Standard Practice for Thin-Walled Tube Sampling of Soils (ASTM D1587.pdf)

V. Key Checks and Preventative Maintenance

- Check that decontamination of equipment is thorough.
- Check that sample collection is swift to avoid loss of volatile organics during sampling.

Soil Boring Sampling–Split Spoon

I. Purpose

To provide a general procedure for sampling subsurface soil produced from a split spoon.

II. Scope

The scope of this procedure is to cover the sample team's responsibility beginning with the opening of the split spoon.

III. Equipment and Materials

- Latex or surgical gloves
- Stainless steel tray or pan or disposable sealable bags
- Field notebook
- Stainless steel spoon or spatula or disposable plastic scoop
- Sampling jars
- Decontamination solutions and equipment

IV. Procedures and Guidelines

1. Field team personnel will wear latex or surgical inner gloves and nitrile or neoprene outer gloves to protect from potential dermal contact with hazardous substances.
2. After the split spoon is removed from the borehole and opened by the driller or driller's assistant, it will be turned over to field team personnel.
3. The sample description, depth, time, and date will be logged in the field notebook.
4. Samples for laboratory analysis will be separated and transferred from the split spoon half into the sample jars by a decontaminated stainless steel utensil or plastic disposable scoop. Samples for VOC analysis will be separated and transferred first, followed by semivolatile samples. For volatile samples, avoid mixing soil before or during transfer. Homogenize the rest of the sample according to SOP *Homogenization of Soil and Sediment Samples*.
5. Split spoon and media transfer tools will be decontaminated before being used again.

V. Attachments

None.

VI. Key Checks and Items

- Latex or surgical gloves.
- Decontaminate split spoon and transfer tools before next sample.
- Sample volatiles first, then semivolatiles.
- Avoid mixing for volatiles samples.

Surface Water Sampling

I. Purpose and Scope

This procedure presents the techniques used in collecting surface water samples. Materials, equipment, and procedures may vary; refer to the Field Sampling Plan and operators manuals for specific details.

II. Materials and Equipment

Materials and equipment vary depending on type of sampling; the Field Sampling Plan should be consulted for project-specific details. Typical equipment required includes:

- Open tube sampler
- Dip sampler
- Weighted bottle sampler
- Hand pump
- Kemmerer or Van Dorn sampler
- Depth-integrating sampler
- Peristaltic pump
- Sample containers
- Meters for specific conductance, temperature, pH, and dissolved oxygen

III. Procedures and Guidelines

Before surface water samples are taken, all sampler assemblies and sample containers are cleaned and decontaminated as described in *SOP Decontamination of Personnel and Equipment*. Surface water samples collected from water bodies tidally influenced should be collected at low tide and under low flow conditions to minimize the dilution of potential contaminants. Methods for surface water sample collection are described below.

A. Manual Sampling

Surface water samples are collected manually by submerging a clean glass, stainless steel, or Teflon container into the water body. Samples may be collected at depth with a covered bottle that can be removed with a tripline. The most common sampler types are beakers, sealable bottles and jars, pond samplers, peristaltic pumps, and weighted bottle samplers. Pond samplers have a fixed or telescoping pole attached to the sample container. Weighted bottle samplers are lowered below water surface, where the attached bottle is opened, allowed to fill, and pulled out of the water. When retrieved, the bottle is tightly capped and removed from the

sampler assembly. Specific types of weighted bottle samplers include Kemmerer or Van Dorn and are acceptable in most instances.

A sample is taken with the following specific steps:

1. The location and desired depth for water sampling are selected.
2. The sample site is approached from downstream in a manner that avoids disturbance of bottom sediments as much as possible. The sample bottle is gently submerged with the mouth pointed upstream and the bottle tilted slightly downstream. Bubbles and floating materials should be prevented from entering the bottle. If using a Peristaltic pump, lower the tubing into the water to the desired depth.
3. For weighted bottle samplers, the assembly is slowly lowered to the desired depth. The bottle stopper is unseated with a sharp tug and the bottle is allowed to fill until bubbles stop rising to the surface.
4. When the bottle is full, it is gently removed from the water. If sample transfer is required, it should be performed at this time.
5. Measure dissolved oxygen, specific conductance, temperature, and pH at the sampling location.

IV. Attachments

None.

V. Key Checks and Items

- Start downstream, work upstream
- Log exact locations using permanent features
- Beware of hidden hazards

Recommended Use Of The Terra Core®



NOTE: The Terra Core® Sampler is a single use device. It cannot be cleaned and/or reused.



Step 1

Have ready a 40ml glass VOA vial containing the appropriate preservative. With the plunger seated in the handle, push the Terra Core® into freshly exposed soil until the sample chamber is filled. A filled chamber will deliver approximately 5 or 10 grams of soil.

Step 2

Wipe all soil or debris from the outside of the Terra Core® sampler. The soil plug should be flush with the mouth of the sampler. Remove any excess soil that extends beyond the mouth of the sampler.



Step 3

Rotate the plunger that was seated in the handle top 90° until it is aligned with the slots in the body. Place the mouth of the sampler into the 40ml VOA vial containing the appropriate preservative and extrude the sample by pushing the plunger down. Quickly place the lid back on the 40ml VOA vial. **Note:** When capping the 40ml VOA vial, be sure to remove any soil or debris from the top and/or threads of the vial.

Terms and Conditions of Sale



- 1. Acceptance.** ALL SALES ARE SUBJECT TO AND EXPRESSLY CONDITIONED UPON THE TERMS AND CONDITIONS CONTAINED HEREIN. NO VARIATION OF THESE TERMS AND CONDITIONS WILL BE BINDING UPON SELLER, UNLESS AGREED TO IN WRITING AND SIGNED BY AN OFFICER OR OTHER AUTHORIZED REPRESENTATIVE OF SELLER. IF THESE TERMS AND CONDITIONS ARE NOT ACCEPTABLE TO BUYER, BUYER MUST SO NOTIFY SELLER IMMEDIATELY IN WRITING.
- 2. Terms, Delivery, Delays.** Unless otherwise specified, terms are net 30 days from the date of invoice, F.O.B. shipping point, freight prepaid and added. All prices are subject to change without notice. Stenographic, clerical and computer errors are subject to correction. If financial condition of Buyer results in the insecurity of Seller, in Seller's sole discretion, as to the ultimate collectibility of the purchase price, Seller may, without notice to Buyer, delay or postpone the delivery of goods, and Seller at its option, is authorized to change the terms of payment to payment in full or in part in advance of shipment of the entire undelivered balance of said goods. Buyer agrees to pay all costs, including but not limited to, reasonable attorney and accounting fees and other expenses of collection resulting from any default by Buyer in any of the terms hereof. All risk of loss or damage during shipping shall be borne by Buyer. Seller reserves the right, in its discretion, to determine the exact method of shipment. Seller reserves the right to make delivery in installments, all such installments to be separately invoiced and paid for when due per invoice, without regard to subsequent deliveries. Delay in delivery of any installment shall not relieve Buyer or Buyer's obligation to accept remaining deliveries. Immediately upon Buyer's receipt of any goods shipped hereunder, Buyer shall inspect the same and shall notify Seller in writing of any claims for shortages, defects or damages and shall hold the goods for Seller's written instructions concerning disposition. Seller shall not be liable for any loss, damage or penalty as a result of any delay in or failure to manufacture, deliver or otherwise perform hereunder due to any cause beyond Seller's reasonable control, including, without limitation, strikes or labor difficulties, acts or omissions of any governmental authority or Buyer, accident, insurrection or riot, fires, floods or other acts of God, breakdowns of essential equipment, priorities or embargoes, shortages, delays in transportation, or inability to obtain necessary labor, fuel, materials, supplies or power at current prices or from usual sources.
- 3. Allocation of Goods.** If Seller is unable for any reason to supply the total demands for goods specified in Buyer's order, Seller may allocate its available supply among any or all buyers on such basis as Seller may deem fair and practical, without liability for any failure of performance which may result therefrom.
- 4. Taxes and Other Charges.** Any use tax, sales tax, excise tax, or any other tax, fee or charge of any nature whatsoever imposed by any governmental authority, on or measured by the transaction between Seller and Buyer, shall be paid by Buyer in addition to the prices quoted or invoiced.
- 5. Warranty.** SELLER MAKES NO WARRANTIES REGARDING THE TERRA CORE™ SAMPLER, WHETHER ORAL, WRITTEN, EXPRESS, IMPLIED OR STATUTORY, INCLUDING ANY INFORMATION PROVIDED BY SALES REPRESENTATIVES IN MARKETING LITERATURE, DIRECTIONS FOR USE, OR ANY OTHER INFORMATION SUPPLIED WITH THE SAMPLER. IMPLIED WARRANTIES OF FITNESS AND MERCHANTABILITY SHALL NOT APPLY. Seller's warranty obligations and Buyer's remedies are solely and exclusively as stated herein. FURTHERMORE, SELLER SPECIFICALLY DISCLAIMS ANY WARRANTIES RELATING TO SAMPLE QUALITY OR SAMPLE PRESERVATION. SELLER DOES NOT WARRANT THAT THE USE OF THE TERRA CORE™ SAMPLER WILL RESULT IN COMPLIANCE WITH ANY SAMPLING METHODS OUTLINED BY ANY REGULATORY BODY. SELLER DOES NOT WARRANTY OR GUARANTEE SAMPLING RESULTS.
- 6. Limitation of Liability.** IN NO EVENT SHALL SELLER BE LIABLE FOR ANTICIPATED PROFITS, INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES, INCLUDING, BUT NOT LIMITED TO, DAMAGES FOR LOSS OF REVENUE, DOWN TIME, REMEDIATION ACTIVITIES, REMOBILIZATION OR RESAMPLING, COST OF CAPITAL, SERVICE INTERRUPTION OR FAILURE OF SUPPLY, ANY LIABILITY OF BUYER TO A THIRD PARTY, OR FOR LABOR, OVERHEAD, TRANSPORTATION, SUBSTITUTE SUPPLY SOURCES OR ANY OTHER EXPENSE, DAMAGE OR LOSS, INCLUDING PERSONAL INJURY OR PROPERTY DAMAGE. SELLER IS NOT RESPONSIBLE FOR INTERPRETATION OF ANY SAMPLING METHODS OUTLINED BY ANY REGULATORY BODY OR BUYER'S INABILITY TO COMPLY WITH OR CORRECTLY FOLLOW ANY SUCH SAMPLING METHODS. SELLER IS NOT LIABLE FOR DAMAGE CAUSED BY ACCIDENT, ABUSE, MISHANDLING OR DROPPING OF SAMPLER, DAMAGES DUE TO SAMPLERS THAT HAVE BEEN OPENED, DISASSEMBLED OR MISHANDLED, OR DAMAGES DUE TO SAMPLERS NOT USED IN ACCORDANCE WITH THE DIRECTIONS. Seller's liability on any claim of any kind shall be replacement of such goods or refund of the purchase price. Seller shall not be liable for penalties of any description whatsoever. In the event the Terra Core™ sampler will be utilized by Buyer on behalf of a third party, such third party shall not occupy the position of a third-party beneficiary of the obligation or warranty provided by Seller, and no such third party shall have the right to enforce same. All claims must be brought within one (1) year of shipment, regardless of their nature.
- 7. Returns.** Written authorization must be obtained from Seller prior to returning any goods. Buyer shall strictly comply with Seller's return shipment instructions. Returned goods will be subject to a restocking charge.
- 8. Technical Assistance.** At Buyer's request, Seller may, at Seller's discretion, furnish technical assistance and information with respect to Seller's products. SELLER MAKES NO WARRANTIES OF ANY KIND OR NATURE, EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, WITH RESPECT TO TECHNICAL ASSISTANCE OR INFORMATION PROVIDED BY SELLER OR SELLER'S REPRESENTATIVES. ANY SUGGESTIONS BY SELLER REGARDING USE, SELECTION, APPLICATION OR SUITABILITY OF THE SAMPLER SHALL NOT BE CONSTRUED AS AN EXPRESS WARRANTY OF ANY KIND, INCLUDING COMPLIANCE WITH ANY SAMPLING METHODS OUTLINED BY ANY REGULATORY BODY, UNLESS SPECIFICALLY DESIGNATED AS SUCH IN A WRITING SIGNED BY AN OFFICER OF SELLER.
- 9. Miscellaneous.** Seller's failure to strictly enforce any term or condition of an order or to exercise any right arising hereunder shall not constitute a waiver of Seller's right to strictly enforce such terms or conditions or exercise such right thereafter. All rights and remedies with respect to any order are cumulative and are in addition to any other rights and remedies Seller may have at law or equity. Any waiver of a default by Buyer hereunder shall be in writing. If any provision of these agreed upon terms and conditions shall be held to be invalid, illegal or unenforceable, the validity, legality and enforceability of the remaining provisions shall not be affected or impaired thereby. The paragraph headings herein are for convenience only; they form no part of the terms and conditions and shall not affect their interpretation. This agreement and the terms and conditions herein shall be binding upon, inure to the benefit of, and be enforceable by, the parties hereto, and their respective heirs, personal representatives, successors and assigns.
- 10. Governing Law.** All disputes relating to the terms hereof, performance of this order or any other claim related to Seller's goods shall be governed by the laws of the State of Wisconsin; provided, however, construction shall be without regard to any rule or presumption requiring construction against the party causing this agreement to be drafted. Buyer and Seller agree that any dispute arising between them which results in either party instituting court proceedings that such action will be maintained in the Circuit Court for Brown County, Wisconsin.

Locating and Clearing Underground Utilities

I. Purpose

The purpose of this SOP is to provide general guidelines and specific procedures that must be followed on Navy CLEAN projects for locating underground utilities and clearing dig locations in order to maximize our ability to avoid hitting underground utilities and to minimize liabilities to CH2M HILL and its subcontractors and health and safety risks to our project staff.

This SOP shall be used by Activity Managers and Project Managers to, in-turn, develop Activity-specific and project-specific utility location procedures. The activity and project-specific procedures will become part of work plans and project instructions and will be used to prepare scopes of work (SOWs) for the procurement of utility location subcontractors to meet the needs of individual projects.

This SOP also identifies the types of utility locating services that are available from subcontractors and the various tools that are used to locate utilities, and discusses when each type of service and tool may or may not be applicable.

II. Scope

Depending on the Navy/Marine Activity we typically find ourselves in one of two scenarios:

Scenario 1

The Activity provides utility locating (or dig clearance) services through the public works department or similar organization, or has a contract with an outside utility clearance service. Some of these services are provided in the form of dig permits which are required before you can dig or drill. In other cases no official permit is required and the process is somewhat vague.

Scenario 2

The Activity does not get involved in any utility locating processes aside from possibly providing the most recent utility maps, and relies on CH2M HILL to clear the dig locations.

Table 1 provides an up to date summary of which scenarios apply to the various primary Activities served under the Navy CLEAN program.

Scenario 1 is preferred because under this scenario the Navy tends to assume the responsibility if the location is improperly cleared, a utility is struck, and property damage results. However, our experience has been that the clearance services provided

by the Navy do not meet the standards that we consider to be adequate, in that they often simply rely on available base maps to mark utilities and do not verify locations using field geophysics. And if they do use locating tools, they do not provide adequate documentation or marking to confirm that a location has been cleared. So while the Navy's process may protect us from liability for property damage, it does not adequately protect our staff and subcontractors from health risks nor does it compensate us for down time, should a utility be hit.

Therefore, regardless of what services the Navy provides, in most cases we still need to supplement this effort with clearance services from our own third party utility location subcontractor following the procedures and guideline outlined in Section IV of this SOP. The cost implications of providing this service will range from \$500 to several \$1,000 depending on the size of the project.

The scope of services that we ask our subcontractors to provide can involve utility marking/mapping or the clearing of individual dig locations. In the former we ask our subs to mark all utilities within a "site" and often ask them to prepare a map based on their work. In the later, we ask them to clear (identify if there are any utilities within) a certain radius of a proposed dig/drill location.

The appropriate requested scope of services for a project will depend on the project. Clearing individual boreholes is often less expensive and allows the sub to concentrate their efforts on a limited area. However if the scope of the investigation is fluid (all borehole locations are not predetermined) it may be best to mark and map an entire site or keep the subcontractor on call.

Clearance of individual dig locations should be done to a minimum 20 foot radius around the location.

An example SOW for a utility subcontractor procurement is provided in Attachment A.

III. Services and Equipment

This section provides a general description of the services available to help us locate subsurface utilities and describes the types of equipment that these services may (or may not) use to perform their work. It identifies the capabilities of each type of equipment to help the PM specify what they should require from our utility location subs.

Services

The services that are available to us for identifying and marking underground utilities are:

- The local public/private utility-run service such as Miss Utility
- Utility location subcontractors (hired by us)

Attachment B provides a detailed description of each type of organization. It also provides contact numbers and web sites for the various Miss-Utility-type organizations in the areas where we do work for the Navy and contacts and services provided by several subcontractors that we have used or spoken to in the past.

Equipment

Attachment C provides a summary of the various types of equipment used for subsurface utility location. It describes the capabilities and limitations of each in order to help the PM determine if the equipment being used by a subcontractor is adequate.

It is important to make the potential subcontractors aware of the possible types of utilities (and utility materials) that are at the site, and to have them explain in their bid what types of equipment they will use to locate utilities / clear dig locations, and what the limitations of these equipment are.

A list of in-house experts that can be used to help you evaluate bids or answer questions you may have is provided in **Appendix C**.

IV. Procedures and Guidelines

This section presents specific procedures to be followed for the utility location work to be conducted by CH2M HILL and our subcontractors. In addition, a PM will have to follow the procedures required by the Activity to obtain their approvals, clearances and dig permits where necessary. These “dig permit” requirements vary by Activity and must be added to the project-specific SOP, or project instructions. It is preferable that the Activity perform their clearance processes before we follow up with our clearance work.

Activity Notification and Dig Permit Procedures

Identify Activity-specific permit and/or procedural requirements for excavation and drilling activities. Contact the Base Civil Engineer and obtain the appropriate form to begin the clearance process.

Activity Specific: To be provided by Activity or Project Manager

CH2M HILL Utility Clearance Procedures

Do not begin subsurface construction activities (e.g., trenching, excavation, drilling, etc.) until a check for underground utilities and similar obstructions has been conducted by CH2M HILL as a follow-up to the services provided by the Navy. The use of as-built drawings and utility company searches must be supplemented with a geophysical or other survey by a qualified, independent survey contractor (subcontracted to CH2M HILL) to identify additional and undiscovered buried utilities.

Examples of the type of geophysical technologies include (these are further described in Attachment C):

- **Ground Penetrating Radar (GPR)**, which can detect pipes, including gas pipes, tanks, conduits, cables etc, both metallic and non-metallic at depths up to 30 feet depending on equipment. Sensitivity for both minimum object size and maximum depth detectable depends on equipment selected, soil conditions, etc.
- **Radio Frequency (RF)**, involves inducing an RF signal in the pipe or cable and using a receiver to trace it. Some electric and telephone lines emit RF naturally and can be

detected without an induced signal. This method requires knowing where the conductive utility can be accessed to induce RF field if necessary.

- **Dual RF**, a modified version of RF detection using multiple frequencies to enhance sensitivity but with similar limitations to RF
- **Ferromagnetic Detectors**, are metal detectors that will detect ferrous and non-ferrous utilities. Sensitivity is limited, e.g. a 100 mm iron disk to a depth of about one meter or a 25 mm steel paper clip to a depth of about 20 cm.
- **Electronic markers**, are emerging technologies that impart a unique electronic signature to materials such as polyethylene pipe to facilitate location and tracing after installation. Promising for future installations but not of help for most existing utilities already in place.

