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FINAL SAMPLING AND ANALYSIS PLAN AT SITE 66 NSWC INDIAN HEAD MD
5/1/2010
CH2MHILL

SAP Worksheet #1—Title and Approval Page

Final

Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) Site 66 – Turkey Run Disposal Area Remedial Investigation

Naval Support Facility Indian Head
Indian Head, Maryland

Contract Task Order JU04

May 2010

Prepared for

Department of the Navy
Naval Facilities Engineering Command
Washington

Under the

Navy CLEAN 1000 Program
Contract N62470-08-D-1000

Prepared by

CH2MHILL

Chantilly, Virginia

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SAP Worksheet #1 — Title and Approval Page (continued)

Review Signatures:

John Tomik
CH2M HILL Activity Quality Manager

Margaret Kasim
CH2M HILL Activity Manager

Christine Metcalf
CH2M HILL Project Manager

Approval Signatures: TUCKER.JONATHAN.P.1239524180

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Date: 2010.04.23 15:09:52 -04'00'

Navy Chemist
NAVFAC Atlantic Chemist/QA Officer

Other Approval Signatures:

Nathan Delong
NAVFAC Washington Remedial Project Manager

Dennis Orenshaw
EPA Region III Remedial Project Manager

Curtis DeTore
MDE Remedial Project Manager

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Executive Summary

Introduction

CH2M HILL has been contracted by the U.S. Navy (Navy), Naval Facilities Engineering Command (NAVFAC) Washington to conduct a Remedial Investigation (RI) for Site 66, the Turkey Run Disposal Area, at Naval Support Facility Indian Head (NSF-IH), Indian Head, Maryland (Figure 1). This Uniform Federal Policy-Sampling and Analysis Plan (UFP-SAP) is designed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986. CH2M HILL prepared this document under the NAVFAC Washington Comprehensive Long-Term Environmental Action Navy (CLEAN) 1000 Contract N62470-08-D-1000, Contract Task Order JU04, for submittal to NAVFAC Washington; the U.S. Environmental Protection Agency Region III; and the Maryland Department of the Environment.

Site 66

Site 66, the Turkey Run Disposal Area, is defined as the area where wastes were observed on the land surface during Site Investigation (SI) activities in 2007, and covers approximately 8.2 acres. It was designated as an Installation Restoration Program site following discovery of the site by NSF-IH personnel during RI activities at Site 11, the Caffee Road Landfill, south of Site 66, and discussion with the Indian Head Installation Restoration Team (IHIRT). Site 66 is an unregulated dump area that contains various solid wastes, including ash, construction debris, metal scrap, lead flooring, scrap wood, asphalt, and laboratory bottles.

Previous Investigations

Environmental sampling was conducted at Site 66 in April 2007 as part of an SI to identify the potential contaminants in site surface soil, subsurface soil, ash material, groundwater, surface water, and sediment. Analytical results were evaluated and compared against human health and ecological screening criteria and installation-specific background concentrations in a two-step screening process. Based on the results of the human health and ecological screening processes, the collection and analysis of additional surface soil, subsurface soil, groundwater, and sediment samples were recommended to further characterize the extent of environmental impacts. The collection of additional ash samples was also recommended to further characterize the content of the waste, based on IHIRT discussion of the SI findings. Surface water was not recommended for further assessment, because the risk screening suggested that exposure to surface water was unlikely to result in unacceptable human health or ecological risks. Based on the proposed level of effort needed to address site media recommended for further assessment, the Team agreed that an RI should be conducted for Site 66.

Proposed RI Activities

The objective of the RI is to answer to following questions:

- What is the nature and extent of contamination in the surface and subsurface soil, including ash, within and outside the current Site 66 boundary?
- What is the nature and extent of contamination in the shallow groundwater at Site 66?
- What is the extent of sediment contamination within and downstream of the current Site 66 boundary?
- What is the extent and thickness of the buried waste material within and outside the current Site 66 boundary?
- Do the concentrations of constituents detected in soil, groundwater, sediment, or ash material present unacceptable human health or ecological risk?
- Do the constituent concentrations in the soil, groundwater, sediment, or ash material warrant further action?

The proposed RI field activities include the collection of 20 collocated surface soil and subsurface soil samples outside the currently defined Site 66 boundary and 4 additional surface soil samples within the Site 66 boundary, as well as the collection of 6 ash samples from the previously delineated ash piles at the site. An additional 14 soil borings will be advanced within the Site 66 boundary; all soil borings will be advanced to native soil and logged for stratigraphy. Activities also include the installation of five monitoring wells and the collection of five groundwater samples at Site 66. Ten sediment samples will be collected from the unnamed stream from locations within the current boundary of Site 66 and downstream of the site between Site 66 and Site 11, which is located south of Site 66. The RI report will include an evaluation of the acquired field and analytical data from both the SI (as appropriate) and the RI, including a baseline human health risk assessment and ecological risk assessment.