The following procedures shall be used to identify and mark underground utilities during subsurface construction activities on the project:

- Contact utility companies or the state/regional utility protection service (such as Miss Utility) at least two (2) working days prior to intrusive activities to advise of the proposed work, and ask them to establish the location of the utility underground installations prior to the start of actual excavation: this is a law. These services will only mark the location of public-utility-owned lines and not Navy-owned utilities. In many cases there will not be any public-utility-owned lines on the Activity. There may also be Base-access issues to overcome.
- Procure and schedule the independent survey.
- The survey contractor shall determine the most appropriate geophysical technique or combinations of techniques to identify the buried utilities on the project site, based on the survey contractor's experience and expertise, types of utilities anticipated to be present and specific site conditions. *The types of utilities must be provided to the bidding subcontractors in the SOW and procedures to be used must be specified by the bidder in their bid. It is extremely helpful to provide the sub with utility maps, with the caveat that all utilities are not necessarily depicted.*
- The survey subcontractor shall employ the same geophysical techniques used to identify the buried utilities, to survey the proposed path of subsurface investigation/construction work to confirm no buried utilities are present.
- Obtain utility clearances for subsurface work on both public and private property.
- Clearances provided by both the "Miss Utility" service and the CH2M HILL-subcontracted service are to be in writing, signed by the party conducting the clearance. The Miss Utility service will have standard notification forms/letters which typically simply state that they have been to the site and have done their work. The CH2M HILL subcontractor shall be required to fill out the form provided in Attachment D (this can be modified for a particular project) indicating that each dig/drill location has been addressed. *This documentation requirement (with a copy of the form) needs to be provided in the subcontractor SOW.*

- Marking shall be done using the color coding presented in Attachment E. The type of material used for marking must be approved by the Activity prior to marking. Some base commanders have particular issues with persistent spray paint on their sidewalks and streets. *Any particular marking requirements need to be provided in the subcontractor SOW.*
- Protect and preserve the markings of approximate locations of facilities until the markings are no longer required for safe and proper excavations. If the markings of utility locations are destroyed or removed before excavation commences or is completed, the Project Manager must notify the utility company or utility protection service to inform them that the markings have been destroyed.
- Perform a field check prior to drilling/digging (preferably while the utility location sub is still at the site) to see if field utility markings coincide with locations on utility maps. Look for fire hydrants, valves, manholes, light poles, lighted signs, etc to see if they coincide with utilities identified by the subcontractor.
- Underground utility locations must be physically verified (or dig locations must be physically cleared) by hand digging using wood or fiberglass-handled tools, air knifing, or by some other acceptable means approved by CH2M HILL, when the dig location (e.g. mechanical drilling, excavating) is expected to be within 5 feet of a marked underground system. Hand clearance shall be done to a depth of four feet unless a utility cross-section is available that indicates the utility is at a greater depth. In that event, the hand clearance shall proceed until the documented depth of the utility is reached.
- Conduct a site briefing for employees at the start of the intrusive work regarding the hazards associated with working near the utilities and the means by which the operation will maintain a safe working environment. Detail the method used to isolate the utility and the hazards presented by breaching the isolation.
- Monitor for signs of utilities during advancement of intrusive work (e.g., sudden change in advancement of auger or split spoon during drilling or change in color, texture or density during excavation that could indicate the ground has been previously disturbed).

IV. Attachments

- A- Example SOW for Utility Location Subcontractor Procurement
- B - Services Available for Identifying and Marking Underground Utilities
- C - Equipment Used for Identifying Underground Utilities
- D - Utility Clearance Documentation Form
- E - Utility Marking Color Codes

Attachment A – Example SOW for Subcontracting Underground Utilities Locating Services

CTO-**XXX**

Scope of Work

Subsurface Utility Locating

Site **XX**

Navy Activity

City, State

A licensed and insured utility locator will be subcontracted to identify and mark out subsurface utilities for an environmental investigation/remediation project at Site **XX** of **<<insert name of base, city, and state>>**. The subcontractor will need to be available beginning at **<<insert time>>** on **<<insert date>>**. It is estimated that the work can be completed within **XX** days.

Proposed Scope of Work

The subcontractor will identify and mark all subsurface utilities (**CHOOSE 1**) that lie within a radius of 20 feet of each of **XX** sampling locations at Site **XX** shown on the attached Figure 1; (OR) that lie within the bounds of Site **XX** as delineated on the attached Figure 1. (If multiple sites are to be cleared, provide maps of each site with sample locations or clearance boundaries clearly delineated and a scale provided.)

Utilities will be identified using all reasonably available as-built drawings, electronic locating devices, and any other means necessary to maintain the safety of drilling and sampling personnel and the protection of the base infrastructure. The location of utilities identified from as-built drawings or other maps must be verified in the field prior to marking.

Base utility drawings for the Site(s) (**CHOOSE 1**) can be found at **<<insert specific department and address or phone number on the base>>** and should be reviewed by the subcontractor and referenced as part of the utility locating. (OR), will be provided to the subcontractor by CH2M HILL upon the award of the subcontract. (OR), are not available. Utility drawings shall not be considered definitive and must be field verified.

Field verification will include detection using nonintrusive subsurface detection equipment (magnetometers, GPR, etc) as well as opening manhole covers to verify pipe directions. As part of the bid, the Subcontractor shall provide a list of the various subsurface investigation tools they propose to have available and use at the site and what the limitations are of each tool.

A CH2M HILL representative shall be present to coordinate utility clearance activities and identify points and features to be cleared.

Field Marking and Documentation

All utilities located within **(CHOOSE 1) a 20-ft radius of the XX proposed soil boring locations (OR) within the boundary of the site(s)** as identified on the attached figure(s) will be marked using **paint (some Bases such as the WNY may have restrictions on the use of permanent paint)** and/or pin flags color coded to indicate electricity, gas, water, steam, telephone, TV cable, fiber optic, sewer, etc. The color coding shall match the industry standard as described on the attached form. In addition, the **Buried Utility Location Tracking Form** (attached) will be completed by the Subcontractor based upon what is identified in the field during the utility locating and submitted back to CH2M HILL (field staff or project manager) within 24 hours of completing the utility locating activities.

(OPTIONAL) The subcontractor shall also provide a map (or hand sketch) of the identified utilities to the Engineer within XX days of field demobilization. The map shall include coordinates or ties from fixed surface features to each identified subsurface utility.

Bid Sheet/Payment Units

The subcontractor will bid on a time and materials basis for time spent on site and researching utility maps. Mobilization (including daily travel to the site) should be bid as a lump sum, as well as the preparation of the AHA **and any required mapping**. The per diem line item should be used if the field crew will require overnight accommodations at the project site.

Health and Safety Requirements

The utility locating subcontractor is to provide and assume responsibility for an adequate corporate Health and Safety Plan for onsite personnel. Standard personal safety equipment including: hard hat, safety glasses, steel-toed boots, gloves are recommended for all project activities. Specific health and safety requirements will be established by the Subcontractor for each project. The health and safety requirements will be subject to the review of CH2M HILL.

The subcontractor shall also prepare and provide to the Engineer, at least 48 hours prior to mobilization, an acceptable Activity Hazard Analysis (AHA) using the attached AHA form or similar.

It is also required that all subcontractor personnel who will be on site attend the daily 15-minute health and safety tailgate meeting at the start of each day in the field.

Subcontractor personnel showing indications of being under the influence of alcohol or illegal drugs will be sent off the job site and their employers will be notified. Subcontractor personnel under the influence of prescription or over-the-counter medication that may impair their ability to operate equipment will not be permitted to do so. It is expected that the subcontractor will assign them other work and provide a capable replacement (if necessary) to operate the equipment to continue work.

Security

The work will be performed on US Navy property. CH2M HILL will identify the Subcontractor personnel who will perform the work to the appropriate Navy facility point-of-contact, and will identify the Navy point-of-contact to the Subcontractor crew. The Subcontractor bears final responsibility for coordinating access of his personnel onto Navy property to perform required work. This responsibility includes arranging logistics and providing to CH2M HILL, in advance or at time of entry as specified, any required identification information for the Subcontractor personnel. Specifically, the following information should be submitted with the bid package for all personnel that will perform the work in question (this information is required to obtain a base pass):

- Name
- Birth Place
- Birth Date
- Social Security Number
- Drivers License State and Number
- Citizenship

Please be advised that no weapons, alcohol, or drugs will be permitted on the Navy facility at any time. If any such items are found, they will be confiscated, and the Subcontractor will be dismissed.

Quality Assurance

The Subcontractor will be licensed and insured to operate in the State of <<state>> and will comply with all applicable federal, state, county and local laws and regulations. The subcontractor will maintain, calibrate, and operate all electronic locating instruments in accordance with the manufacturer's recommendations. Additionally, the Subcontractor shall make all reasonable efforts to review as-built engineering drawings maintained by Base personnel, and shall notify the CH2M HILL Project Manager in writing (email is acceptable) whenever such documentation was not available or could not be reviewed.

Subcontractor Standby Time

At certain periods during the utility locating activities, the Subcontractor's personnel may be asked to stop work and standby when work may normally occur. During such times, the Subcontractor will cease activities until directed by the CH2M HILL representative to resume operations. Subcontractor standby time also will include potential delays caused by the CH2M HILL representative not arriving at the site by the agreed-upon meeting time for start of the work day. Standby will be paid to the

Subcontractor at the hourly rate specified in the Subcontractor's Bid Form attached to these specifications.

Cumulative Subcontractor standby will be accrued in increments no shorter than 15 minutes (i.e., an individual standby episode of less than 15 minutes is not chargeable).

During periods for which standby time is paid, the surveying equipment will not be demobilized and the team will remain at the site. At the conclusion of each day, the daily logs for the Subcontractor and CH2M HILL representative will indicate the amount of standby time incurred by the Subcontractor, if any. Payment will be made only for standby time recorded on CH2M HILL's daily logs.

Down Time

Should equipment furnished by the Subcontractor malfunction, preventing the effective and efficient prosecution of the work, or inclement weather conditions prevent safe and effective work from occurring, down time will be indicated in the Subcontractor's and CH2M Hill representative's daily logs. No payment will be made for down time.

Schedule

It is anticipated that the subsurface utility locating activities will occur on <<insert date>>. It is estimated that the above scope will be completed within XXX days.

Attachment B - Services Available for Identifying and Marking Underground Utilities

The services that are available to us for identifying and marking underground utilities are:

- The Activity's PWC (or similar organization)
- The local public/private utility -run service such as Miss Utility
- Utility location subcontractors (hired by CH2M HILL)

Each are discussed below.

Navy Public Works Department

A Public Works Department (PWD) is usually present at each Activity. The PWD is responsible for maintaining the public works at the base including management of utilities. In many cases, the PWD has a written permit process in place to identify and mark-out the locations of Navy-owned utilities [Note: The PWD is usually NOT responsible for the locations/mark-outs of non-Navy owned, public utilities (e.g., Washington Gas, Virginia Power, municipal water and sewer, etc.). Therefore, it is likely that we will have to contact other organizations besides the PWD in order to identify non-Navy owned, public utilities].

At some Activities, there may not be a PWD, the PWD may not have a written permit process in place, or the PWD may not take responsibility for utility locating and mark-outs. In these cases, the PWD should still be contacted since it is likely that they will have the best understanding of the utility locations at the Activity (i.e., engineering drawings, institutional knowledge, etc.). Subsequently, the PWD should be brought into a cooperative arrangement (if possible) with the other services employed in utility locating and mark-out in order to have the most comprehensive assessment performed.

At all Activities we should have a contact (name and phone number), and preferably an established relationship, with PWD, either directly or through the NAVFAC Atlantic, Midlant, or Washington NTR or Activity Environmental Office that we can work with and contact in the event of problems.

Miss Utility or "One Call" Services for Public Utility Mark-outs

Miss Utility or "One Call" service centers are information exchange centers for excavators, contractors and property owners planning any kind of excavation or digging. The "One Call" center notifies participating public utilities of the upcoming excavation work so they can locate and mark their underground utilities in advance to prevent possible damage to underground utility lines, injury, property damage and service outages. In some instances, such with southeastern Virginia bases, the Navy has entered into agreement with Ms. Utilities and is part of the response process for Miss

Utilities. Generally, a minimum of 48 hours is required for the public utility mark-outs to be performed. The "One Call" services are free to the public. Note that the "One Call" centers only coordinate with participating public utilities. There may be some public utilities that do NOT participate in the "One Call" center which may need to be contacted separately. For example, in Washington, DC, the Miss Utility "One Call" center does not locate and mark public sewer and water lines. Therefore, the municipal water and sewer authority must be contacted separately to have the sewer and water lines marked out. The AM should contact the appropriate one-call center to determine their scope of services.

For the Mid-Atlantic region, the following "One Call" service centers are available.

Name	Phone	Website	Comments
Miss Utility of DELMARVA	800-257-7777	www.missutility.net	Public utility mark-outs in Delaware, Maryland, Washington, DC, and Northern Virginia
Miss Utility of Southern Virginia (One Call)	800-552-7001	not available	Public utility mark-outs in Southern Virginia
Miss Utility of Virginia	800-257-7777 800-552-7007	www.missutilityofvirginia.com	General information on public utility mark-outs in Virginia, with links to Miss Utility of DELMARVA and Miss Utility of Southern Virginia (One Call)
Miss Utility of West Virginia, Inc	800-245-4848	none	Call to determine what utilities they work with in West Virginia
North Carolina One Call Center	800-632-4949	www.ncocc.org/ncocc/default.htm	Public Utility Markouts in North Carolina

Private Subcontractors

- Utility-locating support is required at some level for most all CH2M HILL field projects in "clearing" proposed subsurface boring locations on the project site. Utility location and sample clearance can include a comprehensive effort of GIS map interpretation, professional land surveying, field locating, and geophysical surveying. Since we can usually provide our own GIS-related services for projects and our professional land surveying services are normally procured separately, utility-locating subcontractors will normally only be required for some level of geophysical surveying support in the field. This level of geophysical surveying support can range widely from a simple electromagnetic (EM) survey over a known utility line, to a blind geophysical effort, including a ground-penetrating radar (GPR) survey and/or a comprehensive EM survey to delineate and characterize all unknown subsurface anomalies.

The level of service required from the subcontractor will vary depending on the nature of the site. At sites where utility locations are well defined on the maps and recent construction is limited, CH2M HILL may be confident with a limited effort from a traditional utility-locating subcontractor providing a simple EM survey. At sites where utility locations are not well defined, where recent constructions may have altered utility locations, or the nature of the site makes utility location difficult,

CH2M HILL will require the services of a comprehensive geophysical surveying subcontractor, with a wide range of GPR and EM services available for use on an "as-needed" basis. Typical costs for geophysical surveying subcontractors will range from approximately \$200 per day for a simple EM effort (usually one crew member and one instrument) to approximately \$1,500 per day for a comprehensive geophysical surveying effort (usually a two-person crew and multiple instruments). Comprehensive geophysical surveying efforts may also include field data interpretation (and subsequent report preparation) and non-destructive excavation to field-verify utility depths and locations.

The following table provides a list of recommended geophysical surveying support subcontractors that can be used for utility-locating services:

Company Name and Address	Contact Name and Phone Number	Equipment ¹					Other Services ²		
		1	2	3	4	5	A	B	C
US Radar, Inc.* PO Box 319 Matawan, NJ 07747	Ron LaBarca 732-566-2035			4					
Utilities Search, Inc.*	Jim Davis 703-369-5758	4				4	4	4	4
So Deep, Inc.* 8397 Euclid Avenue Manassas Park, VA 20111	703-361-6005	4					4	4	4
Accurate Locating, Inc. 1327 Ashton Rd., Suite 101 Hanover, MD 21076	Ken Shipley 410-850-0280	4	4						
NAEVA Geophysics, Inc. P.O. Box 7325 Charlottesville, VA 22906	Alan Mazurowski 434-978-3187	4	4	4	4	4	4	4	4
Earth Resources Technology, Inc. 8106 Stayton Rd. Jessup, MD 20794	Peter Li 240-554-0161	4	4	4	4	4	4	4	
Geophex, Ltd 605 Mercury Street Raleigh, NC 27603	I. J. Won 919-839-8515	4	4	4	4	4	4	4	4

Notes:

*Companies denoted with an asterisk have demonstrated reluctance to assume responsibility for damage to underground utilities or an inability to accommodate the insurance requirements that CH2M HILL requests for this type of work at many Navy sites.

¹Equipment types are:

1. Simple electromagnetic instruments, usually hand-held
2. Other, more innovative, electromagnetic instruments, including larger instruments for more area coverage
3. Ground-penetrating radar systems of all kinds
4. Audio-frequency detectors of all kinds
5. Radio-frequency detectors of all kinds

²Other services include:

- A. Data interpretation and/or report preparation to provide a permanent record of the geophysical survey results and a professional interpretation of the findings, including expected accuracy and precision.
- B. Non-destructive excavation to field-verify the depths, locations, and types of subsurface utilities.
- C. Concrete/asphalt coring and pavement/surface restoration.

Attachment C – Equipment Used for Identifying Underground Utilities

This attachment provides a summary of the various types of equipment used for subsurface utility location. It describes the capabilities and limitations of each in order to help the AM and PM determine if the equipment being proposed by a subcontractor or Navy is adequate. A list of in-house experts that can be used to answer questions you may have is provided below.

CH2M HILL In-house Utility Location Experts

Tamir Klaff/WDC

Home Office Phone – 703-669-9611

Electromagnetic Induction (EMI) Methods

EMI instruments, in general, induce an electromagnetic field into the ground (the primary field) and then record the response (the secondary field), if any. Lateral changes in subsurface conductivity, such as caused by the presence of buried metal or by significant soil variations, cause changes in the secondary field recorded by the instrument and thus enable detection and mapping of the subsurface features. It should be noted that EMI only works for electrically conductive materials--plastic or PVC pipes are generally not detected with EMI. Water and gas lines are commonly plastic, although most new lines include a copper “locator” strip on the top of the PVC to allow for detection with EMI.

EMI technology encompasses a wide range of instruments, each with inherent strengths and weaknesses for particular applications. One major division of EMI is between “time-domain” and “frequency-domain” instruments that differ in the aspect of the secondary field they detect. Another difference in EMI instruments is the operating frequency they use to transmit the primary field. Audio- and radio-frequencies are often used for utility detection, although other frequencies are also used. Consideration of the type of utility expected, surface features that could interfere with detection, and the “congestion” of utilities in an area, should be made when choosing a particular EMI instrument for a particular site.

One common EMI tool used for utility location is a handheld unit that can be used to quickly scan an area for utilities and allows for marking locations in “real time”. This method is most commonly used by “dig-safe” contractors marking out known utilities prior to excavation. It should be noted that this method works best when a signal (the primary field) can be placed directly onto the line (i.e., by clamping or otherwise connecting to the end of the line visible at the surface, or for larger utilities such as sewers, by running a transmitter through the utility). These types of tools also have a limited capability to scan an area for unknown utilities. Usually this requires having enough area to separate a hand held transmitter at least a hundred feet from the

receiver. Whether hunting for unknown, or confirming known, utilities, this method will only detect continuous lengths of metallic conductors.

In addition to the handheld EMI units, larger, more powerful EMI tools are available that provide more comprehensive detection and mapping of subsurface features. Generally, data with these methods are collected on a regular grid in the investigation area, and are then analyzed to locate linear anomalies that can be interpreted as utilities. These methods will usually detect *all* subsurface metal (above a minimum size), including pieces of abandoned utilities. In addition, in some situations, backfill can be detected against native soils giving information on trenching and possible utility location. Drawbacks to these methods are that the secondary signals from utilities are often swamped (i.e., undetectable) close to buildings and other cultural features, and that the subsurface at heavily built-up sites may be too complicated to confidently interpret completely.

Hand-held metal detectors (treasure-finders) are usually based on EMI technology. They can be used to locate shallow buried metal associated with utilities (e.g., junctions, manholes, metallic locators). Advantages of these tools is the ease of use and real-time marking of anomalies. Drawbacks include limited depths of investigations and no data storage capacity.

Ground Penetrating Radar (GPR)

GPR systems transmit radio and microwave frequency (e.g., 80 megaHertz to 1,000 megaHertz) waves into the ground and then record reflections of those waves coming back to the surface. Reflections of the radar waves typically occur at lithologic changes, subsurface discontinuities, and subsurface structures. Plastic and PVC pipes can sometimes be detected in GPR data, especially if they are shallow, large, and full of a contrasting material such as air in a wet soil, or water in a dry soil. GPR data are usually collected in regular patterns over an area and then analyzed for linear anomalies that can be interpreted as utilities. GPR is usually very accurate in x-y location of utilities, and can be calibrated at a site to give very accurate depth information as well. A significant drawback to GPR is that depth of investigation is highly dependant on background soil conductivity, and it will not work on all sites. It is not uncommon to get only 1-2 feet of penetration with the signal in damp, clayey environments. Another drawback to GPR is that sites containing significant fill material (e.g., concrete rubble, scrap metal, garbage) will result in complicated anomalies that are difficult or impossible to interpret.

Magnetic Field Methods

Magnetic field methods rely on detecting changes to the earth's magnetic field caused by ferrous metal objects. This method is usually more sensitive to magnetic metal (i.e., deeper detection) than EMI methods. A drawback to this method is it is more susceptible to being swamped by surface features such as fences and cars. In addition, procedures must usually be implemented that account for natural variations in the earth's background field as it changes throughout the day. One common use of the method is to measure and analyze the gradient of the magnetic field, which eliminates most of the drawbacks to the method. It should be noted this method only detects

ferrous metal, primarily iron and steel for utility location applications. Some utility detector combine magnetic and EMI methods into a single hand-held unit.

Optical Methods

Down the hole cameras may be useful in visually reviewing a pipe for empty conduits and/or vaults.

Attachment D – Utility Clearance Documentation Form

Attachment E – Utility Marking Color Codes

The following is the standard color code used by industry to mark various types of utilities and other features at a construction site.

White – Proposed excavations and borings

Pink – Temporary survey markings

Red – Electrical power lines, cables, conduits and lighting cables

Yellow – Gas, oil, steam, petroleum or gaseous materials

Orange – Communication, alarm or signal lines, cables, or conduits

Blue – Potable water

Purple – Reclaimed water, irrigation and slurry lines

Green – Sewer and storm drain lines

VOC Sampling-Water

I. Purpose

To provide general guidelines for sampling aqueous volatile organic compounds.

II. Scope

Standard techniques for collecting representative samples are summarized. Site-specific details are discussed in the Field Sampling Plan.

III. Equipment and Materials

- Sample vials pre-preserved at laboratory with hydrochloric acid (HCl)
- Surgical or latex gloves

IV. Procedures and Guidelines

1. Sample VOCs before sampling other analyte groups.
2. When sampling for VOCs, especially residential wells, evaluate the area around the sampling point for possible sources of air contamination by VOCs. Products that may give off VOCs and possibly contaminate a sample include perfumes and cosmetics, skin applied pharmaceuticals, automotive products (gasoline, starting fluid, windshield deicers, carburetor cleaners, etc.) and household paint products (paint strippers, thinners, turpentine, etc.).
3. Keep the caps off the sample vials for as short a time as possible.
4. Wear clean latex or surgical gloves.
5. Fill the sample vial immediately, allowing the water stream to strike the inner wall of the vial to minimize formation of air bubbles. **DO NOT RINSE THE SAMPLE VIALS BEFORE FILLING.**
6. Fill the sample vial with a minimum of turbulence, until the water forms a positive meniscus at the brim.
7. Replace the cap by gently setting it on the water meniscus. Tighten firmly, but **DO NOT OVERTIGHTEN.**

8. Invert the vial and tap it lightly. If you see air bubbles in the sample, do not add more sample. Use another vial to collect another sample. Repeat if necessary until you obtain a proper sample.

V. Attachments

None.

VI. Key Checks and Items

- Check for possible sources of contamination.
- Fill slowly, with as little turbulence as possible.
- Check for air bubbles.

Water-Level Measurements

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for the measurement of the depth to groundwater in piezometers and monitoring wells, even where a second phase of floating liquid (e.g., gasoline) is encountered, and on staff gages in surface-water bodies. This SOP includes guidelines for discrete measurements of static water levels and does not cover the use of continuously recording loggers (see SOP *Use of Data Loggers and Pressure Transducers*).

II. Equipment and Materials

- Electronic water-level meter (Solinst® or equivalent) with a minimum 100-foot tape; the tape should have graduations in increments of 0.01 feet or less
- Interface probe (Solinst® Model 122 Interface Meter or equivalent)

III. Procedures and Guidelines

Verify that the unit is turned on and functioning properly. Slowly lower the probe on its cable into the piezometer or well until the probe just contacts the water surface; the unit will respond with a tone or light signal. Note the depth from a reference point indicated on the piezometer or well riser. Typically this is the top of the PVC casing. If no reference is clearly visible, measure the depth to water from the northern edge of the PVC casing. If access to the top of the PVC casing is difficult, sight across the top of the locking casing adjacent to the measuring point, recording the position of the cable when the probe is at the water surface.

Measure the distance from this point to the closest interval marker on the tape, and record the water level reading in the logbook. Water levels will be measured to the nearest 0.01-foot. Also when specified in the project plans, measure and record the depth of the piezometer or well. The depth of the piezometer or well may be measured using the water-level probe with the instrument turned off.

Free product light or dense nonaqueous phase liquid may be present in the piezometer or well. If the presence of free product is suspected, the thickness of the product should be determined using appropriate equipment (e.g., Solinst® Model 122 Interface Meter). The depth to water also is determined with this equipment and the water-level meter should not be used in the piezometer or well as long as product is present. Typically, a constant sound is emitted from the device when free product is encountered and an alternating on/off beep sound is emitted when water is encountered.

The apparent elevation of the water level in the well or piezometer is determined by measuring both the apparent depth to water and the thickness of free product. The corrected water-level elevation is calculated by the following equation:

$$WL_c = WL_a + (\text{Free-product thickness} \times 0.80)$$

Where WL_c = Corrected water-level elevation

WL_a = Apparent water-level elevation

0.80 = Typical value for the density of petroleum hydrocarbon products.

If free product is detected on the surface of the water in the piezometer or well, the value of sampling should be reconsidered because of the potential for contaminating the sampling equipment.

Staff gages may be installed in some surface-water bodies. These facilities typically are constructed by attaching a calibrated, marked staff gage to a wood or metal post, driving the post into the bottom of the surface-water body, and surveying the elevation of the top of the post to a resolution or 0.01-foot. The elevation of the water in the surface-water body then can be determined by reading off the distance the water level is from the top of the post. A shield or other protection may be needed to calm the fluctuations in water level if the gage is installed at a location exposed to wind or wave.

IV. Attachments

None.

V. Key Checks

- Before each use, verify that the battery is charged by pressing the test button on the water-level meter.
- Verify that the unit is operating correctly by testing the probe in distilled or de-ionized water. Leave the unit turned off when not in use.

Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, ORP, and Temperature Using a Horiba or YSI Water Quality Parameter Meter with Flow-through Cell

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for using a water quality parameter meter (e.g., Horiba® or YSI) for field measurements of pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature of aqueous samples. The YSI instrument does not measure turbidity. A separate turbidity meter (i.e., Hanna Turbidity Meter) will need to be used in conjunction with the YSI meter. The operator's manual should be consulted for detailed operating procedures.

II. Equipment and Materials

- Water Quality Parameter Meter such as a Horiba® Water Quality Monitoring System or YSI with flow-through cell
- Auto-Calibration Standard Solution (provided by rental company)
- Distilled water in squirt bottle

III. Procedures and Guidelines

A. Parameters and Specifications:

<u>Parameter</u>	<u>Range of measurement</u>	<u>Accuracy</u>
pH	0 to 14 pH units	+/- 0.1 pH units
Specific conductance	0 to 9.99 S/m	+/- 3 % full scale
Turbidity	0 to 800 NTU	+/- 5 % full scale
Dissolved oxygen	0 to 19.99 mg/l	+/- 0.2 mg/l
Temperature	0 to 55 °C	+/- 1.0 °C
ORP	-999 to +999 mV	+/- 15 mV
Salinity	0 to 4 %	+/- 0.3 %

B. Calibration:

Prior to each day's use, clean the probe and flow-through cell using deionized water and calibrate using the Standard Solution.

Horiba Calibration procedure:

1. Fill a calibration beaker with standard solution to the recommended fill line.
2. Insert the probe into the beaker. All the parameter sensors will now be immersed in the standard solution except the D.O. sensor; the D.O. calibration is done using atmospheric air.
3. Turn power on and allow some time for the machine to warm-up prior to starting the calibration. When the initial readings appear to stabilize the instrument is ready to calibrate.
4. Press CAL key to put the unit in the calibration mode.
5. Press the ENT key to start automatic calibration. Wait a moment, and the upper cursor will gradually move across the four auto-calibration parameters one by one: pH, COND, TURB, and DO. When the calibration is complete, the readout will briefly show END. The instrument is now calibrated.
6. If the unit is calibrated properly the instrument readings, while immersed in the standard solution, will match the standard solution values provided on the solution container. The typical standard solution values are: pH = 4.0 +/- 3%, conductivity 4.49 mS/cm +/- 3%, and turbidity = 0 NTU +/- 3%.
7. Record the calibration data (e.g. time, instrument ID, solution lot number and expiration date, final calibrated readings, and solution temperature in the field logbook.

YSI Calibration procedure:

1. Press the **On/off** key to display the run screen
2. Press the **Escape** key to display the main menu screen
3. Use the arrow keys to highlight the **Calibrate**
4. Press the **Enter** key. The Calibrate screen is displayed
5. Choose the parameter to calibrate

A. Conductivity Calibration:

This procedure calibrates specific conductance (recommended), conductivity and salinity. Calibrating any one option automatically calibrates the other two.

- 1) Use the arrow keys to highlight the **Conductivity** selection
- 2) Press **Enter**. The Conductivity Calibration Selection Screen is displayed.
- 3) Use the arrow keys to highlight the Specific Conductance selection.
- 4) Press **Enter**. The Conductivity Calibration Entry Screen is displayed.
- 5) Place the correct amount of conductivity standard (see Instrument Manual) into a clean, dry or pre-rinsed transport/calibration cup.
- 6) Carefully immerse the sensor end of the probe module into the solution.
- 7) Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.

NOTE: The sensor must be completely immersed past its vent hole. Using the recommended volumes from the Instrument Manual Calibration Volumes should ensure that the vent hole is covered.

- 8) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.
NOTE: Do not over tighten as this could cause damage to the threaded portions.
- 9) Use the keypad to enter the calibration value of the standard you are using.
NOTE: Be sure to enter the value in **mS/cm at 25°C**.
- 10) Press **Enter**. The Conductivity Calibration Screen is displayed.
- 11) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
- 12) Observe the reading under Specific Conductance. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
- 13) Press **Enter**. This returns you to the Conductivity Calibrate Selection Screen
- 14) Press **Escape** to return to the calibrate menu.
- 15) Rinse the probe module and sensors in tap or purified water and dry.

B. Dissolved Oxygen Calibration:

This procedure calibrates dissolved oxygen. Calibrating any one option (% or mg/L) automatically calibrates the other.

- 1) Go to the calibrate screen as described in Section
NOTE: The instrument must be on for at least 20 minutes to polarize the DO sensor before calibrating.
- 2) Use the arrow keys to highlight the **Dissolved Oxygen** selection.
- 3) Press **Enter**. The dissolved oxygen calibration screen is displayed.
- 4) DO calibration in mg/L is carried out in a water sample which has a known concentration of dissolved oxygen (usually determined by a Winkler titration).
- 5) Use the arrow keys to highlight the **DO mg/L** selection.
- 6) Press **Enter**. The DO mg/L Entry Screen is displayed.
- 7) Place the probe module in water with a known DO concentration.
NOTE: Be sure to completely immerse all the sensors.
- 8) Use the keypad to enter the known DO concentration of the water.
- 9) Press **Enter**. The Dissolved Oxygen mg/L Calibration Screen is displayed.
- 10) Stir the water with a stir bar, or by rapidly moving the probe module, to provide fresh sample to the DO sensor.
- 11) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
- 12) Observe the DO mg/L reading, when the reading is stable (shows no significant change for approximately 30 seconds), press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
- 13) Press **Enter**. This returns you to the DO calibration screen.
- 14) Press **Escape** to return to the calibrate menu.
- 15) Rinse the probe module and sensors in tap or purified water and dry.

C. pH Calibration:

- 1) Go to the calibrate screen.
- 2) Use the arrow keys to highlight the **pH** selection.
- 3) Press **Enter**. The pH calibration screen is displayed.

- Select the **1-point** option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by carrying out a one point calibration. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select only one pH buffer.
 - Select the **2-point** option to calibrate the pH sensor using only two calibration standards. Use this option if the media being monitored is known to be either basic or acidic. For example, if the pH of a pond is known to vary between 5.5 and 7, a two-point calibration with pH 7 and pH 4 buffers is sufficient. A three point calibration with an additional pH 10 buffer will not increase the accuracy of this measurement since the pH is not within this higher range.
 - Select the **3-point** option to calibrate the pH sensor using three calibration solutions. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select a third pH buffer.
- 4) Use the arrow keys to highlight the **2-point** selection.
 - 5) Press **Enter**. The pH Entry Screen is displayed.
 - 6) Place the correct amount of pH buffer into a clean, dry or pre-rinsed transport/calibration cup.
 - NOTE:** For maximum accuracy, the pH buffers you choose should be within the same pH range as the water you are preparing to sample.
 - NOTE:** Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the pH sensor with a small amount of buffer that can be discarded. Be certain that you avoid cross-contamination of buffers with other solutions.
 - 7) Carefully immerse the sensor end of the probe module into the solution.
 - 8) Gently rotate and/or move the probe module up and down to remove any bubbles from the pH sensor.
 - NOTE:** The sensor must be completely immersed. Using the recommended volumes from Table 6.1 Calibration Volumes, should ensure that the sensor is covered.
 - 9) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.
 - NOTE:** Do not over tighten as this could cause damage to the threaded portions.
 - 10) Use the keypad to enter the calibration value of the buffer you are using **at the current temperature**.
 - NOTE:** pH vs. temperature values are printed on the labels of all YSI pH buffers.
 - 11) Press **Enter**. The pH calibration screen is displayed.
 - 12) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
 - 13) Observe the reading under pH, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
 - 14) Press **Enter**. This returns you to the Specified pH Calibration Screen.

- 15) Rinse the probe module, transport/calibration cup and sensors in tap or purified water and dry.
- 16) Repeat steps 6 through 13 above using a second pH buffer.
- 17) Press **Enter**. This returns you to the pH Calibration Screen.
- 18) Press **Escape** to return to the calibrate menu.
- 19) Rinse the probe module and sensors in tap or purified water and dry.

D. *ORP Calibration:*

- 1) Go to the calibrate screen.
- 2) Use the arrow keys to highlight the **ORP** selection.
- 3) Press **Enter**. The ORP calibration screen is displayed.
- 4) Place the correct amount of a known ORP solution into a clean, dry or pre-rinsed transport/calibration cup.

NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the ORP sensor with a small amount of solution that can be discarded. Be certain that you avoid cross-contamination with other solutions.
- 5) Carefully immerse the sensor end of the probe module into the solution.
- 6) Gently rotate and/or move the probe module up and down to remove any bubbles from the ORP sensor.

NOTE: The sensor must be completely immersed.
- 7) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.
- 8) Use the keypad to enter the correct value of the calibration solution you are using at the current temperature.
- 9) Press **Enter**. The ORP calibration screen is displayed.
- 10) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
- 11) Observe the reading under ORP, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
- 12) Press **Enter**. This returns you to the Calibrate Screen.
- 13) Rinse the probe module and sensors in tap or purified water and dry. Record the calibration data (e.g. time, instrument ID, solution lot number and expiration date, final calibrated readings, and solution temperature in the field logbook.

C. **Sample Measurement:**

Horiba measurement procedure:

As water passes through the flow-through the flow cell, press MEAS to obtain reading; record data in a field notebook.

YSI measurement procedure:

As water passes through the flow-through the flow cell, the readings are displayed for each parameter. Record the water quality parameter data in a field notebook. In addition, the data is recorded in the YSI and can be downloaded to a computer following completion of the sampling event.

IV. Key Checks and Preventive Maintenance

- Calibrate meter
- Clean probe with deionized water when done
- Refer to operations manual for recommended maintenance and troubleshooting
- Check batteries, and have a replacement set on hand
- Due to the importance of obtaining these parameters, the field team should have a spare unit readily available in case of an equipment malfunction.

V. References

YSI 556 Multi Probe System Operator Manual

Appendix B
Laboratory Department of Defense
Environmental Laboratory Accreditation Letters

Scope of Accreditation For Katahdin Analytical Services, Inc.

600 Technology Way
Scarborough, ME 04074
Leslie Dimond
207-874-2400

In recognition of a successful assessment to ISO/IEC 17025:2005 and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM v4.2) based on the National Environmental Laboratory Accreditation Conference Chapter 5 Quality Systems Standard (NELAC Voted Revision June 5, 2003), accreditation is granted to Katahdin Analytical Services to perform the following tests:

Accreditation granted through: February 1, 2016

Testing - Environmental

Non-Potable Water		
Technology	Method	Analyte
GC/ECD	EPA 8081B	2, 4'-DDD
GC/ECD	EPA 8081B	2, 4'-DDE
GC/ECD	EPA 8081B	2, 4'-DDT
GC/ECD	EPA 608; EPA 8081B	4, 4'-DDD
GC/ECD	EPA 608; EPA 8081B	4, 4'-DDE
GC/ECD	EPA 608; EPA 8081B	4, 4'-DDT
GC/ECD	EPA 608; EPA 8081B	Aldrin
GC/ECD	EPA 608; EPA 8081B	alpha-BHC (alpha-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	Alpha-Chlordane
GC/ECD	EPA 608; EPA 8081B	beta-BHC (beta-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	Cis-Nonaclor
GC/ECD	EPA 608; EPA 8081B	Chlordane (tech.)
GC/ECD	EPA 608; EPA 8081B	delta-BHC
GC/ECD	EPA 608; EPA 8081B	Dieldrin
GC/ECD	EPA 608; EPA 8081B	Endosulfan I
GC/ECD	EPA 608; EPA 8081B	Endosulfan II

Non-Potable Water		
Technology	Method	Analyte
GC/ECD	EPA 608; EPA 8081B	Endosulfan sulfate
GC/ECD	EPA 608; EPA 8081B	Endrin
GC/ECD	EPA 608; EPA 8081B	Endrin aldehyde
GC/ECD	EPA 8081B	Endrin Ketone
GC/ECD	EPA 8081B	gamma-BHC (Lindane gamma-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	gamma-Chlordane
GC/ECD	EPA 608; EPA 8081B	Heptachlor
GC/ECD	EPA 608; EPA 8081B	Heptachlor epoxide
GC/ECD	EPA 8081B	Hexachlorobenzene
GC/ECD	EPA 8081B	Methoxychlor
GC/ECD	EPA 8081B	Mirex
GC/ECD	EPA 8081B	Oxychlordane
GC/ECD	EPA 608; EPA 8081B	Toxaphene (Chlorinated camphene)
GC/ECD	EPA 8081B	trans-Nonachlor
GC/ECD	EPA 608; EPA 8082A	Aroclor-1016 (PCB-1016)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1221 (PCB-1221)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1232 (PCB-1232)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1242 (PCB-1242)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1248 (PCB-1248)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1254 (PCB-1254)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1260 (PCB-1260)
GC/ECD	EPA 8082A MOD	Aroclor-1262 (PCB-1262)
GC/ECD	EPA 8082A MOD	Aroclor-1268 (PCB-1268)
GC/ECD	EPA 8082A	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (BZ 206)
GC/ECD	EPA 8082A	2,2',3,3',4,4',5,6-Octachlorobiphenyl (BZ 195)
GC/ECD	EPA 8082A	2,2',3,3',4,4',5-Heptachlorobiphenyl (BZ 170)
GC/ECD	EPA 8082A	2,2',3,3',4,4'-Hexachlorobiphenyl (BZ 128)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 5, 5'-Heptachlorobiphenyl (BZ 180)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 5', 6-Heptachlorobiphenyl (BZ 183)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 5-Hexachlorobiphenyl (BZ 138)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 6, 6'-Heptachlorobiphenyl (BZ 184)