CH2M HILL prepared this UFP-SAP in accordance with the Navy's UFP-SAP policy guidance to ensure that environmental data collected are scientifically sound, of known and documented quality, and suitable for intended uses. The laboratory information cited in this UFP-SAP is specific to Katahdin Analytical Services, Inc. in Scarborough, Maine; TestAmerica, Inc. in Burlington, Maine; TestAmerica, Inc. in West Sacramento, California; and Columbia Analytical Services, Inc. in Houston, Texas. These laboratories were chosen based on a competitive selection process and will support all laboratory needs for this project. If additional laboratory services are requested that require modification to this UFP-SAP, revised UFP-SAP worksheets will be submitted to the Navy and regulatory agencies for approval.

UFP-SAP Outline

This SAP contains 37 worksheets, which are grouped into four areas:

- Project Management (Worksheets 1-16)
- Measurements/Data Acquisition (Worksheets 17-30)
- Assessment Oversight (Worksheets 31-33)
- Data Review (Worksheets 34-37)

The Project Management worksheets document and establish the roles and responsibilities of the organizations and individuals involved in the planning process (Worksheets 1-8). Worksheet 9 documents scoping sessions during which the team defined the project and data quality objectives (PQOs and DQOs), project action limits (PALs), the problem definition, and the measurement performance criteria. These project plans are presented in Worksheets 10-16.

Worksheets 17-30 present the sampling tasks, analytical tasks, field and quality control sample collection, and data management tasks. These worksheets explain the sampling design and rationale, the standard operating procedures (SOPs) for collecting samples, and establish the quality control and analytical methods that will meet the PQOs/DQOs and PALs, respectively.

The Assessment Oversight worksheets (Worksheets 31-33) list the audits that will be performed to ensure project activities are being performed according to SOPs and the Quality Assurance Project Plans. These worksheets also document how problems will be corrected, how quality assurance will be reported, and evaluate the effectiveness of project activities.

The Data Review worksheets document the verification, validation, and usability of the data (Worksheets 34-37).

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SAP Worksheets

List of Figures

Appendices

Acronyms and Abbreviations

µg/kg	micrograms per kilogram
µg/L	micrograms per liter
AM	Activity Manager
amsl	above mean sea level
AQM	Activity Quality Manager
bgs	below ground surface
CA	corrective action
CCB	continuing calibration blank
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CLEAN	Comprehensive Long-Term Environmental Action, Navy
CoC	chain of custody
COPC	constituent of potential concern
CSM	conceptual site model
DOD QSM	Department of Defense Quality Systems Manual
DPT	direct-push technology
DQE	data quality evaluation
DQI	data quality indicator
DQO	data quality objective
EDL	estimated detection limit
EIS	Environmental Information Specialist
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
FTL	Field Team Leader
g	gram(s)
GC/MS	gas chromatograph/mass spectrometer
GIS	geographic information system
H&S	health and safety
HASP	Health and Safety Plan
HDPE	high-density polyethylene
HHRA	human health risk assessment
HSA	hollow stem auger
ICB	initial calibration blank
ICP	inductively coupled plasma
IDW	investigation-derived waste

IHIRT	Indian Head Installation Restoration Team
IR	Installation Restoration
IS	internal standard
L	liter
LCL	lower confidence level
LCS	laboratory control sample
LIMS	laboratory information management system
MCL	maximum contaminant level
MDE	Maryland Department of the Environment
MDL	method detection limit
mg/kg	milligrams per kilogram
mL	milliliter
MS/MSD	matrix spike/matrix spike duplicate
N/A	not applicable
NAVFAC	U.S. Naval Facilities Engineering Command
Navy	U.S. Navy
NFESC	Naval Facilities Envineering Service Center
ng/kg	nanogram per kilogram
NSF-IH	Naval Support Facility Indian Head
PAL	project action limits
PCB	polychlorinated biphenyl
PE	performance evaluation
pg/L	picogram per liter
PID	photoionization detector
PM	Project Manager
POC	point of contact
PPE	personal protective equipment
ppm	parts per million
PQO	project quality objective
PQL	project quantitation limit
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QL	quantitation limit
RI	Remedial Investigation
RL	reporting limit
RPD	relative percent difference
RPM	Remedial Project Manager
RSD	relative standard deviation
RSL	regional screening level
RT	retention time

SAP	Sampling and Analysis Plan
SERA	screening ecological risk assessment
SI	Site Investigation
SIM	selective ion monitoring
SOP	standard operating procedure
SSC	Site Safety Coordinator
SVOC	semivolatile organic compound
TAL	target analyte list
TAT	turn around time
TBD	to be determined
TCL	target compound list
TOC	total organic carbon
UCL	upper confidence limit
UFP	Uniform Federal Policy
VOC	volatile organic compound

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SAP Worksheet #2—SAP Identifying Information

Site Name: Naval Support Facility Indian Head (NSF-IH)

Site Number: Site 66 – Turkey Run Disposal Area

Contractor Name: CH2M HILL

Contract Number: N62470-08-D-1000

Contract Title: Comprehensive Long-Term Environmental Action Navy (CLEAN) Program 1000

Work Assignment Number: Contract Task Order JU04

1. **SAP Requirements:** This Uniform Federal Policy (UFP)-Sampling and Analysis Plan (SAP) was prepared in accordance with the following requirements:

- Uniform Federal Policy for Quality Assurance Plans (UFP-QAPP) (EPA, 2005)
- EPA Guidance for Quality Assurance Project Plans (EPA, 2002)

2. **Regulatory program:** Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
3. **Type of SAP:** This is a project-specific SAP for Remedial Investigation (RI) activities at Site 66.
4. **Dates of scoping sessions:**

Scoping Session	Date
Indian Head Installation Restoration Team (IHIRT) Tier I Partnering Team Meeting	October 2, 2008
IHIRT Tier I Partnering Team Meeting	July 22, 2009

5. **Dates and titles of SAP documents written for previous site work that are relevant to the current investigation:**

Title	Date
Final Site Inspection Work Plan for Site 66 Turkey Run Disposal Area, Naval Support Facility Indian Head, Indian Head, Maryland (CH2M HILL, 2007)	July 2007

6. **Organizational partners (stakeholders) and connection with lead organization:**
U.S. Environmental Protection Agency (EPA) Region III – regulatory stakeholder
Maryland Department of the Environment (MDE) – regulatory stakeholder
7. **Lead organization:** U.S. Navy (Navy) – lead agency
8. **Applicable SAP elements:** All the required UFP-SAP elements are included in this UFP-SAP; therefore, a crosswalk table is not necessary for this project.

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SAP Worksheet #3—Distribution List

Name of SAP Recipients	Title/Role	Organization	Telephone Number (Optional)	E-mail Address or Mailing Address
Nathan Delong	Remedial Project Manager (RPM)	Naval Facilities Engineering Command (NAVFAC) Washington	202-685-3279	nathan.delong@navy.mil
Nicholas Carros	Installation Restoration (IR) Program Project Manager	NSF-IH	301-744-2263	nicholas.carros@navy.mil
Dennis Orenshaw	RPM	EPA Region III	215-814-3361	orenshaw.dennis@epamail.epa.gov
Curtis De Tore	RPM	MDE	410-537-3791	cdetore@mde.state.md.us
Margaret Kasim	Activity Manager (AM)	CH2M HILL	703-376-5154	margaret.kasim@ch2m.com
Christine Metcalf	Project Manager (PM)	CH2M HILL	703-376-5193	christine.metcalf@ch2m.com
John Tomik	Activity Quality Manager (AQM)	CH2M HILL	757-671-6259	john.tomik@ch2m.com
Mike Zamboni	Project Chemist	CH2M HILL	703-376-5301	Michael.Zamboni@ch2m.com
Anita Dodson	Navy CLEAN Program Chemist	CH2M HILL	757-671-6218	Anita.dodson@ch2m.com
Rebecca Calimer	UFP-SAP Primary Author	CH2M HILL	937-220-2918	rebecca.calimer@ch2m.com
Lisa Carter	Field Auditor	CH2M HILL	703-376-5057	Lisa.carter@ch2m.com
To Be Determined (TBD)	Field Team Leader (FTL)	CH2M HILL	TBD	TBD
TBD	Field Staff	CH2M HILL	TBD	TBD
Andrea Colby	PM	Katahdin Analytical Services	207-874-2400	acolby@katahdinlab.com
Leslie Dimond	Quality Assurance (QA) Officer	Katahdin Analytical Services	207-874-2400 ext 20	ldimond@katahdinlab.com
Karen Sellers	PM	TestAmerica, West Sacramento	916-374-4442	Karen.sellers@testamericaninc.com

SAP Worksheet #3 — Distribution List (continued)

Name of SAP Recipients	Title/Role	Organization	Telephone Number (Optional)	E-mail Address or Mailing Address
Douglas Wier	QA Officer	TestAmerica, West Sacramento	916-374-4389	Douglas.weir@testamericainc.com
Rayburn Lavigne	PM	TestAmerica, Burlington	802-923-1024	Rayburn.lavigne@testamerica.com
Kristin McCracken	QA Officer	TestAmerica, Burlington	902-923-1019	Kristinl.mccracken@testamerica.com
Karen Verschoor	PM	Columbia Analytical Services	281-994-2960	kverschoor@caslab.com
Andrew Biddle	QA Officer	Columbia Analytical Services	713-266-1599	abiddle@caslab.com
Kevin Harmon	Data Validator	Validata Chemical Services, Inc.	770-232-0130	KHarmonvcs@aol.com
TBD	Utility Locating Subcontractor			
TBD	Drilling Subcontractor			
TBD	Direct-Push Technology (DPT) Subcontractor			
TBD	Investigation-Derived Waste (IDW) Subcontractor			