Non-Potable Water		
Technology	Method	Analyte
GC/ECD	EPA 8082A	2, 2', 3, 4', 5, 5', 6-Heptachlorobiphenyl (BZ 187)
GC/ECD	EPA 8082A	2, 2', 3, 4, 5'-Pentachlorobiphenyl (BZ 87)
GC/ECD	EPA 8082A	2, 2', 3, 5'-Tetrachlorobiphenyl (BZ 44)
GC/ECD	EPA 8082A	2, 2', 4, 4', 5, 5'-Hexachlorobiphenyl (BZ 153)
GC/ECD	EPA 8082A	2, 2', 4, 5, 5'-Pentachlorobiphenyl (BZ 101)
GC/ECD	EPA 8082A	2, 2', 4, 5-Tetrachlorobiphenyl (BZ 48)
GC/ECD	EPA 8082A	2, 2', 4, 5'-Tetrachlorobiphenyl (BZ 49)
GC/ECD	EPA 8082A	2, 2', 5, 5'-Tetrachlorobiphenyl (BZ 52)
GC/ECD	EPA 8082A	2, 2', 5-Trichlorobiphenyl (BZ 18)
GC/ECD	EPA 8082A	2, 3, 3', 4, 4', 5-Hexachlorobiphenyl (BZ 156)
GC/ECD	EPA 8082A	2, 3, 3', 4, 4', 5'-Hexachlorobiphenyl (BZ 157)
GC/ECD	EPA 8082A	2, 3, 3', 4, 4'-Pentachlorobiphenyl (BZ 105)
GC/ECD	EPA 8082A	2, 3, 3', 4, 4', 5, 5'-Heptachlorobiphenyl (BZ 189)
GC/ECD	EPA 8082A	2, 3', 4, 4', 5, 5'-Hexachlorobiphenyl (BZ 167)
GC/ECD	EPA 8082A	2, 3', 4, 4', 5-Pentachlorobiphenyl (BZ 118)
GC/ECD	EPA 8082A	2, 3', 4, 4',5'-Pentachlorobiphenyl (BZ 123)
GC/ECD	EPA 8082A	2, 3', 4, 4'-Tetrachlorobiphenyl (BZ 66)
GC/ECD	EPA 8082A	2, 3, 4, 4', 5-Pentachlorobiphenyl (BZ 114)
GC/ECD	EPA 8082A	2, 4, 4'-Trichlorobiphenyl (BZ 28)
GC/ECD	EPA 8082A	2, 4'-Dichlorobiphenyl (BZ 8)
GC/ECD	EPA 8082A	3, 3', 4, 4', 5, 5'-Hexachlorobiphenyl (BZ 169)
GC/ECD	EPA 8082A	3, 3', 4, 4', 5-Pentachlorobiphenyl (BZ 126)
GC/ECD	EPA 8082A	3, 3', 4, 4'-Tetrachlorobiphenyl (BZ 77)
GC/ECD	EPA 8082A	3, 4, 4', 5-Tetrachlorobiphenyl (BZ 81)
GC/ECD	EPA 8082A	Decachlorobiphenyl (BZ 209)
GC/ECD	EPA 8151A	2, 4, 5-T
GC/ECD	EPA 8151A	2, 4-D
GC/ECD	EPA 8151A	2, 4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichloroprop

Non-Potable Water		
Technology	Method	Analyte
GC/ECD	EPA 8151A	Dinoseb
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPPP
GC/ECD	EPA 8151A	Pentachlorophenol
GC/ECD	EPA 8151A	Silvex (2, 4, 5-TP)
GC/FID	EPA 8015C/D MOD	Diesel range organics (DRO)
GC/FID	EPA 8015C/D MOD	Total Petroleum Hydrocarbon (TPH)
GC/FID	EPA 8015C/D MOD	Gasoline range organics (GRO)
GC/FID/PID	MA DEP VPH	Volatile Organic Hydrocarbons
GC/FID	MA DEP EPH	Extractable Petroleum Hydrocarbons
GC/FID	CT ETPH	Total Petroleum Hydrocarbons
GC/FID	TNRCC Method 1005	Total Petroleum Hydrocarbons
GC/FID	FL-PRO	Petroleum Range Organics
GC/ECD	EPA 8011; EPA 504	1, 2-Dibromoethane (EDB)
GC/ECD	EPA 8011; EPA 504	1, 2-Dibromo-3-chloropropane
GC/FID	RSK-175	Methane Ethane Ethene
GC/MS	EPA 8260B/C; EPA 524.2	1, 1, 1, 2-Tetrachloroethane
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	1, 1, 1-Trichloroethane
GC/MS	EPA 624; 8260B/C; EPA 524.2	1, 1, 2, 2-Tetrachloroethane
GC/MS	EPA 8260B/C	1,1,2-Trichloro-1,2,2-trifluoroethane
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	1, 1, 2-Trichloroethane
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	1, 1-Dichloroethane
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	1, 1-Dichloroethene
GC/MS	EPA 8260B/C; EPA 524.2	1, 1-Dichloropropene
GC/MS	EPA 8260B/C; EPA 524.2	1, 2, 3-Trichlorobenzene
GC/MS	EPA 8260B/C; EPA 524.2	1, 2, 3-Trichloropropane
GC/MS	EPA 8260B/C	1,2,3-Trimethylbenzene
GC/MS	EPA 8260B/C; EPA 524.2	1, 2, 4-Trichlorobenzene
GC/MS	EPA 8260B/C; EPA 524.2	1, 2, 4-Trimethylbenzene

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8260B/C; EPA 524.2	1, 2-Dibromo-3-chloropropane
GC/MS	EPA 8260B/C; EPA 524.2	1, 2-Dibromoethane (EDB)
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	1, 2-Dichlorobenzene
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	1, 2-Dichloroethane
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	1, 2-Dichloropropane
GC/MS	EPA 8260B/C	1,3,5-Trichlorobenzene
GC/MS	EPA 8260B/C; EPA 524.2	1, 3, 5-Trimethylbenzene
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	1, 3-Dichlorobenzene
GC/MS	EPA 8260B/C; EPA 524.2	1, 3-Dichloropropane
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	1, 4-Dichlorobenzene
GC/MS	EPA 8260B/C	1, 4-Dioxane
GC/MS	EPA 8260B/C	1-Chlorohexane
GC/MS	EPA 8260B/C; EPA 524.2	2, 2-Dichloropropane
GC/MS	EPA 8260B/C; EPA 524.2	2-Butanone
GC/MS	EPA 624; EPA 8260B/C	2-Chloroethyl vinyl ether
GC/MS	EPA 8260B/C; EPA 524.2	2-Chlorotoluene
GC/MS	EPA 8260B/C; EPA 524.2	2-Hexanone
GC/MS	EPA 8260B/C; EPA 524.2	4-Chlorotoluene
GC/MS	EPA 8260B/C; EPA 524.2	4-Methyl-2-pentanone
GC/MS	EPA 8260B/C; EPA 524.2	Acetone
GC/MS	EPA 8260B/C	Acetonitrile
GC/MS	EPA 624; EPA 8260B/C	Acrolein
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Acrylonitrile
GC/MS	EPA 8260B/C; EPA 524.2	Allyl chloride
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Benzene
GC/MS	EPA 8260B/C	Benzyl chloride
GC/MS	EPA 8260B/C; EPA 524.2	Bromobenzene
GC/MS	EPA 8260B/C; EPA 524.2	Bromochloromethane

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Bromodichloromethane
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Bromoform
GC/MS	EPA 8260B/C; EPA 524.2	Carbon disulfide
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Carbon tetrachloride
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Chlorobenzene
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Chloroethane
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Chloroform
GC/MS	EPA 8260B/C	Chloroprene
GC/MS	EPA 8260B/C; EPA 524.2	cis-1, 2-Dichloroethene
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	cis-1, 3-Dichloropropene
GC/MS	EPA 8260B/C	Cis-1,4-Dichloro-2-butene
GC/MS	EPA 8260B/C	Cyclohexane
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Dibromochloromethane
GC/MS	EPA 8260B/C; EPA 524.2	Dibromomethane
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Dichlorodifluoromethane
GC/MS	EPA 8260B/C; EPA 524.2	Diethyl ether
GC/MS	EPA 8260B/C	Di-isopropylether
GC/MS	EPA 8260B/C; EPA 524.2	Ethyl methacrylate
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Ethylbenzene
GC/MS	EPA 8260B/C	Ethyl-t-butylether
GC/MS	EPA 8260B/C; EPA 524.2	Hexachlorobutadiene
GC/MS	EPA 8260B/C	Iodomethane
GC/MS	EPA 8260B/C	Isobutyl alcohol
GC/MS	EPA 8260B/C	Isopropyl alcohol
GC/MS	EPA 8260B/C; EPA 524.2	Isopropyl benzene
GC/MS	EPA 8260B/C; EPA 524.2	m p-xylenes
GC/MS	EPA 8260B/C	Methyl acetate

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8260B/C; EPA 524.2	Methacrylonitrile
GC/MS	EPA 624 / 8260B,C	Methyl bromide (Bromomethane)
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Methyl chloride (Chloromethane)
GC/MS	EPA 8260B/C; EPA 524.2	Methyl methacrylate
GC/MS	EPA 8260B/C; EPA 524.2	Methyl tert-butyl ether
GC/MS	EPA 8260B/C	Methylcyclohexane
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Methylene chloride
GC/MS	EPA 8260B/C; EPA 524.2	Naphthalene
GC/MS	EPA 8260B/C; EPA 524.2	n-Butylbenzene
GC/MS	EPA 8260B/C; EPA 524.2	n-Propylbenzene
GC/MS	EPA 8260B/C; EPA 524.2	o-Xylene
GC/MS	EPA 8260B/C	Pentachloroethane
GC/MS	EPA 8260B/C; EPA 524.2	p-Isopropyltoluene
GC/MS	EPA 8260B/C; EPA 524.2	Propionitrile
GC/MS	EPA 8260B/C; EPA 524.2	sec-butylbenzene
GC/MS	EPA 8260B/C; EPA 524.2	Styrene
GC/MS	EPA 8260B/C	t-Amylmethylether
GC/MS	EPA 8260B/C; EPA 524.2	tert-Butyl alcohol
GC/MS	EPA 8260B/C	tert-Butylbenzene
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Tetrachloroethene (Perchloroethylene)
GC/MS	EPA 8260B/C; EPA 524.2	Tetrahydrofuran
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Toluene
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	trans-1, 2-Dichloroethylene
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	trans-1, 3-Dichloropropylene
GC/MS	EPA 8260B/C; EPA 524.2	trans-1, 4-Dichloro-2-butene
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Trichloroethene (Trichloroethylene)
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Trichlorofluoromethane
GC/MS	EPA 8260B/C	Vinyl acetate

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 624; EPA 8260B/C; EPA 524.2	Vinyl chloride
GC/MS	EPA 624 / 8260B,C	Xylene
GC/MS	EPA 8260B/C SIM	1,1,1,2-Tetrachloroethane
GC/MS	8260B, C SIM	1,1,1-Trichloroethane
GC/MS	EPA 8260B/C SIM	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B/C SIM	1, 1, 2-Trichloroethane
GC/MS	EPA 8260B/C SIM	1,2,3-Trichloropropane
GC/MS	EPA 8260B/C SIM	1,1-Dichloroethane
GC/MS	EPA 8260B/C SIM	1,1-Dichloroethene
GC/MS	EPA 8260B/C SIM	1,2,4-Trichlorobenzene
GC/MS	EPA 8260B/C SIM	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B/C SIM	1,2-Dibromo-3-chloropropane
GC/MS	EPA 8260B/C SIM	1,2-Dibromoethane
GC/MS	EPA 8260B/C SIM	1,2-Dichlorobenzene
GC/MS	EPA 8260B/C SIM	1,2-Dichloroethane
GC/MS	EPA 8260B/C SIM	1,2-Dichloropropane
GC/MS	EPA 8260B/C SIM	1,3-Dichlorobenzene
GC/MS	EPA 8260B/C SIM	1,3-Dichloropropane
GC/MS	EPA 8260B/C SIM	1,4-Dichlorobenzene
GC/MS	EPA 8260B/C SIM	2-Hexanone
GC/MS	EPA 8260B/C SIM	4-Methyl-2-pentanone
GC/MS	EPA 8260B/C SIM	Benzene
GC/MS	EPA 8260B/C SIM	Bromodichloromethane
GC/MS	EPA 8260B/C SIM	Carbon Tetrachloride
GC/MS	EPA 8260B/C SIM	Chloroform
GC/MS	EPA 8260B/C SIM	Chloromethane
GC/MS	EPA 8260B/C SIM	cis-1,2-Dichloroethene
GC/MS	EPA 8260B/C SIM	cis-1,3-Dichloropropene
GC/MS	EPA 8260B/C SIM	Dibromochloromethane
GC/MS	EPA 8260B/C SIM	Ethylbenzene
GC/MS	EPA 8260B/C SIM	Isopropylbenzene

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8260B/C SIM	Hexachlorobutadiene
GC/MS	EPA 8260B/C SIM	Methylcyclohexane
GC/MS	EPA 8260B/C SIM	m,p-Xylene
GC/MS	EPA 8260B/C SIM	o-Xylene
GC/MS	EPA 8260B/C SIM	Tetrachloroethene
GC/MS	EPA 8260B/C SIM	trans-1,2-Dichloroethene
GC/MS	EPA 8260B/C SIM	Trans-1,3-Dichloropropene
GC/MS	EPA 8260B/C SIM	Trichloroethene
GC/MS	EPA 8260B/C SIM	Trichlorofluoromethane
GC/MS	EPA 8260B/C SIM	Vinyl Chloride
GC/MS	EPA 8260B/C SIM	Xylenes (total)
GC/MS	EPA 8270C/D	1, 2, 4, 5-Tetrachlorobenzene
GC/MS	EPA 625; EPA 8270C/D	1, 2, 4-Trichlorobenzene
GC/MS	EPA 625; EPA 8270C/D	1, 2-Dichlorobenzene
GC/MS	EPA 8270C/D	1, 2-Diphenylhydrazine
GC/MS	EPA 8270C/D	1, 3, 5-Trinitrobenzene
GC/MS	EPA 625; EPA 8270C/D	1, 3-Dichlorobenzene
GC/MS	EPA 8270C/D	1, 3-Dinitrobenzene
GC/MS	EPA 625; EPA 8270C/D	1, 4-Dichlorobenzene
GC/MS	EPA 8270C/D	1, 4-Dioxane
GC/MS	EPA 8270C/D	1, 4-Naphthoquinone
GC/MS	EPA 8270C/D	1, 4-Phenylenediamine
GC/MS	EPA 8270C/D	1-Chloronaphthalene
GC/MS	EPA 8270C/D	1-Methylnaphthalene
GC/MS	EPA 8270C/D	1-Naphthylamine
GC/MS	EPA 8270C/D	2, 3, 4, 6-Tetrachlorophenol
GC/MS	EPA 8270C/D	2, 4, 5-Trochlorophenol
GC/MS	EPA 625; EPA 8270C/D	2, 4, 6-Trichlorophenol
GC/MS	EPA 625; EPA 8270C/D	2, 4-Dichlorophenol
GC/MS	EPA 625; EPA 8270C/D	2, 4-Dimethylphenol
GC/MS	EPA 625; EPA 8270C/D	2, 4-Dinitrophenol

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 625; EPA 8270C/D	2, 4-Dinitrotoluene (2, 4-DNT)
GC/MS	EPA 8270C/D	2, 6-Dichlorophenol
GC/MS	EPA 625; EPA 8270C/D	2, 6-Dinitrotoluene (2, 6-DNT)
GC/MS	EPA 8270C/D	2-Acetylaminofluorene
GC/MS	EPA 625; EPA 8270C/D	2-Chloronaphthalene
GC/MS	EPA 625; EPA 8270C/D	2-Chlorophenol
GC/MS	EPA 625; EPA 8270C/D	2-Methyl-4 6-dinitrophenol
GC/MS	EPA 8270C/D	2-Methylnaphthalene
GC/MS	EPA 8270C/D	2-Methylphenol
GC/MS	EPA 8270C/D	2-Naphthylamine
GC/MS	EPA 8270C/D	2-Nitroaniline
GC/MS	EPA 625; EPA 8270C/D	2-Nitrophenol
GC/MS	EPA 8270C/D	2-Picoline
GC/MS	EPA 8270C/D	3-Methylcholanthrene
GC/MS	EPA 8270C/D	3-Nitroaniline
GC/MS	EPA 8270C/D	4-Aminobiphenyl
GC/MS	EPA 625; EPA 8270C/D	4-Bromophenyl phenyl ether
GC/MS	EPA 625; EPA 8270C/D	4-Chloro-3-methylphenol
GC/MS	EPA 8270C/D	4-Chloroaniline
GC/MS	EPA 625; EPA 8270C/D	4-Chlorophenyl phenylether
GC/MS	EPA 8270C/D	4-Dimethyl aminoazobenzene
GC/MS	EPA 8270C/D	3, 4-Methylphenol
GC/MS	EPA 8270C/D	4-Nitroaniline
GC/MS	EPA 625; EPA 8270C/D	4-Nitrophenol
GC/MS	EPA 8270C/D	4-Nitroquinoline-1-oxide
GC/MS	EPA 8270C/D	5-Nitro-o-toluidine
GC/MS	EPA 8270C/D	7, 12-Dimethylbenz(a)anthracene
GC/MS	EPA 8270C/D	a a-Dimethylphenethylamine
GC/MS	EPA 625; EPA 8270C/D	Acenaphthene
GC/MS	EPA 625; EPA 8270C/D	Acenaphthylene
GC/MS	EPA 8270C/D	Acetophenone

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8270C/D	Aniline
GC/MS	EPA 625; EPA 8270C/D	Anthracene
GC/MS	EPA 8270C/D	Aramite
GC/MS	EPA 8270C/D	Atrazine
GC/MS	EPA 8270C/D	Azobenzene
GC/MS	EPA 8270C/D	Benzaldehyde
GC/MS	EPA 625; EPA 8270C/D	Benzidine
GC/MS	EPA 625; EPA 8270C/D	Benzo(a)anthracene
GC/MS	EPA 625; EPA 8270C/D	Benzo(a)pyrene
GC/MS	EPA 625; EPA 8270C/D	Benzo(b)fluoranthene
GC/MS	EPA 625; EPA 8270C/D	Benzo(g h i)perylene
GC/MS	EPA 625; EPA 8270C/D	Benzo(k)fluoranthene
GC/MS	EPA 8270C/D	Benzoic Acid
GC/MS	EPA 8270C/D	Benzyl alcohol
GC/MS	EPA 8270C/D	1,1-Biphenyl
GC/MS	EPA 625; EPA 8270C/D	bis(2-Chloroethoxy)methane
GC/MS	EPA 625; EPA 8270C/D	bis(2-Chloroethyl) ether
GC/MS	EPA 625; EPA 8270C/D	bis(2-Chloroisopropyl) ether (2, 2'-Oxybis(1-chloropropane)
GC/MS	EPA 625; EPA 8270C/D	bis(2-Ethylhexyl)adipate
GC/MS	EPA 625; EPA 8270C/D	bis(2-Ethylhexyl) phthalate (DEHP)
GC/MS	EPA 625; EPA 8270C/D	Butyl benzyl phthalate
GC/MS	EPA 8270C/D	Caprolactam
GC/MS	EPA 8270C/D	Carbazole
GC/MS	EPA 8270C/D	Chlorobenzilate
GC/MS	EPA 625; EPA 8270C/D	Chrysene
GC/MS	EPA 8270C/D	Diallate
GC/MS	EPA 8270C/D	Dibenzo(a,j)acridine
GC/MS	EPA 625; EPA 8270C/D	Dibenz(a h)anthracene
GC/MS	EPA 8270C/D	Dibenzofuran
GC/MS	EPA 8270C/D	Diethyladipate
GC/MS	EPA 625; EPA 8270C/D	Diethyl phthalate

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8270C/D	Dimethoate
GC/MS	EPA 625; EPA 8270C/D	Dimethyl phthalate
GC/MS	EPA 625; EPA 8270C/D	Di-n-butyl phthalate
GC/MS	EPA 625; EPA 8270C/D	Di-n-octyl phthalate
GC/MS	EPA 8270C/D	Dinoseb
GC/MS	EPA 8270C/D	Disulfoton
GC/MS	EPA 8270C/D	Ethyl methanesulfonate
GC/MS	EPA 8270C/D	Ethyl parathion
GC/MS	EPA 8270C/D	Ethyl methacrylate
GC/MS	EPA 8270C/D	Famfur
GC/MS	EPA 625; EPA 8270C/D	Fluoranthene
GC/MS	EPA 625; EPA 8270C/D	Fluorene
GC/MS	EPA 625; EPA 8270C/D	Hexachlorobenzene
GC/MS	EPA 625; EPA 8270C/D	Hexachlorobutadiene
GC/MS	EPA 625; EPA 8270C/D	Hexachlorocyclopentadiene
GC/MS	EPA 625; EPA 8270C/D	Hexachloroethane
GC/MS	EPA 8270C/D	Hexachlorophene
GC/MS	EPA 8270C/D	Hexachloropropene
GC/MS	EPA 625; EPA 8270C/D	Indeno(1, 2, 3-cd)pyrene
GC/MS	EPA 8270C/D	Isodrin
GC/MS	EPA 625; EPA 8270C/D	Isophorone
GC/MS	EPA 8270C/D	Isosafrole
GC/MS	EPA 8270C/D	Kepone
GC/MS	EPA 8270C/D	Methapyriline
GC/MS	EPA 8270C/D	Methy methanesulfonate
GC/MS	EPA 8270C/D	Methyl parathion
GC/MS	EPA 625; EPA 8270C/D	Naphthalene
GC/MS	EPA 625; EPA 8270C/D	Nitrobenzene
GC/MS	EPA 8270C/D	Nitroquinoline-1-oxide
GC/MS	EPA 8270C/D	n-Nitrosodiethylamine
GC/MS	EPA 625; EPA 8270C/D	n-Nitrosodimethylamine