SAP Worksheet #4—Project Personnel Sign-Off Sheet

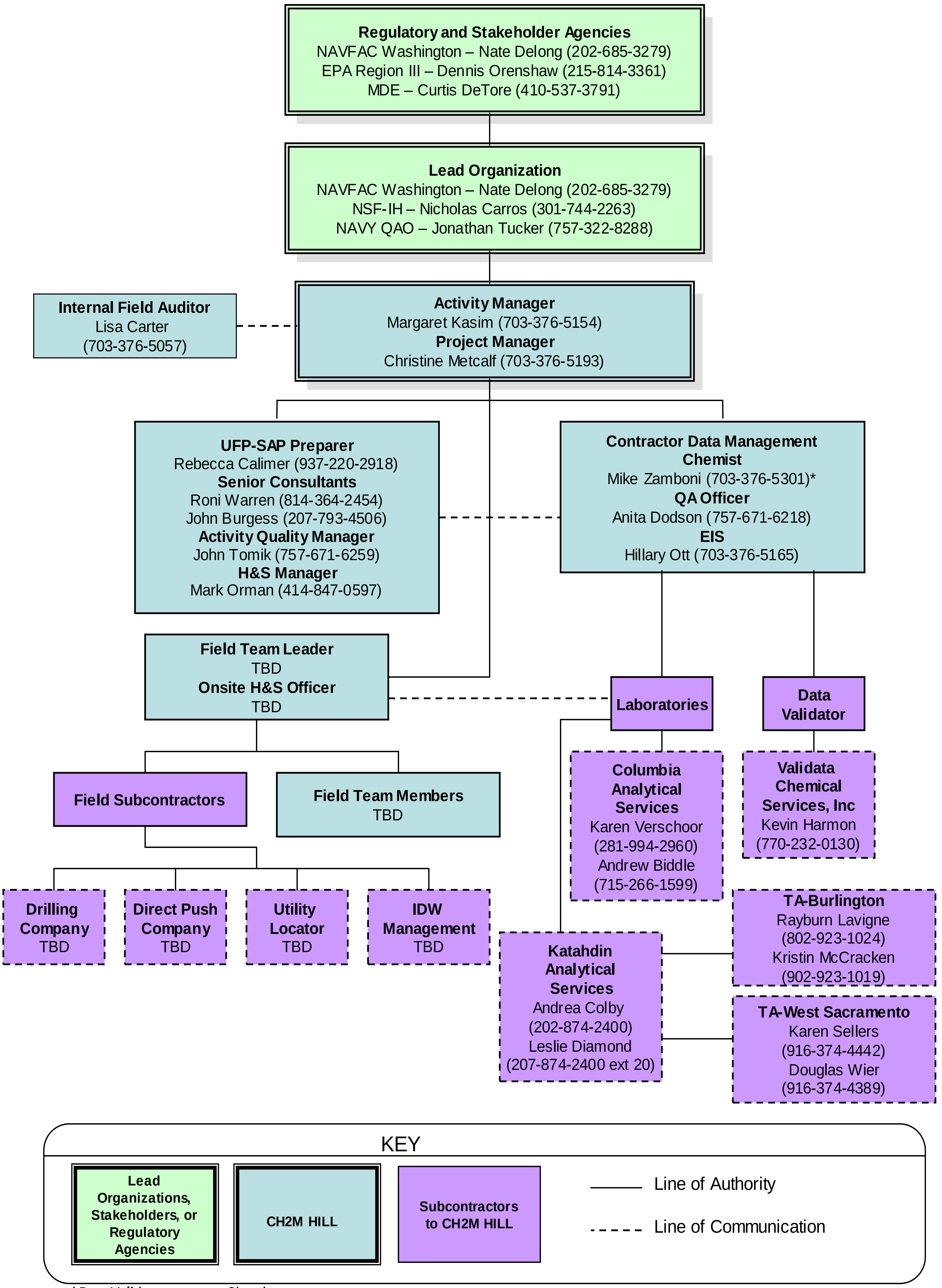
The personnel listed below acknowledge their receipt, acceptance, and approval for the listed sections of this UFP-SAP for RI activities at Site 66, NSF-IH, Indian Head, Maryland. The signed version of this document becomes a part of the administrative record for the NSF-IH, and a copy will be maintained in CH2M HILL's project file.

Name	Organization-Title-Role	Telephone Number	Signature/email receipt	Date SAP Read	SAP Section Reviewed
Margaret Kasim	CH2M HILL – AM	703-376-5154			
Christine Metcalf	CH2M HILL – PM	703-376-5193			
John Tomik	CH2M HILL – AQM	757-671-6259			
Roni Warren	CH2M HILL – Human Health Risk Assessor	814-364-2454			
John Burgess	CH2M HILL – Ecological Risk Assessor	617-523-2002			
Brett Doerr	CH2M HILL – Navy CLEAN Program UFP-SAP Reviewer	757-671-6219			
Anita Dodson	CH2M HILL – Navy CLEAN Program Chemist	757-671-6218			
Mike Zamboni	CH2M HILL – Project Chemist	703-376-5301			
Hillary Ott	CH2M HILL – EIS	703-376-5165			
Mark Orman	CH2M HILL – Health and Safety Officer	414-847-0597			
Lisa Carter	CH2M HILL – Field Auditor	703-376-5057			
TBD	CH2M HILL – FTL				
TBD	CH2M HILL – Field Team Member				
Andrea Colby	Katahdin Analytical Services – PM	207-874-2400			
Leslie Diamond	Katahdin Analytical Services – QA Officer	207-874-2400 ext 20			
Karen Verschoor	Columbia Analytical Services – PM	281-994-2960			