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8270C/D	n-Nitroso-di-n-butylamine
GC/MS	EPA 625; EPA 8270C/D	n-Nitrosodi-n-propylamine
GC/MS	EPA 625; EPA 8270C/D	n-Nitrosodiphenylamine
GC/MS	EPA 8270C/D	n-Nitrosomethylethylamine
GC/MS	EPA 8270C/D	n-Nitrosomorpholine
GC/MS	EPA 8270C/D	n-Nitrosopiperidine
GC/MS	EPA 8270C/D	n-Nitrosopyrrolidine
GC/MS	EPA 8270C/D	O,O,O-Triethyl phosphorothioate
GC/MS	EPA 8270C/D	o,o-Diethyl o-2pyrazinyl phosphorothioate
GC/MS	EPA 8270C/D	o-Toluidine
GC/MS	EPA 8270C/D	Pentachlorobenzene
GC/MS	EPA 8270C/D	Pentachloronitrobenzene
GC/MS	EPA 625; EPA 8270C/D	Pentachlorophenol
GC/MS	EPA 8270C/D	Phenacetin
GC/MS	EPA 625; EPA 8270C/D	Phenanthrene
GC/MS	EPA 625; EPA 8270C/D	Phenol
GC/MS	EPA 8270C/D	Phorate
GC/MS	EPA 8270C/D	Pronamide
GC/MS	EPA 625; EPA 8270C/D	Pyrene
GC/MS	EPA 8270C/D	Pyridine
GC/MS	EPA 8270C/D	Safrole
GC/MS	EPA 8270C/D	Sulfotepp
GC/MS	EPA 8270C/D	Thionazin
GC/MS	EPA 625; EPA 8270C/D	3, 3'-Dichlorobenzidine
GC/MS	EPA 8270C/D	3, 3'-Dimethylbenzidine
GC/MS	EPA 8270C/D SIM	1,1'-Biphenyl
GC/MS	EPA 8270C/D SIM	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270C/D SIM	1,4-Dioxane
GC/MS	EPA 8270C/D SIM	1-Methylnaphthalene
GC/MS	EPA 8270C/D SIM	2,2'-Oxybis(1-chloropropane
GC/MS	EPA 8270C/D SIM	2,3,4,6-Tetrachlorophenol

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8270C/D SIM	2,4,5-Trichlorophenol
GC/MS	EPA 8270C/D SIM	2,4,6-Trichlorophenol
GC/MS	EPA 8270C/D SIM	2,4-Dichlorophenol
GC/MS	EPA 8270C/D SIM	2,4-Dimethylphenol
GC/MS	EPA 8270C/D SIM	2,4-Dinitrophenol
GC/MS	EPA 8270C/D SIM	2,4-Dinitrotoluene
GC/MS	EPA 8270C/D SIM	2,6-Dinitrotoluene
GC/MS	EPA 8270C/D SIM	2-Chloronaphthalene
GC/MS	EPA 8270C/D SIM	2-Chlorophenol
GC/MS	EPA 8270C/D SIM	2-Methylnaphthalene
GC/MS	EPA 8270C/D SIM	2-Methylphenol
GC/MS	EPA 8270C/D SIM	2-Nitroaniline
GC/MS	EPA 8270C/D SIM	2-Nitrophenol
GC/MS	EPA 8270C/D SIM	3&4-Methylphenol
GC/MS	EPA 8270C/D SIM	3,3'-Dichlorobenzidine
GC/MS	EPA 8270C/D SIM	3-Nitroaniline
GC/MS	EPA 8270C/D SIM	4,6-Dinitro-2-methylphenol
GC/MS	EPA 8270C/D SIM	4-Bromophenyl-phenylether
GC/MS	EPA 8270C/D SIM	4-Chloro-3-methylphenol
GC/MS	EPA 8270C/D SIM	4-Chloroaniline
GC/MS	EPA 8270C/D SIM	4-Chlorophenyl-phenylether
GC/MS	EPA 8270C/D SIM	4-Nitroaniline
GC/MS	EPA 8270C/D SIM	4-Nitrophenol
GC/MS	EPA 8270C/D SIM	Acenaphthene
GC/MS	EPA 8270C/D SIM	Acenaphthylene
GC/MS	EPA 8270C/D SIM	Acetophenone
GC/MS	EPA 8270C/D SIM	Anthracene
GC/MS	EPA 8270C/D SIM	Atrazine
GC/MS	EPA 8270C/D SIM	Benzaldehyde
GC/MS	EPA 8270C/D SIM	Benzo(a)anthracene
GC/MS	EPA 8270C/D SIM	Benzo(a)pyrene

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8270C/D SIM	Benzo(b)fluoranthene
GC/MS	EPA 8270C/D SIM	Benzo(g,h,i)perylene
GC/MS	EPA 8270C/D SIM	Benzo(k)fluoranthene
GC/MS	EPA 8270C/D SIM	Bis(2-chloroethoxy)methane
GC/MS	EPA 8270C/D SIM	Bis(2-chloroethyl)ether
GC/MS	EPA 8270C/D SIM	Bis(2-ethylhexyl)phthalate
GC/MS	EPA 8270C/D SIM	Butylbenzylphthalate
GC/MS	EPA 8270C/D SIM	Caprolactam
GC/MS	EPA 8270C/D SIM	Carbazole
GC/MS	EPA 8270C/D SIM	Chrysene
GC/MS	EPA 8270C/D SIM	Dibenzo(a,h)anthracene
GC/MS	EPA 8270C/D SIM	Dibenzofuran
GC/MS	EPA 8270C/D SIM	Diethylphthalate
GC/MS	EPA 8270C/D SIM	Dimethyl phthalate
GC/MS	EPA 8270C/D SIM	Di-n-butylphthalate
GC/MS	EPA 8270C/D SIM	Di-n-octylphthalate
GC/MS	EPA 8270C/D SIM	Fluoranthene
GC/MS	EPA 8270C/D SIM	Fluorene
GC/MS	EPA 8270C/D SIM	Hexachlorobenzene
GC/MS	EPA 8270C/D SIM	Hexachlorobutadiene
GC/MS	EPA 8270C/D SIM	Hexachlorocyclopentadiene
GC/MS	EPA 8270C/D SIM	Hexachloroethane
GC/MS	EPA 8270C/D SIM	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270C/D SIM	Isophorone
GC/MS	EPA 8270C/D SIM	Naphthalene
GC/MS	EPA 8270C/D SIM	Nitrobenzene
GC/MS	EPA 8270C/D SIM	n-Nitroso-di-n-propylamine
GC/MS	EPA 8270C/D SIM	n-Nitrosodiphenylamine
GC/MS	EPA 8270C/D SIM	Pentachlorophenol
GC/MS	EPA 8270C/D SIM	Phenanthrene
GC/MS	EPA 8270C/D SIM	Phenol

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8270C/D SIM	Pyrene
HPLC/UV	EPA 8330A/B	1, 3, 5-Trinitrobenzene
HPLC/UV	EPA 8330A/B	1, 3-Dinitrobenzene
HPLC/UV	EPA 8330A/B	2, 4, 6-Trinitrotoluene
HPLC/UV	EPA 8330A/B	2, 4-Dinitrotoluene
HPLC/UV	EPA 8330A/B	2, 6-Dinitrotoluene
HPLC/UV	EPA 8330A/B	2-Amino-4, 6 -Dinitrotoluene
HPLC/UV	EPA 8330A/B	2-Nitrotoluene
HPLC/UV	EPA 8330A/B	3-Nitrotoluene
HPLC/UV	EPA 8330A/B	3,5-Dinitroaniline
HPLC/UV	EPA 8330A/B	4-Amino-2, 6-Dinitrotoluene
HPLC/UV	EPA 8330A/B	4-Nitrotoluene
HPLC/UV	EPA 8330A/B	Ethylene glycol dinitrate (EGDN)
HPLC/UV	EPA 8330A/B	Hexahydro-1, 3, 5-trinitro-1, 3, 5-triazine (RDX)
HPLC/UV	EPA 8330A/B	Nitrobenzene
HPLC/UV	EPA 8330A MOD	Nitroglycerin
HPLC/UV	EPA 8330B	Nitroglycerin
HPLC/UV	EPA 8330A/B	Octahydro-1, 3, 5, 7-tetrazocine (HMX)
HPLC/UV	EPA 8330A/B	Pentaerythritol Tetranitrate (PETN)
HPLC/UV	EPA 8330A/B	Tetryl
CVAA	EPA 245.1; EPA 7470A	Mercury
CVAF	EPA 1631E	Low Level Mercury
ICP/AES	EPA 200.7; EPA 6010B/C	Aluminum
ICP/AES	EPA 200.7; EPA 6010B/C	Antimony
ICP/AES	EPA 200.7; EPA 6010B/C	Arsenic
ICP/AES	EPA 200.7; EPA 6010B/C	Barium
ICP/AES	EPA 200.7; EPA 6010B/C	Beryllium
ICP/AES	EPA 200.7; EPA 6010B/C	Boron
ICP/AES	EPA 200.7; EPA 6010B/C	Cadmium
ICP/AES	EPA 200.7; EPA 6010B/C	Calcium
ICP/AES	EPA 200.7; EPA 6010B/C	Chromium

Non-Potable Water		
Technology	Method	Analyte
ICP/AES	EPA 200.7; EPA 6010B/C	Cobalt
ICP/AES	EPA 200.7; EPA 6010B/C	Copper
ICP/AES	EPA 200.7; EPA 6010B/C	Iron
ICP/AES	EPA 200.7; EPA 6010B/C	Lead
ICP/AES	EPA 200.7; EPA 6010B/C	Magnesium
ICP/AES	EPA 200.7; EPA 6010B/C	Manganese
ICP/AES	EPA 200.7; EPA 6010B/C	Molybdenum
ICP/AES	EPA 200.7; EPA 6010B/C	Nickel
ICP/AES	EPA 200.7; EPA 6010B/C	Potassium
ICP/AES	EPA 200.7; EPA 6010B/C	Selenium
ICP/AES	EPA 200.7; EPA 6010B/C	Silicon
ICP/AES	EPA 200.7; EPA 6010B/C	Silver
ICP/AES	EPA 200.7; EPA 6010B/C	Sodium
ICP/AES	EPA 6010B/C	Strontium
ICP/AES	EPA 200.7; EPA 6010B/C	Thallium
ICP/AES	EPA 200.7; EPA 6010B/C	Tin
ICP/AES	EPA 200.7; EPA 6010B/C	Titanium
ICP/AES	EPA 200.7; EPA 6010B/C	Vanadium
ICP/AES	EPA 200.7; EPA 6010B/C	Zinc
ICP/MS	EPA 200.8; EPA 6020A	Aluminum
ICP/MS	EPA 200.8; EPA 6020A	Antimony
ICP/MS	EPA 200.8; EPA 6020A	Arsenic
ICP/MS	EPA 200.8; EPA 6020A	Barium
ICP/MS	EPA 200.8; EPA 6020A	Beryllium
ICP/MS	EPA 200.8; EPA 6020A	Boron
ICP/MS	EPA 200.8; EPA 6020A	Cadmium
ICP/MS	EPA 200.8; EPA 6020A	Calcium
ICP/MS	EPA 200.8; EPA 6020A	Chromium
ICP/MS	EPA 200.8; EPA 6020A	Cobalt
ICP/MS	EPA 200.8; EPA 6020A	Copper
ICP/MS	EPA 200.8; EPA 6020A	Iron

Non-Potable Water		
Technology	Method	Analyte
ICP/MS	EPA 200.8; EPA 6020A	Lead
ICP/MS	EPA 200.8; EPA 6020A	Magnesium
ICP/MS	EPA 200.8; EPA 6020A	Manganese
ICP/MS	EPA 200.8; EPA 6020A	Molybdenum
ICP/MS	EPA 200.8; EPA 6020A	Nickel
ICP/MS	EPA 200.8; EPA 6020A	Potassium
ICP/MS	EPA 200.8; EPA 6020A	Selenium
ICP/MS	EPA 200.8; EPA 6020A	Silicon
ICP/MS	EPA 200.8; EPA 6020A	Silver
ICP/MS	EPA 200.8; EPA 6020A	Sodium
ICP/MS	EPA 6020A	Strontium
ICP/MS	EPA 200.8; EPA 6020A	Thallium
ICP/MS	EPA 200.8; EPA 6020A	Tin
ICP/MS	EPA 200.8; EPA 6020A	Titanium
ICP/MS	EPA 200.8; EPA 6020A	Tungsten
ICP/MS	EPA 200.8	Uranium
ICP/MS	EPA 200.8; EPA 6020A	Vanadium
ICP/MS	EPA 200.8; EPA 6020A	Zinc
IC	EPA 300.0; EPA 9056A	Bromide
IC	EPA 300.0; EPA 9056A	Chloride
IC	EPA 300.0; EPA 9056A	Fluoride
IC	EPA 300.0; EPA 9056A	Nitrate as N
IC	EPA 300.0; EPA 9056A	Nitrite as N
IC	EPA 300.0; EPA 9056A	Nitrate + Nitrite
IC	EPA 300.0; EPA 9056A	Orthophosphate as P
IC	EPA 300.0; EPA 9056A	Sulfate
IC	SOP CA-776	Lactic Acid
IC	SOP CA-776	Acetic Acid
IC	SOP CA-776	Propionic Acid
IC	SOP CA-776	Formic Acid
IC	SOP CA-776	Butyric Acid

Non-Potable Water		
Technology	Method	Analyte
IC	SOP CA-776	Pyruvic Acid
IC	SOP CA-776	i-Pentanoic Acid
IC	SOP CA-776	Pentanoic Acid
IC	SOP CA-776	i-Hexanoic Acid
IC	SOP CA-776	Hexanoic Acid
Titration	EPA 310.1; SM 2320B	Alkalinity
Calculation	SM 2340B	Hardness
Gravimetric	EPA 1664A; EPA 9070A	Oil and Grease, Oil and Grease with SGT
Gravimetric	SM 2540B/C/D	Solids
ISE	EPA 120.1; SM 2510B	Conductivity
ISE	SM 2520B	Practical Salinity
ISE	SM 4500F- C	Fluoride
ISE	SM 4500H+ B	pH
ISE	SM 5210B	TBOD / CBOD
Physical	EPA 1010A	Ignitability
Physical	EPA 9040C	pH
Titration	SM 2340C	Hardness
Titration	SM 4500SO ₃ B	Sulfite
Titration	EPA 9034; SM 4500S ²⁻ F	Sulfide
Titration	EPA SW-846 Chapter 7.3.4	Reactive Sulfide
IR	EPA 9060A; SM 5310B	Total organic carbon
Turbidimetric	EPA 180.1; SM 2130B	Turbidity
Turbidimetric	EPA 9038; ASTM 516-02	Sulfate
UV/VIS	EPA 335.4; EPA 9012B; SM 4500-CN G	Amenable cyanide
UV/VIS	EPA 350.1; SM 4500NH ₃ H	Ammonia as N
UV/VIS	SM 3500Fe D	Ferrous Iron
UV/VIS	EPA 351.2	Kjeldahl nitrogen - total
UV/VIS	EPA 353.2; SM 4500NO ₃ F	Nitrate + Nitrite
UV/VIS	EPA 353.2; SM 4500NO ₃ F	Nitrate as N
UV/VIS	EPA 353.2; SM 4500NO ₃ F	Nitrite as N
UV/VIS	EPA 365.2; SM 4500P E	Orthophosphate as P

Non-Potable Water		
Technology	Method	Analyte
UV/VIS	EPA 365.4	Phosphorus total
UV/VIS	EPA 821/R-91-100	AVS-SEM
UV/VIS	EPA 410.4	COD
UV/VIS	EPA 420.1; EPA 9065	Total Phenolics
UV/VIS	SM 4500Cl G	Total Residual Chlorine
UV/VIS	SM 5540C	MBAS
UV/VIS	EPA 7196A; SM 3500-Cr D	Chromium VI
UV/VIS	EPA 9012B; EPA 335.4	Total Cyanide
UV/VIS	EPA 9251; SM 4500Cl E	Chloride
UV/VIS	EPA SW-846 Chapter 7.3.4	Reactive Cyanide

Preparation	Method	Type
Cleanup Methods	EPA 3640A	Gel Permeation Clean-up
Cleanup Methods	EPA 3630C	Silica Gel
Cleanup Methods	EPA 3660B	Sulfur Clean-Up
Cleanup Methods	EPA 3665A	Sulfuric Acid Clean-Up
Organic Preparation	EPA 3510C	Separatory Funnel Extraction
Organic Preparation	EPA 3520C	Continuous Liquid-Liquid Extraction
Inorganic Preparation	EPA 3010A	Hotblock
Volatile Organic Preparation	EPA 5030C	Purge and Trap

Solid and Chemical Waste		
Technology	Method	Analyte
GC/ECD	EPA 8081B	2,4'-DDD
GC/ECD	EPA 8081B	2,4'-DDE
GC/ECD	EPA 8081B	2,4'-DDT
GC/ECD	EPA 8081B	4, 4'-DDD
GC/ECD	EPA 8081B	4, 4'-DDE
GC/ECD	EPA 8081B	4, 4'-DDT
GC/ECD	EPA 8081B	Aldrin

Solid and Chemical Waste		
Technology	Method	Analyte
GC/ECD	EPA 8081B	alpha-BHC (alpha-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	Alpha-Chlordane
GC/ECD	EPA 8081B	beta-BHC (beta-Hexachlorocyclohexane)
GC/ECD	EPA 608; EPA 8081B	Chlordane (tech.)
GC/ECD	EPA 8081B	Cis-Nonachlor
GC/ECD	EPA 8081B	delta-BHC
GC/ECD	EPA 8081B	Dieldrin
GC/ECD	EPA 8081B	Endosulfan I
GC/ECD	EPA 8081B	Endosulfan II
GC/ECD	EPA 8081B	Endosulfan sulfate
GC/ECD	EPA 8081B	Endrin
GC/ECD	EPA 8081B	Endrin aldehyde
GC/ECD	EPA 8081B	Endrin Ketone
GC/ECD	EPA 8081B	gamma-BHC (Lindane gamma-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	gamma-Chlordane
GC/ECD	EPA 8081B	Heptachlor
GC/ECD	EPA 8081B	Heptachlor epoxide
GC/ECD	EPA 8081B	Hexachlorobenzene
GC/ECD	EPA 8081B	Methoxychlor
GC/ECD	EPA 8081B	Mirex
GC/ECD	EPA 8081B	Oxychlordane
GC/ECD	EPA 8081B	Toxaphene (Chlorinated camphene)
GC/ECD	EPA 8081B	Trans-Nonachlor
GC/ECD	EPA 8082A	Aroclor-1016 (PCB-1016)
GC/ECD	EPA 8082A	Aroclor-1221 (PCB-1221)
GC/ECD	EPA 8082A	Aroclor-1232 (PCB-1232)
GC/ECD	EPA 8082A	Aroclor-1242 (PCB-1242)
GC/ECD	EPA 8082A	Aroclor-1248 (PCB-1248)
GC/ECD	EPA 8082A	Aroclor-1254 (PCB-1254)
GC/ECD	EPA 8082A	Aroclor-1260 (PCB-1260)
GC/ECD	EPA 8082A MOD	Aroclor-1262 (PCB-1262)