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

Name	Organization-Title-Role	Telephone Number	Signature/email receipt	Date SAP Read	SAP Section Reviewed
Andrew Biddle	Columbia Analytical Services – QA Officer	713-266-1599			
Karen Sellers	TestAmerica, West Sacramento - PM	916-374-4442			
Douglas Wier	TestAmerica, West Sacramento – QA Officer	916-374-4389			
Rayburn Lavigne	TestAmerica, Burlington – PM	802-923-1024			
Kristin McCracken	TestAmerica, Burlington – QA Officer	902-923-1019			
Kevin Harmon	Validata Chemical Services, Inc. – Data Validator	770-232-0130			
TBD	Utility Locating Subcontractor				
TBD	Drilling Subcontractor				
TBD	Direct-Push Technology (DPT) Subcontractor				
TBD	Investigation-Derived Waste (IDW) Subcontractor				

SAP Worksheet #5—Project Organizational Chart



* Laboratory and Data Validator report to Chemist

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SAP Worksheet #6—Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure
Communication with Navy (lead agency)	Navy RPM	Nate Delong	202-685-3279 nathan.delong@navy.mil	• Primary point of contact (POC) for Navy • Delegate communication to other internal or external points of contact • RPM will notify EPA and MDE via email within 24hrs for field changes affecting the scope or implementation of the design • Navy will have 30 calendar days for work plan review
Communication with NSF-IH	NSF-IH	Nicholas Carros	301-744-2263 nicholas.carros@navy.mil	• Primary POC for NSF-IH • Delegate communication to other internal or external points of contact • The IR Program PM will be provided daily reports of all construction activities. If field issues occur that affect the mission of the facility, the IR Program PM or his delegated personal should be notified immediately.
Communication with EPA (regulatory agency)	RPM	Dennis Orenshaw	215-814-3361 Orenshaw.Dennis@epamail.epa.gov	• Primary POC for EPA • Delegate communication to other internal or external POCs • Upon notification of field changes, EPA will have up to 24 hrs to approve or comment on the field changes
Communication with MDE (regulatory agency)	RPM	Curtis DeTore John Fairbank	410-537-3791 410-537-3440 cdetore@mde.state.md.us jfairbank@mde.state.md.us	• Primary /secondary POC for MDE • Delegate communication to other internal or external points of contact • Upon notification of field changes, MDE will have up to 24 hrs to approve or comment on the field changes
Communication regarding overall project status and implementation and primary POC with Navy RPM, EPA, and MDE	AM	Margaret Kasim	703-376-5154 Margaret.Kasim@ch2m.com	• Will forward all relevant information and materials about the project to Nate Delong (NAVFAC Washington), Dennis Orenshaw (EPA), and Curtis DeTore (MDE) • Oversee the overall project status

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure
Technical communications for project implementation and data interpretation	AQM	John Tomik	352-335-5877 John.Tomik@ch2m.com	• Contact AQM regarding questions/issues encountered in the field, input on data interpretation, as needed • Have up to 24 hrs to respond to technical field questions as necessary • Review of the data as necessary prior to partnering team discussion
Communications regarding project management and implementation of all project phases, and primary POC with Navy RPM	PM	Christine Metcalf	703-376-5193 Christine.Metcalf@ch2m.com	• Forward all information and materials about the project to Navy RPM on a daily basis • If field changes occur during construction activities, PMs will work with the Navy RPM to communicate field changes to the team via email within 24 hrs
UFP-SAP changes in field	FTL	TBD	TBD	• Document deviations from the work plan in the field logbook and notifies PM immediately • Execute deviations only after PM approval
Daily field progress reports	FTL	TBD	TBD	• Communicates the daily field progress reports to PM on a daily basis via email or fax
Health and safety (H&S)	Onsite H&S Officer	TBD	TBD	• Responsible for the adherence of team members to the site safety requirements described in the H&S Plan (HASP) • Will report H&S incidents and near losses to PM
Reporting lab data quality issues	Laboratory QA officer	Leslie Diamond Douglas Wier Kristin McCracken Andrew Biddle	207-874-2400 ext 20 916-374-4389 902-923-1019 713-266-1599	• Report all Quality Assurance/Quality Control (QA/QC) issues with project field samples to the Project Chemist as soon as identified, not to exceed 24 hours

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure
Data tracking from collection through upload to database	Environmental Information Specialist (EIS)	Hillary Ott	703-376-5165 Hillary.Ott@ch2m.com	• Track data from sample collection through upload to the database, ensuring Work Plan requirements are met by laboratory and field staff • Act as main POC for laboratory QA/QC officer. • Report the lab issues to the PM and project chemist within 4 hrs
Field and analytical corrective actions (Cas)	Project Chemist	Mike Zamboni	703-376-5301 Michael.Zamboni@ch2m.com	• In collaboration with FTL, develop any Cas for field and analytical issues and report to the PM within 4 hrs
Release of analytical data	Project Chemist	Mike Zamboni	703-376-5301 Michael.Zamboni@ch2m.com	• No analytical data can be released until validation of the data is completed and has been approved by the Project Chemist • Review analytical results within 7 days of receipt for release to the project team
Field audit	Field Auditor	Lisa Carter	703-376-5057 Lisa.Carter@ch2m.com	• Report results of internal field audit to PM

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SAP Worksheet #7—Personnel Responsibilities Table

Name	Title/Role	Organizational Affiliation	Responsibilities
Nathan Delong	Navy RPM	NAVFAC Washington	Manages all NSF-IH IR Program activities
Dennis Orenshaw	RPM	EPA Region III	Reviews and provides input for EPA on development of the Site 66 RI
Curtis DeTore	RPM	MDE	Reviews and provides input for MDE on the Site 66 RI
Margaret Kasim	AM	CH2M HILL	Oversees overall project status for all projects implemented at NSF-IH
Christine Metcalf	PM	CH2M HILL	Manages Site 66 project, oversees all project activities, and is responsible for all aspects of the work performed under this UFP-SAP
John Tomik	AQM	CH2M HILL	Provides overall technical quality control of the field investigation design and implementation; responsible for audits, CA, checks of QA performance
Brett Doerr	Navy CLEAN Program UFP-SAP Reviewer	CH2M HILL	Program-level review of UFP-SAP
Anita Dodson	Navy CLEAN Program Chemist	CH2M HILL	Provides SAP delivery support and program-level review of UFP-SAP
Roni Warren	Human Health Risk Assessor	CH2M HILL	Provides human health risk assessment (HHRA) oversight for Site 66
John Burgess	Ecological Risk Assessor	CH2M HILL	Provides ecological risk assessment (ERA) oversight for Site 66
Mike Zamboni	Project Chemist	CH2M HILL	Coordinates laboratory and data validation subcontracts and oversees performance of laboratory and data validation
Hillary Ott	EIS	CH2M HILL	Provides sample tracking, data management, and communication with laboratory
Mark Orman	H&S Officer	CH2M HILL	Develops and approves project HASPs
TBD	FTL	CH2M HILL	Supervises field implementation of the UFP-SAP

SAP Worksheet #7—Personnel Responsibilities Table (continued)

Name	Title/Role	Organizational Affiliation	Responsibilities
Andrea Colby	Laboratory PM	Katahdin Analytical Services, Inc.	Manages sample tracking and maintains good communication with Project Chemist and EIS
Leslie Dimond	Laboratory QA officer	Katahdin Analytical Services, Inc.	Responsible for audits, CAs, checks of QA performance within the laboratory
Karen Sellers	Laboratory PM	TestAmerica-West Sacramento	Manages sample tracking and maintains good communication with Project Chemist and EIS
Douglas Wier	Laboratory QA officer	TestAmerica-West Sacramento	Responsible for audits, CAs, checks of QA performance within the laboratory
Rayburn Lavigne	Laboratory PM	TestAmerica-Burlington	Manages sample tracking and maintains good communication with Project Chemist and EIS
Kristin McCracken	Laboratory QA officer	TestAmerica-Burlington	Responsible for audits, CAs, checks of QA performance within the laboratory
Karen Verschoor	Laboratory PM	Columbia Analytical Services, Inc. -Houston	Manages sample tracking and maintains good communication with Project Chemist and EIS
Andrew Biddle	Laboratory QA officer	Columbia Analytical Services, Inc.-Houston	Responsible for audits, CAs, checks of QA performance within the laboratory
Kevin Harmon	Data Validator	Validata Chemical Services, Inc.	External third-party data validation of all analytical laboratory data.
TBD	DPT Subcontractor	TBD	Performs DPT to facilitate sample collection
TBD	Hollow Stem Auger (HSA) Drilling Subcontractor	TBD	Performs drilling and installs monitoring wells
TBD	IDW Subcontractor	TBD	Responsible for manifesting, transporting, and disposing of IDW

SAP Worksheet #8—Special Personnel Training Requirements Table

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
Soil, groundwater, ash, and sediment sampling	Hazardous Waste Operations 40-hour Training, 8-hour annual refreshers as applicable	Registered training organization	Organization-specific	FTL (TBD), field team members (TBD), Site Safety Coordinator (SSC,TBD), onsite subcontractors (TBD), Navy and agency representatives	Field team leader, field team members, and site safety coordinator from CH2M HILL; onsite subcontractors TBD; onsite visitors from Navy, EPA, and MDE	CH2M HILL, Navy, regulatory agency, or subcontractor Human Resources Department
Soil, groundwater, ash, and sediment sampling	CPR/First Aid Trained, SSC	Registered training organization	Organization-specific	SSC	Onsite SSC from CH2M HILL	CH2M HILL Human Resources Department

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SAP Worksheet #9-1a—Project Scoping Session 1 Participants Sheet