Solid and Chemical Waste		
Technology	Method	Analyte
GC/ECD	EPA 8082A MOD	Aroclor-1268 (PCB-1268)
GC/ECD	EPA 8082A	2, 2', 3, 3', 4, 4', 5, 5', 6-Nonachlorobiphenyl (BZ 206)
GC/ECD	EPA 8082A	2, 2', 3, 3', 4, 4', 5, 6-Octachlorobiphenyl (BZ 195)
GC/ECD	EPA 8082A	2, 2', 3, 3', 4, 4', 5-Heptachlorobiphenyl (BZ 170)
GC/ECD	EPA 8082A	2, 2', 3, 3', 4, 4'-Hexachlorobiphenyl (BZ 128)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 5, 5'-Heptachlorobiphenyl (BZ 180)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 5', 6-Heptachlorobiphenyl (BZ 183)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 5-Hexachlorobiphenyl (BZ 138)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 6, 6'-Heptachlorobiphenyl (BZ 184)
GC/ECD	EPA 8082A	2, 2', 3, 4', 5, 5', 6-Heptachlorobiphenyl (BZ 187)
GC/ECD	EPA 8082A	2, 2', 3, 4, 5'-Pentachlorobiphenyl (BZ 87)
GC/ECD	EPA 8082A	2, 2', 3, 5'-Tetrachlorobiphenyl (BZ 44)
GC/ECD	EPA 8082A	2, 2', 4, 4', 5, 5'-Hexachlorobiphenyl (BZ 153)
GC/ECD	EPA 8082A	2, 2', 4, 5, 5'-Pentachlorobiphenyl (BZ 101)
GC/ECD	EPA 8082A	2, 2', 4, 5-Tetrachlorobiphenyl (BZ 48)
GC/ECD	EPA 8082A	2, 2', 4, 5'-Tetrachlorobiphenyl (BZ 49)
GC/ECD	EPA 8082A	2, 2', 5, 5'-Tetrachlorobiphenyl (BZ 52)
GC/ECD	EPA 8082A	2, 2', 5-Trichlorobiphenyl (BZ 18)
GC/ECD	EPA 8082A	2, 3, 3', 4, 4', 5-Hexachlorobiphenyl (BZ 156)
GC/ECD	EPA 8082A	2, 3, 3', 4, 4', 5'-Hexachlorobiphenyl (BZ 157)
GC/ECD	EPA 8082A	2, 3, 3', 4, 4'-Pentachlorobiphenyl (BZ 105)
GC/ECD	EPA 8082A	2, 3, 3', 4, 4', 5, 5'-Heptachlorobiphenyl (BZ 189)
GC/ECD	EPA 8082A	2, 3', 4, 4', 5, 5'-Hexachlorobiphenyl (BZ 167)
GC/ECD	EPA 8082A	2, 3', 4, 4', 5-Pentachlorobiphenyl (BZ 118)
GC/ECD	EPA 8082A	2, 3', 4, 4',5'-Pentachlorobiphenyl (BZ 123)
GC/ECD	EPA 8082A	2, 3', 4, 4'-Tetrachlorobiphenyl (BZ 66)
GC/ECD	EPA 8082A	2, 3, 4, 4', 5-Pentachlorobiphenyl (BZ 114)
GC/ECD	EPA 8082A	2, 4, 4'-Trichlorobiphenyl (BZ 28)
GC/ECD	EPA 8082A	2, 4'-Dichlorobiphenyl (BZ 8)
GC/ECD	EPA 8082A	3, 3', 4, 4', 5, 5'-Hexachlorobiphenyl (BZ 169)
GC/ECD	EPA 8082A	3, 3', 4, 4', 5-Pentachlorobiphenyl (BZ 126)

Solid and Chemical Waste		
Technology	Method	Analyte
GC/ECD	EPA 8082A	3, 3', 4, 4'-Tetrachlorobiphenyl (BZ 77)
GC/ECD	EPA 8082A	3, 4, 4', 5-Tetrachlorobiphenyl (BZ 81)
GC/ECD	EPA 8082A	Decachlorobiphenyl (BZ 209)
GC/ECD	EPA 8151A	2, 4, 5-T
GC/ECD	EPA 8151A	2, 4-D
GC/ECD	EPA 8151A	2, 4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichloroprop
GC/ECD	EPA 8151A	Dinoseb
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPP
GC/ECD	EPA 8151A	Pentachlorophenol
GC/ECD	EPA 8151A	Silvex (2, 4, 5-TP)
GC/FID	EPA 8015C/D	Diesel range organics (DRO)
GC/FID	EPA 8015C/D	Total Petroleum Hydrocarbons (TPH)
GC/FID	EPA 8015C/D	Gasoline range organics (GRO)
GC/FID/PID	MA DEP VPH	Volatile Organic Hydrocarbons
GC/FID	MA DEP EPH	Extractable Petroleum Hydrocarbons
GC/FID	MA DEP EPH EPA 3546	Extractable Petroleum Hydrocarbons Microwave Extraction Preparation
GC/FID	CT-ETPH	Total Petroleum Hydrocarbons
GC/FID	TNRCC Method 1005	Total Petroleum Hydrocarbons
GC/FID	FL-PRO	Petroleum Range Organics
GC/ECD	EPA 8011	1, 2-Dibromoethane (EDB)
GC/ECD	EPA 8011	1, 2-Dibromo-3-chloropropane
GC/MS	EPA 8260B/C	1, 1, 1, 2-Tetrachloroethane
GC/MS	EPA 8260B/C	1,1,2-Trichloro-1,2,2-trifluoroethane
GC/MS	EPA 8260B/C	1, 1, 1-Trichloroethane
GC/MS	EPA 8260B/C	1, 1, 2, 2-Tetrachloroethane
GC/MS	EPA 8260B/C	1, 1, 2-Trichloroethane
GC/MS	EPA 8260B/C	1, 1-Dichloroethane

Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8260B/C	1, 1-Dichloroethylene
GC/MS	EPA 8260B/C	1, 1-Dichloropropene
GC/MS	EPA 8260B/C	1, 2, 3-Trichlorobenzene
GC/MS	EPA 8260B/C	1, 2, 3-Trichloropropane
GC/MS	EPA 8260B/C	1,2,3-Trimethylbenzene
GC/MS	EPA 8260B/C	1, 2, 4-Trichlorobenzene
GC/MS	EPA 8260B/C	1, 2, 4-Trimethylbenzene
GC/MS	EPA 8260B/C	1, 2-Dibromo-3-chloropropane
GC/MS	EPA 8260B/C	1, 2-Dibromoethane
GC/MS	EPA 8260B/C	1, 2-Dichlorobenzene
GC/MS	EPA 8260B/C	1, 2-Dichloroethane
GC/MS	EPA 8260B/C	1, 2-Dichloropropane
GC/MS	EPA 8260B/C	1,3,5-Trichlorobenzene
GC/MS	EPA 8260B/C	1, 3, 5-Trimethylbenzene
GC/MS	EPA 8260B/C	1, 3-Dichlorobenzene
GC/MS	EPA 8260B/C	1, 3-Dichloropropane
GC/MS	EPA 8260B/C	1, 4-Dichlorobenzene
GC/MS	EPA 8260B/C	1, 4-Dioxane
GC/MS	EPA 8260B/C	1-Chlorohexane
GC/MS	EPA 8260B/C	2, 2-Dichloropropane
GC/MS	EPA 8260B/C	2-Butanone
GC/MS	EPA 8260B/C	2-Chloroethyl vinyl ether
GC/MS	EPA 8260B/C	2-Chlorotoluene
GC/MS	EPA 8260B/C	2-Hexanone
GC/MS	EPA 8260B/C	4-Chlorotoluene
GC/MS	EPA 8260B/C	4-Methyl-2-pentanone
GC/MS	EPA 8260B/C	Acetone
GC/MS	EPA 8260B/C	Acetonitrile
GC/MS	EPA 8260B/C	Acrolein
GC/MS	EPA 8260B/C	Acrylonitrile
GC/MS	EPA 8260B/C	Allyl chloride

Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8260B/C	Benzene
GC/MS	EPA 8260B/C	Benzyl chloride
GC/MS	EPA 8260B/C	Bromobenzene
GC/MS	EPA 8260B/C	Bromochloromethane
GC/MS	EPA 8260B/C	Bromodichloromethane
GC/MS	EPA 8260B/C	Bromoform
GC/MS	EPA 8260B/C	Carbon disulfide
GC/MS	EPA 8260B/C	Carbon tetrachloride
GC/MS	EPA 8260B/C	Chlorobenzene
GC/MS	EPA 8260B/C	Chloroethane
GC/MS	EPA 8260B/C	Chloroform
GC/MS	EPA 8260B/C	Chloroprene
GC/MS	EPA 8260B/C	cis-1, 2-Dichloroethene
GC/MS	EPA 8260B/C	cis-1, 3-Dichloropropene
GC/MS	EPA 8260B/C	cis-1,3-Dichloro-2-butene
GC/MS	EPA 8260B/C	Cyclohexane
GC/MS	EPA 8260B/C	Dibromochloromethane
GC/MS	EPA 8260B/C	Dibromomethane
GC/MS	EPA 8260B/C	Dichlorodifluoromethane
GC/MS	EPA 8260B/C	Diethyl ether
GC/MS	EPA 8260B/C	Di-isopropylether
GC/MS	EPA 8260B/C	1,2-Dibromoethane (EDB)
GC/MS	EPA 8260B/C	Ethyl methacrylate
GC/MS	EPA 8260B/C	Ethylbenzene
GC/MS	EPA 8260B/C	Ethyl-t-butylether
GC/MS	EPA 8260B/C	Hexachlorobutadiene
GC/MS	EPA 8260B/C	Iodomethane
GC/MS	EPA 8260B/C	Isobutyl alcohol
GC/MS	EPA 8260B/C	Isopropyl alcohol
GC/MS	EPA 8260B/C	Isopropyl benzene
GC/MS	EPA 8260B/C	m p-xylenes

Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8260B, C	Methyl acetate
GC/MS	EPA 8260B/C	Methacrylonitrile
GC/MS	EPA 8260B/C	Methyl bromide (Bromomethane)
GC/MS	EPA 8260B/C	Methyl chloride (Chloromethane)
GC/MS	EPA 8260B/C	Methyl methacrylate
GC/MS	EPA 8260B/C	Methyl tert-butyl ether
GC/MS	EPA 8260B/C	Methylcyclohexane
GC/MS	EPA 8260B/C	Methylene chloride
GC/MS	EPA 8260B/C	Naphthalene
GC/MS	EPA 8260B/C	n-Butylbenzene
GC/MS	EPA 8260B/C	n-propylbenzene
GC/MS	EPA 8260B/C	o-Xylene
GC/MS	EPA 8260B/C	pentachloroethane
GC/MS	EPA 8260B/C	p-Isopropyltoluene
GC/MS	EPA 8260B/C	Propionitrile
GC/MS	EPA 8260B/C	sec-butylbenzene
GC/MS	EPA 8260B/C	Styrene
GC/MS	EPA 8260B/C	t-Amylmethylether
GC/MS	EPA 8260B/C	tert-Butyl alcohol
GC/MS	EPA 8260B/C	tert-Butylbenzene
GC/MS	EPA 8260B/C	Tetrachloroethylene (Perchloroethylene)
GC/MS	EPA 8260B/C	Tetrahydrofuran
GC/MS	EPA 8260B/C	Toluene
GC/MS	EPA 8260B/C	trans-1, 2-Dichloroethylene
GC/MS	EPA 8260B/C	trans-1, 3-Dichloropropylene
GC/MS	EPA 8260B/C	Trans-1, 4-Dichloro-2-butene
GC/MS	EPA 8260B/C	Trichloroethene (Trichloroethylene)
GC/MS	EPA 8260B/C	Trichlorofluoromethane
GC/MS	EPA 8260B/C	Vinyl acetate
GC/MS	EPA 8260B/C	Vinyl chloride
GC/MS	EPA 8260B/C	Xylene

Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8260B/C SIM	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260B/C SIM	1,1,1-Trichloroethane
GC/MS	EPA 8260B/C SIM	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B/C SIM	1, 1, 2-Trichloroethane
GC/MS	EPA 8260B/C SIM	1,2,3-Trichloropropane
GC/MS	EPA 8260B/C SIM	1,1-Dichloroethane
GC/MS	EPA 8260B/C SIM	1,1-Dichloroethene
GC/MS	EPA 8260B/C SIM	1,2,4-Trichlorobenzene
GC/MS	EPA 8260B/C SIM	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B/C SIM	1,2-Dibromo-3-chloropropane
GC/MS	EPA 8260B/C SIM	1,2-Dibromoethane
GC/MS	EPA 8260B/C SIM	1,2-Dichlorobenzene
GC/MS	EPA 8260B/C SIM	1,2-Dichloroethane
GC/MS	EPA 8260B/C SIM	1,2-Dichloropropane
GC/MS	EPA 8260B/C SIM	1,3-Dichlorobenzene
GC/MS	EPA 8260B/C SIM	1,3-Dichloropropane
GC/MS	EPA 8260B/C SIM	1,4-Dichlorobenzene
GC/MS	EPA 8260B/C SIM	2-Hexanone
GC/MS	EPA 8260B/C SIM	4-Methyl-2-pentanone
GC/MS	EPA 8260B/C SIM	Benzene
GC/MS	EPA 8260B/C SIM	Bromodichloromethane
GC/MS	EPA 8260B/C SIM	Carbon Tetrachloride
GC/MS	EPA 8260B/C SIM	Chloroform
GC/MS	EPA 8260B/C SIM	Chloromethane
GC/MS	EPA 8260B/C SIM	cis-1,2-Dichloroethene
GC/MS	EPA 8260B/C SIM	cis-1,3-Dichloropropene
GC/MS	EPA 8260B/C SIM	Dibromochloromethane
GC/MS	EPA 8260B/C SIM	Ethylbenzene
GC/MS	EPA 8260B/C SIM	Isopropylbenzene
GC/MS	EPA 8260B/C SIM	Hexachlorobutadiene
GC/MS	EPA 8260B/C SIM	Methylcyclohexane

Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8260B/C SIM	m,p-Xylene
GC/MS	EPA 8260B/C SIM	o-Xylene
GC/MS	EPA 8260B/C SIM	Tetrachloroethene
GC/MS	EPA 8260B/C SIM	trans-1,2-Dichloroethene
GC/MS	EPA 8260B/C SIM	Trans-1,3-Dichloropropene
GC/MS	EPA 8260B/C SIM	Trichloroethene
GC/MS	EPA 8260B/C SIM	Trichlorofluoromethane
GC/MS	EPA 8260B/C SIM	Vinyl Chloride
GC/MS	EPA 8260B/C SIM	Xylenes (total)
GC/MS	EPA 8270C/D	1, 2, 4, 5-Tetrachlorobenzene
GC/MS	EPA 8270C/D	1, 2, 4-Trichlorobenzene
GC/MS	EPA 8270C/D	1, 2-Dichlorobenzene
GC/MS	EPA 8270C/D	1, 2-Diphenylhydrazine
GC/MS	EPA 8270C/D	1, 3, 5-Trinitrobenzene
GC/MS	EPA 8270C/D	1, 3-Dichlorobenzene
GC/MS	EPA 8270C/D	1, 3-Dinitrobenzene
GC/MS	EPA 8270C/D	1, 4-Dichlorobenzene
GC/MS	EPA 8270C/D	1, 4-Dioxane
GC/MS	EPA 8270C/D	1, 4-Naphthoquinone
GC/MS	EPA 8270C/D	1, 4-Phenylenediamine
GC/MS	EPA 8270C/D	1,1-Biphenyl
GC/MS	EPA 8270C/D	1-Chloronaphthalene
GC/MS	EPA 8270C/D	1-Methylnaphthalene
GC/MS	EPA 8270C/D	1-Naphthylamine
GC/MS	EPA 8270C/D	2, 3, 4, 6-Tetrachlorophenol
GC/MS	EPA 8270C/D	2, 4, 5-Trochlorophenol
GC/MS	EPA 8270C/D	2, 4, 6-Trichlorophenol
GC/MS	EPA 8270C/D	2, 4-Dichlorophenol
GC/MS	EPA 8270C/D	2, 4-Dimethylphenol
GC/MS	EPA 8270C/D	2, 4-Dinitrophenol
GC/MS	EPA 8270C/D	2, 4-Dinitrotoluene (2 4-DNT)

Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8270C/D	2, 6-Dichlorophenol
GC/MS	EPA 8270C/D	2, 6-Dinitrotoluene (2 6-DNT)
GC/MS	EPA 8270C/D	2-Acetylaminofluorene
GC/MS	EPA 8270C/D	2-Chloronaphthalene
GC/MS	EPA 8270C/D	2-Chlorophenol
GC/MS	EPA 8270C/D	2-Methyl-4, 6-dinitrophenol
GC/MS	EPA 8270C/D	2-Methylnaphthalene
GC/MS	EPA 8270C/D	2-Methylphenol
GC/MS	EPA 8270C/D	2-Naphthylamine
GC/MS	EPA 8270C/D	2-Nitroaniline
GC/MS	EPA 8270C/D	2-Nitrophenol
GC/MS	EPA 8270C/D	2-Picoline
GC/MS	EPA 8270C/D	3, 3'-Dichlorobenzidine
GC/MS	EPA 8270C/D	3, 3'-Dimethylbenzidine
GC/MS	EPA 8270C/D	3,4-Methylphenol
GC/MS	EPA 8270C/D	3-Methylcholanthrene
GC/MS	EPA 8270C/D	3-Nitroaniline
GC/MS	EPA 8270C/D	4-Aminobiphenyl
GC/MS	EPA 8270C/D	4-Bromophenyl phenyl ether
GC/MS	EPA 8270C/D	4-Chloro-3-methylphenol
GC/MS	EPA 8270C/D	4-Chloroaniline
GC/MS	EPA 8270C/D	4-Chlorophenyl phenylether
GC/MS	EPA 8270C/D	4-Dimethyl aminoazobenzene
GC/MS	EPA 8270C/D	4-Nitroaniline
GC/MS	EPA 8270C/D	4-Nitrophenol
GC/MS	EPA 8270C/D	4-Nitroquinoline-1-oxide
GC/MS	EPA 8270C/D	5-Nitro-o-toluidine
GC/MS	EPA 8270C/D	7,12-Dimethylbenz(a)anthracene
GC/MS	EPA 8270C/D	a a-Dimethylphenethylamine
GC/MS	EPA 8270C/D	Acenaphthene
GC/MS	EPA 8270C/D	Acenaphthylene

Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8270C/D	Acetophenone
GC/MS	EPA 8270C/D	Aniline
GC/MS	EPA 8270C/D	Anthracene
GC/MS	EPA 8270C/D	Aramite
GC/MS	EPA 8270C/D	Atrazine
GC/MS	EPA 8270C/D	Azobenzene
GC/MS	EPA 8270C/D	Benzaldehyde
GC/MS	EPA 8270C/D	Benzidine
GC/MS	EPA 8270C/D	Benzo(a)anthracene
GC/MS	EPA 8270C/D	Benzo(a)pyrene
GC/MS	EPA 8270C/D	Benzo(b)fluoranthene
GC/MS	EPA 8270C/D	Benzo(g h i)perylene
GC/MS	EPA 8270C/D	Benzo(k)fluoranthene
GC/MS	EPA 8270C/D	Benzoic Acid
GC/MS	EPA 8270C/D	Benzyl alcohol
GC/MS	EPA 8270C/D	bis(2-Chloroethoxy)methane
GC/MS	EPA 8270C/D	bis(2-Chloroethyl) ether
GC/MS	EPA 8270C/D	bis(2-Chloroisopropyl) ether (2, 2'-Oxybis(1-chloropropane))
GC/MS	EPA 8270C/D	bis(2-Ethylhexyl) phthalate (DEHP)
GC/MS	EPA 625; EPA 8270C/D	Bis(2-Ethylhexyl)adipate
GC/MS	EPA 8270C/D	Butyl benzyl phthalate
GC/MS	EPA 8270C/D	Caprolactam
GC/MS	EPA 8270C/D	Carbazole
GC/MS	EPA 8270C/D	Chlorobenzilate
GC/MS	EPA 8270C/D	Chrysene
GC/MS	EPA 8270C/D	Diallate
GC/MS	EPA 8270C/D	Dibenz(a h)anthracene
GC/MS	EPA 8270C/D	Dibenzo(a,j)acridine
GC/MS	EPA 8270C/D	Dibenzofuran
GC/MS	EPA 8270C/D	Diethyl phthalate
GC/MS	EPA 8270C/D	Diethyladipate

Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8270C/D	Dimethoate
GC/MS	EPA 8270C/D	Dimethyl phthalate
GC/MS	EPA 8270C/D	Di-n-butyl phthalate
GC/MS	EPA 8270C/D	Di-n-octyl phthalate
GC/MS	EPA 8270C/D	Dinoseb
GC/MS	EPA 8270C/D	Disulfoton
GC/MS	EPA 8270C/D	Ethyl methacrylate
GC/MS	EPA 8270C/D	Ethyl methanesulfonate
GC/MS	EPA 8270C/D	Ethyl parathion
GC/MS	EPA 8270C/D	Famfur
GC/MS	EPA 8270C/D	Fluoranthene
GC/MS	EPA 8270C/D	Fluorene
GC/MS	EPA 8270C/D	Hexachlorobenzene
GC/MS	EPA 8270C/D	Hexachlorobutadiene
GC/MS	EPA 8270C/D	Hexachlorocyclopentadiene
GC/MS	EPA 8270C/D	Hexachloroethane
GC/MS	EPA 8270C/D	Hexachlorophene
GC/MS	EPA 8270C/D	Hexachloropropene
GC/MS	EPA 8270C/D	Indeno(1, 2, 3-cd)pyrene
GC/MS	EPA 8270C/D	Isodrin
GC/MS	EPA 8270C/D	Isophorone
GC/MS	EPA 8270C/D	Isosafrole
GC/MS	EPA 8270C/D	Kepone
GC/MS	EPA 8270C/D	Methapyriline
GC/MS	EPA 8270C/D	Methyl methanesulfonate
GC/MS	EPA 8270C/D	Methyl parathion
GC/MS	EPA 8270C/D	Naphthalene
GC/MS	EPA 8270C/D	Nitrobenzene
GC/MS	EPA 8270C/D	n-Nitrosodiethylamine
GC/MS	EPA 8270C/D	n-Nitrosodimethylamine
GC/MS	EPA 8270C/D	n-Nitroso-di-n-butylamine

Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8270C/D	n-Nitrosodi-n-propylamine
GC/MS	EPA 8270C/D	n-Nitrosodiphenylamine
GC/MS	EPA 8270C/D	n-Nitrosomethylethylamine
GC/MS	EPA 8270C/D	n-Nitrosomorpholine
GC/MS	EPA 8270C/D	n-Nitrosopiperidine
GC/MS	EPA 8270C/D	n-Nitrosopyrrolidine
GC/MS	EPA 8270C/D	O, O, O-Triethyl phosphorothioate
GC/MS	EPA 8270C/D	o,o-Diethyl o-2-pyrazinyl phosphorothioate
GC/MS	EPA 8270C/D	o-Toluidine
GC/MS	EPA 8270C/D	Pentachlorobenzene
GC/MS	EPA 8270C/D	Pentachloronitrobenzene
GC/MS	EPA 8270C/D	Pentachlorophenol
GC/MS	EPA 8270C/D	Phenacetin
GC/MS	EPA 8270C/D	Phenanthrene
GC/MS	EPA 8270C/D	Phenol
GC/MS	EPA 8270C/D	Phorate
GC/MS	EPA 8270C/D	Pronamide
GC/MS	EPA 8270C/D	Pyrene
GC/MS	EPA 8270C/D	Pyridine
GC/MS	EPA 8270C/D	Safrole
GC/MS	EPA 8270C/D	Sulfotepp
GC/MS	EPA 8270C/D	Thionazin
GC/MS	EPA 8270C/D SIM	1,1'-Biphenyl
GC/MS	EPA 8270C/D SIM	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270C/D SIM	1,4-Dioxane
GC/MS	EPA 8270C/D SIM	1-Methylnaphthalene
GC/MS	EPA 8270C/D SIM	2,2'-Oxybis(1-chloropropane
GC/MS	EPA 8270C/D SIM	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270C/D SIM	2,4,5-Trichlorophenol
GC/MS	EPA 8270C/D SIM	2,4,6-Trichlorophenol
GC/MS	EPA 8270C/D SIM	2,4-Dichlorophenol

Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8270C/D SIM	2,4-Dimethylphenol
GC/MS	EPA 8270C/D SIM	2,4-Dinitrophenol
GC/MS	EPA 8270C/D SIM	2,4-Dinitrotoluene
GC/MS	EPA 8270C/D SIM	2,6-Dinitrotoluene
GC/MS	EPA 8270C/D SIM	2-Chloronaphthalene
GC/MS	EPA 8270C/D SIM	2-Chlorophenol
GC/MS	EPA 8270C/D SIM	2-Methylnaphthalene
GC/MS	EPA 8270C/D SIM	2-Methylphenol
GC/MS	EPA 8270C/D SIM	2-Nitroaniline
GC/MS	EPA 8270C/D SIM	2-Nitrophenol
GC/MS	EPA 8270C/D SIM	3&4-Methylphenol
GC/MS	EPA 8270C/D SIM	3,3'-Dichlorobenzidine
GC/MS	EPA 8270C/D SIM	3-Nitroaniline
GC/MS	EPA 8270C/D SIM	4,6-Dinitro-2-methylphenol
GC/MS	EPA 8270C/D SIM	4-Bromophenyl-phenylether
GC/MS	EPA 8270C/D SIM	4-Chloro-3-methylphenol
GC/MS	EPA 8270C/D SIM	4-Chloroaniline
GC/MS	EPA 8270C/D SIM	4-Chlorophenyl-phenylether
GC/MS	EPA 8270C/D SIM	4-Nitroaniline
GC/MS	EPA 8270C/D SIM	4-Nitrophenol
GC/MS	EPA 8270C/D SIM	Acenaphthene
GC/MS	EPA 8270C/D SIM	Acenaphthylene
GC/MS	EPA 8270C/D SIM	Acetophenone
GC/MS	EPA 8270C/D SIM	Anthracene
GC/MS	EPA 8270C/D SIM	Atrazine
GC/MS	EPA 8270C/D SIM	Benzaldehyde
GC/MS	EPA 8270C/D SIM	Benzo(a)anthracene
GC/MS	EPA 8270C/D SIM	Benzo(a)pyrene
GC/MS	EPA 8270C/D SIM	Benzo(b)fluoranthene
GC/MS	EPA 8270C/D SIM	Benzo(g,h,i)perylene
GC/MS	EPA 8270C/D SIM	Benzo(k)fluoranthene

Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8270C/D SIM	Bis(2-chloroethoxy)methane
GC/MS	EPA 8270C/D SIM	Bis(2-chloroethyl)ether
GC/MS	EPA 8270C/D SIM	Bis(2-ethylhexyl)phthalate
GC/MS	EPA 8270C/D SIM	Butylbenzylphthalate
GC/MS	EPA 8270C/D SIM	Caprolactam
GC/MS	EPA 8270C/D SIM	Carbazole
GC/MS	EPA 8270C/D SIM	Chrysene
GC/MS	EPA 8270C/D SIM	Dibenzo(a,h)anthracene
GC/MS	EPA 8270C/D SIM	Dibenzofuran
GC/MS	EPA 8270C/D SIM	Diethylphthalate
GC/MS	EPA 8270C/D SIM	Dimethyl phthalate
GC/MS	EPA 8270C/D SIM	Di-n-butylphthalate
GC/MS	EPA 8270C/D SIM	Di-n-octylphthalate
GC/MS	EPA 8270C/D SIM	Fluoranthene
GC/MS	EPA 8270C/D SIM	Fluorene
GC/MS	EPA 8270C/D SIM	Hexachlorobenzene
GC/MS	EPA 8270C/D SIM	Hexachlorobutadiene
GC/MS	EPA 8270C/D SIM	Hexachlorocyclopentadiene
GC/MS	EPA 8270C/D SIM	Hexachloroethane
GC/MS	EPA 8270C/D SIM	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270C/D SIM	Isophorone
GC/MS	EPA 8270C/D SIM	Naphthalene
GC/MS	EPA 8270C/D SIM	Nitrobenzene
GC/MS	EPA 8270C/D SIM	n-Nitroso-di-n-propylamine
GC/MS	EPA 8270C/D SIM	n-Nitrosodiphenylamine
GC/MS	EPA 8270C/D SIM	Pentachlorophenol
GC/MS	EPA 8270C/D SIM	Phenanthrene
GC/MS	EPA 8270C/D SIM	Phenol
GC/MS	EPA 8270C/D SIM	Pyrene
HPLC/UV	EPA 8330A	1, 3, 5-Trinitrobenzene
HPLC/UV	EPA 8330A	1, 3-Dinitrobenzene

Solid and Chemical Waste		
Technology	Method	Analyte
HPLC/UV	EPA 8330A	2, 4, 6-Trinitrotoluene
HPLC/UV	EPA 8330A	2, 4-Dinitrotoluene
HPLC/UV	EPA 8330A	2, 6-Dinitrotoluene
HPLC/UV	EPA 8330A	2-Amino-4, 6-dinitrotoluene
HPLC/UV	EPA 8330A	2-Nitrotoluene
HPLC/UV	EPA 8330A	3-Nitrotoluene
HPLC/UV	EPA 8330A	3,5-Dinitroaniline
HPLC/UV	EPA 8330A	4-Amino-2,6-dinitrotoluene
HPLC/UV	EPA 8330A	4-Nitrotoluene
HPLC/UV	EPA 8330A	Ethylene glycol dinitrate (EGDN)
HPLC/UV	EPA 8330A	Hexahydr-1, 3, 5-trinitro-1, 3, 5-triazine (RDX)
HPLC/UV	EPA 8330A	Nitrobenzene
HPLC/UV	EPA 8330A MOD	Nitroglycerin
HPLC/UV	EPA 8330A	Octahydro-1, 3, 5, 7-tetrazocine (HMX)
HPLC/UV	EPA 8330A	Pentaerythritol Tetranitrate (PETN)
HPLC/UV	EPA 8330A	Tetryl
HPLC/UV	8330B (W/O Soil Grinding)	1, 3, 5-Trinitrobenzene
HPLC/UV	8330B (W/O Soil Grinding)	1, 3-Dinitrobenzene
HPLC/UV	8330B (W/O Soil Grinding)	2, 4, 6-Trinitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	2, 4-Dinitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	2, 6-Dinitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	2-Amino-4, 6 –Dinitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	2-Nitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	3-Nitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	3,5-Dinitroaniline
HPLC/UV	8330B (W/O Soil Grinding)	4-Amino-2,3-Dinitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	4-Nitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	Ethylene glycol dinitrate (EGDN)
HPLC/UV	8330B (W/O Soil Grinding)	Hexahydr-1, 3, 5-trinitro-1, 3, 5-triazine (RDX)
HPLC/UV	8330B (W/O Soil Grinding)	Nitrobenzene
HPLC/UV	8330B (W/O Soil Grinding)	Nitroglycerin

Solid and Chemical Waste		
Technology	Method	Analyte
HPLC/UV	8330B (W/O Soil Grinding)	Octahydro-1, 3, 5, 7-tetrazocine (HMX)
HPLC/UV	8330B (W/O Soil Grinding)	Pentaerythritol Tetranitrate (PETN)
HPLC/UV	8330B (W/O Soil Grinding)	Tetryl
CVAA	EPA 7471B	Mercury
CVAF	EPA 1631E	Low Level Mercury
ICP/AES	EPA 6010B/C	Aluminum
ICP/AES	EPA 6010B/C	Antimony
ICP/AES	EPA 6010B/C	Arsenic
ICP/AES	EPA 6010B/C	Barium
ICP/AES	EPA 6010B/C	Beryllium
ICP/AES	EPA 6010B/C	Boron
ICP/AES	EPA 6010B/C	Cadmium
ICP/AES	EPA 6010B/C	Calcium
ICP/AES	EPA 6010B/C	Chromium
ICP/AES	EPA 6010B/C	Cobalt
ICP/AES	EPA 6010B/C	Copper
ICP/AES	EPA 6010B/C	Iron
ICP/AES	EPA 6010B/C	Lead
ICP/AES	EPA 6010B/C	Magnesium
ICP/AES	EPA 6010B/C	Manganese
ICP/AES	EPA 6010B/C	Molybdenum
ICP/AES	EPA 6010B/C	Nickel
ICP/AES	EPA 6010B/C	Potassium
ICP/AES	EPA 6010B/C	Selenium
ICP/AES	EPA 6010B/C	Silicon
ICP/AES	EPA 6010B/C	Silver
ICP/AES	EPA 6010B/C	Sodium
ICP/AES	EPA 6010B/C	Strontium
ICP/AES	EPA 6010B/C	Thallium
ICP/AES	EPA 6010B/C	Tin
ICP/AES	EPA 6010B/C	Titanium

Solid and Chemical Waste		
Technology	Method	Analyte
ICP/AES	EPA 6010B/C	Vanadium
ICP/AES	EPA 6010B/C	Zinc
ICP/MS	EPA 6020A	Aluminum
ICP/MS	EPA 6020A	Antimony
ICP/MS	EPA 6020A	Arsenic
ICP/MS	EPA 6020A	Barium
ICP/MS	EPA 6020A	Beryllium
ICP/MS	EPA 6020A	Boron
ICP/MS	EPA 6020A	Cadmium
ICP/MS	EPA 6020A	Calcium
ICP/MS	EPA 6020A	Chromium
ICP/MS	EPA 6020A	Cobalt
ICP/MS	EPA 6020A	Copper
ICP/MS	EPA 6020A	Iron
ICP/MS	EPA 6020A	Lead
ICP/MS	EPA 6020A	Magnesium
ICP/MS	EPA 6020A	Manganese
ICP/MS	EPA 6020A	Molybdenum
ICP/MS	EPA 6020A	Nickel
ICP/MS	EPA 6020A	Potassium
ICP/MS	EPA 6020A	Selenium
ICP/MS	EPA 6020A	Silver
ICP/MS	EPA 6020A	Sodium
ICP/MS	EPA 6020A	Strontium
ICP/MS	EPA 6020A	Thallium
ICP/MS	EPA 6020A	Tin
ICP/MS	EPA 6020A	Titanium
ICP/MS	EPA 6020A	Tungsten
ICP/MS	EPA 6020A	Vanadium
ICP/MS	EPA 6020A	Zinc
IC	EPA 9056A	Chloride

Solid and Chemical Waste		
Technology	Method	Analyte
IC	EPA 9056A	Fluoride
IC	EPA 9056A	Nitrate as N
IC	EPA 9056A	Nitrite as N
IC	EPA 9056A	Orthophosphate
IC	EPA 9056A	Sulfate
Gravimetric	EPA 9071A; EPA 9071B	Oil and Grease, Oil and Grease with SGT
Physical	EPA 1010A	Ignitability
Physical	EPA 9045D	pH
Titration	EPA SW-846 Chapter 7.3.4	Reactive Sulfide
Titration	Walkley-Black	Total Organic Carbon
IR	Lloyd Kahn	Total organic carbon
Turbidimetric	EPA 9038; ASTM 516-02	Sulfate
UV/VIS	EPA 350.1; SM 4500NH3 H	Ammonia as N
UV/VIS	EPA 9251; SM 4500Cl E	Chloride
UV/VIS	EPA SW-846 Chapter 7.3.4	Reactive Cyanide
UV/VIS	EPA 821/R-91-100	AVS-SEM
UV/VIS	SM 3500Fe D	Ferrous Iron
Cleanup Methods	EPA 3630C	Silica Gel
UV/VIS	EPA 7196	Chromium VI
UV/VIS	EPA 7196A	Chromium VI
UV/VIS	EPA 9012B	Total cyanide
Preparation	Method	Type
Preparation	EPA 1311	Toxicity Characteristic Leaching Procedure
Preparation	EPA 1312	Synthetic Precipitation Leaching Procedure
Cleanup Methods	EPA 3660B	Sulfur Clean-up
Cleanup Methods	EPA 3620C	Florsil Clean-up
Cleanup Methods	EPA 3630C	Silica Gel Clean-up
Cleanup Methods	EPA 3640A	GPC Clean-up
Organic Preparation	EPA 3540C	Soxhlet Extraction
Organic Preparation	EPA 3545A	Pressurized Fluid Extraction

Solid and Chemical Waste		
Technology	Method	Analyte
Organic Preparation	EPA 3546	Microwave Extraction Preparation for EPA 8082A, 8081B and 8270C, D
Organic Preparation	EPA 3550C	Sonication
Inorganics Preparation	EPA 3050B	Hotblock
Inorganics Preparation	EPA 3060A	Alkaline Digestion
Volatile Organics Preparation	EPA 5035/5035A	Closed System Purge and Trap

Air		
Technology	Method	Analyte
GC/MS	EPA TO-15	Propene
GC/MS	EPA TO-15	1, 1, 1-Trichloroethane
GC/MS	EPA TO-15	1, 1, 2, 2-Tetrachloroethane
GC/MS	EPA TO-15	1, 1, 2-Trichloroethane
GC/MS	EPA TO-15	1, 1-Dichloroethane
GC/MS	EPA TO-15	1, 1-Dichloroethylene
GC/MS	EPA TO-15	1, 2, 4-Trichlorobenzene
GC/MS	EPA TO-15	1, 2, 4-Trimethylbenzene
GC/MS	EPA TO-15	1, 2-Dibromoethane (EDB)
GC/MS	EPA TO-15	1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114)
GC/MS	EPA TO-15	1, 2-Dichlorobenzene
GC/MS	EPA TO-15	1, 2-Dichloroethane
GC/MS	EPA TO-15	1, 2-Dichloroethenes (Total)
GC/MS	EPA TO-15	1, 2-Dichloropropane
GC/MS	EPA TO-15	1, 3, 5-Trimethylbenzene
GC/MS	EPA TO-15	1, 3-Butadiene
GC/MS	EPA TO-15	1, 3-Dichlorobenzene
GC/MS	EPA TO-15	1, 4-Dichlorobenzene
GC/MS	EPA TO-15	1,4-Difluorobenzene
GC/MS	EPA TO-15	1, 4-Dioxane
GC/MS	EPA TO-15	2-Butanone
GC/MS	EPA TO-15	2-Hexanone

Air		
Technology	Method	Analyte
GC/MS	EPA TO-15	2-Propanol
GC/MS	EPA TO-15	4-Ethyltoluene
GC/MS	EPA TO-15	4-Methyl-2-pentanone
GC/MS	EPA TO-15	Acetone
GC/MS	EPA TO-15	Acrolein
GC/MS	EPA TO-15	Benzene
GC/MS	EPA TO-15	Benzyl chloride
GC/MS	EPA TO-15	Bromochloromethane
GC/MS	EPA TO-15	Bromodichloromethane
GC/MS	EPA TO-15	Bromoform
GC/MS	EPA TO-15	Carbon disulfide
GC/MS	EPA TO-15	Carbon tetrachloride
GC/MS	EPA TO-15	Chlorobenzene
GC/MS	EPA TO-15	Chloroethane
GC/MS	EPA TO-15	Chloroform
GC/MS	EPA TO-15	Cis-1, 2-Dichloroethene
GC/MS	EPA TO-15	Cis-1, 3-Dichloropropene
GC/MS	EPA TO-15	Cyclohexane
GC/MS	EPA TO-15	Dibromochloromethane
GC/MS	EPA TO-15	Dichlorodifluoromethane (Freon 12)
GC/MS	EPA TO-15	Ethanol
GC/MS	EPA TO-15	Ethyl acetate
GC/MS	EPA TO-15	Ethylbenzene
GC/MS	EPA TO-15	Hexachlorobutadiene
GC/MS	EPA TO-15	Isopropyl alcohol
GC/MS	EPA TO-15	m, p-Xylene
GC/MS	EPA TO-15	Methyl bromide (Bromomethane)
GC/MS	EPA TO-15	Methyl chloride (Chloromethane)
GC/MS	EPA TO-15	Methyl methacrylate
GC/MS	EPA TO-15	Methyl tert-butyl ether
GC/MS	EPA TO-15	Methylene chloride



Air		
Technology	Method	Analyte
GC/MS	EPA TO-15	Naphthalene
GC/MS	EPA TO-15	n-Heptane
GC/MS	EPA TO-15	n-Hexane
GC/MS	EPA TO-15	o-Xylene
GC/MS	EPA TO-15	Styrene
GC/MS	EPA TO-15	Tetrachloroethylene (Perchloroethylene)
GC/MS	EPA TO-15	Tetrahydrofuran
GC/MS	EPA TO-15	Toluene
GC/MS	EPA TO-15	trans-1, 2-Dichloroethylene
GC/MS	EPA TO-15	trans-1, 3-Dichloropropylene
GC/MS	EPA TO-15	Trichloroethene (Trichloroethylene)
GC/MS	EPA TO-15	Trichlorofluoromethane (Freon 11)
GC/MS	EPA TO-15	1,1,2-Trichloro1,2,2-trifluoroethane (Freon 113)
GC/MS	EPA TO-15	Vinyl acetate
GC/MS	EPA TO-15	Vinyl chloride
GC/MS	EPA TO-15	Xylenes (Total)

Notes:

- 1) This laboratory offers commercial testing service.