Project Name: Site 66 RI **Projected Date(s) of Sampling**: February 2010 **Project Manager**: Christine Metcalf/CH2M HILL			**Site Name**: Site 66 **Site Location**: NSF-IH, Indian Head, Maryland	
Date of Session: October 2, 2008 **Scoping Session Purpose**: Discuss the post-Site Investigation path forward.				
Name	**Title/Project Role**	**Affiliation**	**Phone #**	**E-mail Address**
Joe Rail, P.E.	Navy RPM	NAVFAC Washington	202-685-3105	joseph.rail@navy.mil
Dennis Orenshaw	RPM	EPA Region III	215-814-3361	Orenshaw.dennis@epamail.epa.gov
Curtis DeTore	RPM	MDE	410-537-3791	cdetore@mde.state.md.us
Margaret Kasim	AM	CH2M HILL	703-376-5154	Margaret.Kasim@ch2m.com
Christine Metcalf	PM	CH2M HILL	703-376-5193	christine.metcalf@ch2m.com

Comments

The Team reviewed a summary of the surveying, sampling, and analytical activities conducted during the site investigation (SI) at Site 66. The SI concluded that further evaluation was warranted for surface and subsurface soil, sediment, and groundwater based on conservative human health and/or ecological risk screening results.

Based on the proposed level of effort needed to address these site media, the Team agreed that an RI should be conducted for Site 66. The following additional field investigation activities were discussed and recommended by the Team:

- Surface soil – 20 samples, or as needed, to delineate the lateral extent of contamination outside the current site boundary.
- Subsurface soil – 20 samples, or as needed, to delineate the lateral extent of contamination outside the current site boundary. In addition, soil borings across the buried waste area (within and outside the current site boundary) to delineate the thickness of buried waste materials and to log the subsurface stratigraphy.
- Groundwater – Five permanent monitoring wells (1 hydrogeologically upgradient of the site, 2 within the site boundary, and 2 downgradient of the site) to obtain groundwater data suitable for risk assessment purposes.
- Sediment – 10 samples between the southern boundary of Site 66 and the northern boundary of Site 11 to delineate the downstream extent of contamination outside the current Site 66 boundary.
- Ash – Three samples of surface ash material for analysis of metals, and three subsurface ash samples for analysis of dioxins/furans and metals.

SAP Worksheet #9-1a—Project Scoping Session 1 Participants Sheet (continued)

CH2M HILL was to check with its risk assessor to identify any remaining surface water issues with Site 11, which is downgradient of Site 66. In addition, CH2M HILL was to check the area between Site 66 and Site 11 for buildings that might contribute additional contamination to the area downstream of Site 66. The risk assessment of Site 11 did not identify any surface water issues; therefore, no additional surface water sampling was recommended for the Site 66 RI. In addition, no buildings were identified that might contribute additional contamination to the area downstream of Site 66.

The Team discussed two options for laboratory analysis of the RI samples: limit analytical parameters to those that failed conservative SI screening for each medium, or analyze samples for the full suite of parameters. The Team decided that it might be too early in the process to limit the analytical suite, so samples will be analyzed for the full suite of parameters.

Decisions

The team agreed to have CH2M HILL develop a specific technical approach for a more-detailed discussion by the Tier I team.

SAP Worksheet #9-1b—Project Scoping Session 2 Participants Sheet

Project Name: Site 66 RI **Projected Date(s) of Sampling**: February 2010 **Project Manager**: Christine Metcalf/CH2M HILL			**Site Name**: Site 66 **Site Location**: NSF-IH, Indian Head, Maryland	
Date of Session: July 22, 2009 **Scoping Session Purpose**: Team agreement on the RI objectives; proposed sample media, numbers, locations, and analyses; and data evaluation.				
Name	**Title/Project Role**	**Affiliation**	**Phone #**	**E-mail Address**
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Comments

Site 66 is an unregulated dump area that contains various solid wastes, including construction debris, metal scrap, lead flooring, scrap wood, asphalt, and laboratory bottles. Environmental sampling activities conducted during the SI included the collection and analysis of 10 DPT samples (surface soil, subsurface soil, *in situ* groundwater), 10 surface soil grab samples, 5 surface water samples, 5 sediment samples, and 3 ash samples. The results indicated that surface water does not require further evaluation, and surface soil, subsurface soil, groundwater, and sediment require further evaluation for human health and/or ecological risks.

Additional activities were proposed to meet the objectives of the RI and to define the nature and extent of soil contamination, as follows:

- Conduct additional environmental sampling (20 collocated surface and subsurface soil samples outside the current Site 66 boundary, 4 surface soil samples within the current Site 66 boundary, 6 ash samples from previously identified ash piles within the current Site 66 boundary, and 10 sediment samples within and downgradient of the Site 66 boundary)
- Install 5 permanent monitoring wells and collect groundwater samples from each location
- Obtain 14 soil borings and log the stratigraphy from the surface to the native soil to determine the thickness of the buried waste material at the site

SAP Worksheet #9-1b—Project Scoping Session 2 Participants Sheet (continued)

- Conduct baseline HHRA and a screening-level ERA (SERA)

Action Items

The UFP-SAP is scheduled to be submitted to Tier I for review in October 2009.