Approved by: 
R. Douglas Leonard
Chief Technical Officer

Date: February 1, 2013

Re-issued: 2/1/13

Appendix C
Ecological Screening Values

Appendix C

Ecological Screening Values (ESVs) for Freshwater Sediment

Analytical Group	Chemical	Type	ESV	Units	TOC (%)	Reference	Comment
Inorganics	Aluminum	Freshwater	25,500	mg/kg		Buchman 2008	ARCS TEL
Inorganics	Antimony	Freshwater	3.00	mg/kg		Buchman 2008	UET
Inorganics	Arsenic	Freshwater	9.79	mg/kg		MacDonald et al. 2000a	TEC
Inorganics	Barium	Freshwater	20.0	mg/kg		MacDonald et al. 2003	TEC
Inorganics	Beryllium	Freshwater	NSV	--		--	
Inorganics	Cadmium	Freshwater	0.99	mg/kg		MacDonald et al. 2000a	TEC
Inorganics	Calcium	Freshwater	NSV	--		--	
Inorganics	Chromium	Freshwater	43.4	mg/kg		MacDonald et al. 2000a	TEC
Inorganics	Cobalt	Freshwater	50.0	mg/kg		Persuad et al. 1993	OWDG
Inorganics	Copper	Freshwater	31.6	mg/kg		MacDonald et al. 2000a	TEC
Inorganics	Cyanide	Freshwater	NSV	--		--	
Inorganics	Iron	Freshwater	20,000	mg/kg		Persuad et al. 1993	LEL
Inorganics	Lead	Freshwater	35.8	mg/kg		MacDonald et al. 2000a	TEC
Inorganics	Magnesium	Freshwater	NSV	--		--	
Inorganics	Manganese	Freshwater	460	mg/kg		Persuad et al. 1993	LEL
Inorganics	Mercury	Freshwater	0.18	mg/kg		MacDonald et al. 2000a	TEC
Inorganics	Nickel	Freshwater	22.7	mg/kg		MacDonald et al. 2000a	TEC
Inorganics	Potassium	Freshwater	NSV	--		--	
Inorganics	Selenium	Freshwater	2.00	mg/kg		USEPA 2006b	
Inorganics	Silver	Freshwater	1.00	mg/kg		MacDonald et al. 2003	TEC
Inorganics	Sodium	Freshwater	NSV	--		--	
Inorganics	Thallium	Freshwater	NSV	--		--	
Inorganics	Vanadium	Marine	57.0	mg/kg		Buchman 2008	AET
Inorganics	Zinc	Freshwater	121	mg/kg		MacDonald et al. 2000a	TEC
Pesticides	4,4'-DDD	Freshwater	4.88	ug/kg		MacDonald et al. 2000a	TEC
Pesticides	4,4'-DDE	Freshwater	3.16	ug/kg		MacDonald et al. 2000a	TEC
Pesticides	4,4'-DDT	Freshwater	4.16	ug/kg		MacDonald et al. 2000a	TEC
Pesticides	Aldrin	Freshwater	2.00	ug/kg		Persuad et al. 1993	LEL
Pesticides	alpha-BHC	Freshwater	6.00	ug/kg		Persuad et al. 1993	LEL
Pesticides	alpha-Chlordane	Freshwater	3.24	ug/kg		MacDonald et al. 2000a	TEC
Pesticides	beta-BHC	Freshwater	5.00	ug/kg		Persuad et al. 1993	LEL
Pesticides	delta-BHC	Freshwater	3.00	ug/kg		Persuad et al. 1993	LEL
Pesticides	Dieldrin	Freshwater	1.90	ug/kg		MacDonald et al. 2000a	TEC
Pesticides	Endosulfan I	Freshwater	2.90	ug/kg	1	USEPA 1996	
Pesticides	Endosulfan II	Freshwater	14.0	ug/kg	1	USEPA 1996	
Pesticides	Endosulfan sulfate	Freshwater	5.40	ug/kg	1	USEPA 1996	
Pesticides	Endrin	Freshwater	2.22	ug/kg		MacDonald et al. 2000a	TEC
Pesticides	Endrin aldehyde	Freshwater	2.22	ug/kg		Endrin	
Pesticides	Endrin ketone	Freshwater	2.22	ug/kg		Endrin	
Pesticides	gamma-BHC (Lindane)	Freshwater	2.37	ug/kg		MacDonald et al. 2000a	TEC

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Ecological Screening Values (ESVs) for Freshwater Sediment

Analytical Group	Chemical	Type	ESV	Units	TOC (%)	Reference	Comment
Pesticides	gamma-Chlordane	Freshwater	3.24	ug/kg		MacDonald et al. 2000a	TEC
Pesticides	Heptachlor	Freshwater	68.0	ug/kg	1	Jones et al. 1997	
Pesticides	Heptachlor epoxide	Freshwater	2.47	ug/kg		MacDonald et al. 2000a	TEC
Pesticides	Methoxychlor	Freshwater	19.0	ug/kg	1	USEPA 1996	
Pesticides	Toxaphene	Freshwater	28.0	ug/kg	1	USEPA 1996	
PCBs	Aroclor-1016	Freshwater	59.8	ug/kg		MacDonald et al. 2000b	TEC
PCBs	Aroclor-1221	Freshwater	59.8	ug/kg		MacDonald et al. 2000b	TEC
PCBs	Aroclor-1232	Freshwater	59.8	ug/kg		MacDonald et al. 2000b	TEC
PCBs	Aroclor-1242	Freshwater	59.8	ug/kg		MacDonald et al. 2000b	TEC
PCBs	Aroclor-1248	Freshwater	59.8	ug/kg		MacDonald et al. 2000b	TEC
PCBs	Aroclor-1254	Freshwater	59.8	ug/kg		MacDonald et al. 2000b	TEC
PCBs	Aroclor-1260	Freshwater	59.8	ug/kg		MacDonald et al. 2000b	TEC
PCBs	Aroclor-1262	Freshwater	59.8	ug/kg		MacDonald et al. 2000b	TEC
PCBs	Aroclor-1268	Freshwater	59.8	ug/kg		MacDonald et al. 2000b	TEC
SVOCs	1,1-Biphenyl	Freshwater	1,100	ug/kg	1	USEPA 1996	
SVOCs	1,2,3-Trichlorobenzene	Freshwater	858	ug/kg	1	USEPA 2006b	
SVOCs	1,2,4-Trichlorobenzene	Freshwater	9,200	ug/kg	1	USEPA 1996	
SVOCs	1,2,4,5-Tetrachlorobenzene	Freshwater	1,093	ug/kg	1	USEPA 2006b	
SVOCs	1,2-Dichlorobenzene	Freshwater	340	ug/kg	1	USEPA 1996	
SVOCs	1,3-Dichlorobenzene	Freshwater	1,700	ug/kg	1	USEPA 1996	
SVOCs	1,4-Dichlorobenzene	Freshwater	350	ug/kg	1	USEPA 1996	
SVOCs	2,2'-Oxybis(1-chloropropane)	Freshwater	NSV	--		--	
SVOCs	2,3,4,6-Tetrachlorophenol	Freshwater	284	ug/kg	1	USEPA 2006b	
SVOCs	2,4,5-Trichlorophenol	Freshwater	NSV	--		--	
SVOCs	2,4,6-Trichlorophenol	Freshwater	213	ug/kg	1	USEPA 2006b	
SVOCs	2,4-Dichlorophenol	Freshwater	117	ug/kg	1	USEPA 2006b	
SVOCs	2,4-Dimethylphenol	Freshwater	NSV	--		--	
SVOCs	2,4-Dinitrophenol	Freshwater	NSV	--		--	
SVOCs	2,4-Dinitrotoluene	Freshwater	41.6	ug/kg	1	USEPA 2006b	
SVOCs	2,6-Dinitrotoluene	Freshwater	NSV	--		--	
SVOCs	2-Chloronaphthalene	Freshwater	NSV	--		--	
SVOCs	2-Chlorophenol	Freshwater	31.2	ug/kg	1	USEPA 2006b	
SVOCs	2-Methylnaphthalene	Marine	70.0	ug/kg		Long et al. 1995	ER-L
SVOCs	2-Methylphenol	Freshwater	NSV	--		--	
SVOCs	2-Nitroaniline	Freshwater	NSV	--		--	
SVOCs	2-Nitrophenol	Freshwater	NSV	--		--	
SVOCs	3- and 4-Methylphenol	Freshwater	NSV	--		--	
SVOCs	3,3'-Dichlorobenzidine	Freshwater	127	ug/kg	1	USEPA 2006b	
SVOCs	3-Nitroaniline	Freshwater	NSV	--		--	
SVOCs	4,6-Dinitro-2-methylphenol	Freshwater	NSV	--		--	

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Ecological Screening Values (ESVs) for Freshwater Sediment

Analytical Group	Chemical	Type	ESV	Units	TOC (%)	Reference	Comment
SVOCs	4-Bromophenyl-phenylether	Freshwater	1,300	ug/kg	1	USEPA 1996	
SVOCs	4-Chloro-3-methylphenol	Freshwater	NSV	--		--	
SVOCs	4-Chloroaniline	Freshwater	NSV	--		--	
SVOCs	4-Chlorophenyl-phenylether	Freshwater	NSV	--		--	
SVOCs	4-Methylphenol	Freshwater	NSV	--		--	
SVOCs	4-Nitroaniline	Freshwater	NSV	--		--	
SVOCs	4-Nitrophenol	Freshwater	NSV	--		--	
SVOCs	Acenaphthene	Freshwater	290	ug/kg		Buchman 2008	UET
SVOCs	Acenaphthylene	Freshwater	160	ug/kg		Buchman 2008	UET
SVOCs	Acetophenone	Freshwater	NSV	--		--	
SVOCs	Anthracene	Freshwater	57.2	ug/kg		MacDonald et al. 2000a	TEC
SVOCs	Atrazine	Freshwater	6.62	ug/kg	1	USEPA 2006b	
SVOCs	Benzaldehyde	Freshwater	NSV	--		--	
SVOCs	Benzo(a)anthracene	Freshwater	108	ug/kg		MacDonald et al. 2000a	TEC
SVOCs	Benzo(a)pyrene	Freshwater	150	ug/kg		MacDonald et al. 2000a	TEC
SVOCs	Benzo(b)fluoranthene	Freshwater	240	ug/kg		Benzo(k)fluoranthene value	
SVOCs	Benzo(g,h,i)perylene	Freshwater	170	ug/kg		Persuad et al. 1993	LEL
SVOCs	Benzo(k)fluoranthene	Freshwater	240	ug/kg		Persuad et al. 1993	LEL
SVOCs	Benzoic acid	Freshwater	NSV	--		--	
SVOCs	Benzyl alcohol	Freshwater	NSV	--		--	
SVOCs	bis(2-Chloroethoxy)methane	Freshwater	NSV	--		--	
SVOCs	bis(2-Chloroethyl)ether	Freshwater	NSV	--		--	
SVOCs	bis(2-Chloroisopropyl)ether	Freshwater	NSV	--		--	
SVOCs	bis(2-Ethylhexyl)phthalate	Freshwater	750	ug/kg		Buchman 2008	UET
SVOCs	Butylbenzylphthalate	Freshwater	11,000	ug/kg	1	USEPA 1996	
SVOCs	Caprolactam	Freshwater	NSV	--		--	
SVOCs	Carbazole	Freshwater	140	ug/kg		Cubbage et al. 1997	AET
SVOCs	Chrysene	Freshwater	166	ug/kg		MacDonald et al. 2000a	TEC
SVOCs	Dibenz(a,h)anthracene	Freshwater	33.0	ug/kg		MacDonald et al. 2000a	TEC
SVOCs	Dibenzofuran	Freshwater	5,100	ug/kg		Buchman 2008	UET
SVOCs	Diethylphthalate	Freshwater	630	ug/kg		MacDonald et al. 2003	TEC
SVOCs	Dimethyl phthalate	Freshwater	NSV	--		--	
SVOCs	Di-n-butylphthalate	Freshwater	110	ug/kg		Buchman 2008	UET
SVOCs	Di-n-octylphthalate	Freshwater	NSV	--		--	
SVOCs	Fluoranthene	Freshwater	423	ug/kg		MacDonald et al. 2000a	TEC
SVOCs	Fluorene	Freshwater	77.4	ug/kg		MacDonald et al. 2000a	TEC
SVOCs	Hexachlorobenzene	Freshwater	20.0	ug/kg		Persuad et al. 1993	LEL
SVOCs	Hexachlorobutadiene	Freshwater	550	ug/kg	1	MacDonald et al. 2003	
SVOCs	Hexachlorocyclopentadiene	Freshwater	NSV	--		--	
SVOCs	Hexachloroethane	Freshwater	1,000	ug/kg	1	USEPA 1996	

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Ecological Screening Values (ESVs) for Freshwater Sediment

Analytical Group	Chemical	Type	ESV	Units	TOC (%)	Reference	Comment
SVOCs	Indeno(1,2,3-cd)pyrene	Freshwater	200	ug/kg		Persuad et al. 1993	LEL
SVOCs	Isophorone	Freshwater	NSV	--		--	
SVOCs	Naphthalene	Freshwater	176	ug/kg		MacDonald et al. 2000a	TEC
SVOCs	Nitrobenzene	Freshwater	1,779	ug/kg	1	NAVFAC 2007	
SVOCs	n-Nitroso-di-n-propylamine	Freshwater	NSV	--		--	
SVOCs	n-Nitrosodiphenylamine	Freshwater	2,684	ug/kg	1	USEPA 2006b	
SVOCs	PAH (total)	Freshwater	3,553	ug/kg		Jones et al. 1997	ARCS TEC
SVOCs	PAH (HMW)	Freshwater	2,900	ug/kg		Jones et al. 1997	ARCS TEC
SVOCs	PAH (LMW)	Freshwater	786	ug/kg		Jones et al. 1997	ARCS TEC
SVOCs	Pentachlorophenol	Freshwater	504	ug/kg	1	USEPA 2006b	
SVOCs	Phenanthrene	Freshwater	204	ug/kg		MacDonald et al. 2000a	TEC
SVOCs	Phenol	Freshwater	48.0	ug/kg		Buchman 2008	UET
SVOCs	Pyrene	Freshwater	195	ug/kg		MacDonald et al. 2000a	TEC
VOCs	1,1,1-Trichloroethane	Freshwater	170	ug/kg	1	USEPA 1996	
VOCs	1,1,2,2-Tetrachloroethane	Freshwater	940	ug/kg	1	USEPA 1996	
VOCs	1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	Freshwater	NSV	--		--	
VOCs	1,1,2-Trichloroethane	Freshwater	1,200	ug/kg	1	Jones et al. 1997	
VOCs	1,1-Dichloroethane	Freshwater	27.0	ug/kg	1	Jones et al. 1997	
VOCs	1,1-Dichloroethene	Freshwater	31.0	ug/kg	1	Jones et al. 1997	
VOCs	1,2,3-Trichlorobenzene	Freshwater	858	ug/kg	1	USEPA 2006b	
VOCs	1,2,4-Trichlorobenzene	Freshwater	9,200	ug/kg	1	USEPA 1996	
VOCs	1,2-Dibromo-3-chloropropane	Freshwater	NSV	--		--	
VOCs	1,2-Dibromoethane	Freshwater	NSV	--		--	
VOCs	1,2-Dichlorobenzene	Freshwater	340	ug/kg	1	USEPA 1996	
VOCs	1,2-Dichloroethane	Freshwater	250	ug/kg	1	Jones et al. 1997	
VOCs	1,2-Dichloroethene (total)	Freshwater	400	ug/kg	1	Jones et al. 1997	
VOCs	1,2-Dichloropropane	Freshwater	NSV	--		--	
VOCs	1,3-Dichlorobenzene	Freshwater	1,700	ug/kg	1	USEPA 1996	
VOCs	1,4-Dichlorobenzene	Freshwater	350	ug/kg	1	USEPA 1996	
VOCs	2-Butanone	Freshwater	270	ug/kg	1	Jones et al. 1997	Polar
VOCs	2-Hexanone	Freshwater	NSV	--		--	
VOCs	4-Methyl-2-pentanone	Freshwater	33.0	ug/kg	1	Jones et al. 1997	Polar
VOCs	Acetone	Freshwater	NSV	--		--	
VOCs	Benzene	Freshwater	57.0	ug/kg	1	USEPA 1996	
VOCs	Bromochloromethane	Freshwater	NSV	--		--	
VOCs	Bromodichloromethane	Freshwater	NSV	--		--	
VOCs	Bromoform	Freshwater	650	ug/kg	1	USEPA 1996	
VOCs	Bromomethane	Freshwater	NSV	--		--	
VOCs	Carbon disulfide	Freshwater	0.85	ug/kg	1	Jones et al. 1997	
VOCs	Carbon tetrachloride	Freshwater	1,200	ug/kg	1	USEPA 1996	

Appendix C

Ecological Screening Values (ESVs) for Freshwater Sediment

Analytical Group	Chemical	Type	ESV	Units	TOC (%)	Reference	Comment
VOCs	Chlorobenzene	Freshwater	820	ug/kg	1	USEPA 1996	
VOCs	Chloroethane	Freshwater	NSV	--		--	
VOCs	Chloroform	Freshwater	22.0	ug/kg	1	Jones et al. 1997	
VOCs	Chloromethane	Freshwater	NSV	--		--	
VOCs	cis-1,2-Dichloroethene	Freshwater	400	ug/kg	1	Jones et al. 1997	
VOCs	cis-1,3-Dichloropropene	Freshwater	0.051	ug/kg	1	Jones et al. 1997	
VOCs	Cyclohexane	Freshwater	NSV	--		--	
VOCs	Dibromochloromethane	Freshwater	NSV	--		--	
VOCs	Dichlorodifluoromethane(Freon-12)	Freshwater	NSV	--		--	
VOCs	Ethylbenzene	Freshwater	3,600	ug/kg	1	USEPA 1996	
VOCs	Isopropylbenzene	Freshwater	86.0	ug/kg	1	USEPA 2006b	
VOCs	m- and p-Xylene	Freshwater	160	ug/kg	1	Jones et al. 1997	Total xylenes
VOCs	Methyl acetate	Freshwater	NSV	--		--	
VOCs	Methylcyclohexane	Freshwater	NSV	--		--	
VOCs	Methylene chloride	Freshwater	370	ug/kg	1	Jones et al. 1997	
VOCs	Methyl-tert-butyl ether (MTBE)	Freshwater	NSV	--		--	
VOCs	o-Xylene	Freshwater	160	ug/kg	1	Jones et al. 1997	Total xylenes
VOCs	Styrene	Freshwater	559	ug/kg	1	USEPA 2006b	
VOCs	Tetrachloroethene	Freshwater	530	ug/kg	1	USEPA 1996	
VOCs	Toluene	Freshwater	670	ug/kg	1	USEPA 1996	
VOCs	trans-1,2-Dichloroethene	Freshwater	400	ug/kg	1	Jones et al. 1997	
VOCs	trans-1,3-Dichloropropene	Freshwater	0.051	ug/kg	1	Jones et al. 1997	
VOCs	Trichloroethene	Freshwater	1,600	ug/kg	1	USEPA 1996	
VOCs	Trichlorofluoromethane(Freon-11)	Freshwater	NSV	--		--	
VOCs	Vinyl chloride	Freshwater	278	ug/kg	1	Calculated	
VOCs	Xylene, total	Freshwater	160	ug/kg	1	Jones et al. 1997	

NSV - No Screening Value

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