Decisions

The Team finds the sampling approach reasonable.

SAP Worksheet #10—Problem Definition

This worksheet provides the problem definition for the Site 66 RI, including site location and description; a brief site history of NSF-IH and Site 66; previous investigations conducted for Site 66; and information to support a conceptual site model (CSM).

Site Location and Description

NSF-IH is a Navy facility located in northwestern Charles County, Maryland, approximately 25 miles southwest of Washington, D.C. The facility consists of two tracts of land: the Main Area on the Cornwallis Neck Peninsula and the Stump Neck Annex across Mattawoman Creek from the Main Area (Figure 1).

The Main Area is approximately 2,500 acres and is bounded by the Potomac River to the northwest, west, and south; Mattawoman Creek to the south and east; and the town of Indian Head to the northeast. Included as part of the Main Area are Marsh Island and Thoroughfare Island in Mattawoman Creek. Elevations range from sea level to approximately 125 feet above mean sea level (amsl). The Stump Neck Annex is approximately 1,084 acres and is bounded by Mattawoman Creek to the northeast, the Potomac River to the northwest, and Chicamuxen Creek to the south-southwest. Elevations range from sea level to approximately 10 feet amsl. Both the Main Area and the Annex are on the National Priorities List, but they are separated by Mattawoman Creek (noncontiguous), have separate EPA identification numbers, and perform dissimilar operations.

Site 66, the Turkey Run Disposal Area, is in the Main Area, west of West Caffee Road, and extending approximately 900 feet north of Olsen Road along both sides of the unnamed creek that discharges into Mattawoman Creek, a tributary of the Potomac River (Figure 2). The site is defined as the area that includes obvious wastes present on the land surface, and it covers approximately 8.2 acres.

Site History

Site 66 was designated as an IR Program site following discovery of the site by NSF-IH personnel during RI activities at Site 11, the Caffee Road Landfill, and discussion with the IHIRT. Site 66 is an unregulated dump area that contains various solid wastes, including construction debris, metal scrap, lead flooring, scrap wood, asphalt, and laboratory bottles.

Previous Investigations

An initial site reconnaissance was conducted by CH2M HILL, NAVFAC Washington, NSF-IH, and MDE on October 11, 2006. Waste materials such as lead flooring, transite roofing, ash/slag, metal debris (sheeting, pipes, copper pieces, rebar), laboratory bottles and empty 5-gallon containers, concrete pads and debris, creosote telephone poles, land-clearing debris, and other miscellaneous materials (tires, trash cans, appliances) were observed at the site. The IHIRT discussed the observations during the November 8, 2006, partnering team meeting and developed a proposed sampling approach for the site. Previous environmental investigations had not been conducted at this site.

An SI was conducted at Site 66 in April 2007 to identify the potential contaminants in site surface soil, subsurface soil, groundwater, surface water, and sediment. During the SI, collocated surface soil, subsurface soil, and *in situ* groundwater samples were collected from

SAP Worksheet #10—Problem Definition (continued)

10 DPT soil boring locations across the site. In addition, 5 collocated surface water and sediment samples and an additional 10 surface soil grab samples were collected. Three samples were also collected from the ash-like material observed at the site. All soil, groundwater, surface water, and sediment samples were analyzed for EPA SW-846 target compound list (TCL) volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and pesticides/ polychlorinated biphenyls (PCBs); target analyte list (TAL) total metals and cyanide; explosives including nitroglycerine and nitroguanidine; and perchlorate. In addition, soil and sediment samples were analyzed for pH and total organic carbon (TOC), and surface water samples were analyzed for TAL dissolved metals and hardness. TAL dissolved metals were also analyzed in groundwater samples. The ash-like samples were analyzed for dioxins and furans. The analytical results were validated by a third party in accordance with applicable EPA guidance.

Following the completion of the fieldwork, field observations, field measurements, and analytical data from the site were reviewed and interpreted. Analytical results were evaluated and compared against human health and ecological screening criteria and installation-specific background concentrations in a two-step screening process.

The human health risk-based screening was performed to determine whether the chemicals detected in site media pose a potentially unacceptable risk to human receptors that may come in contact with these media. The results of the two-step human health screening process (i.e., comparison to screening criteria and comparison to installation-specific background values) are summarized below:

- **Surface Soil** - Exceedance of 11 SVOCs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, dibenz(a,h)anthracene, dibenzofuran, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene), 1 pesticide (dieldrin), and 3 inorganics (arsenic, mercury, and vanadium)
- **Subsurface Soil** - Exceedance of six SVOCs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene), two pesticides (4,4'-DDD and heptachlor epoxide), and five inorganics (arsenic, iron, lead, manganese, and vanadium)
- ***In Situ* Groundwater** - Exceedance of two pesticides (4,4'-DDD and heptachlor epoxide), seven total metals (arsenic, barium, chromium, iron, lead, nickel, and vanadium) and three dissolved metals (arsenic, manganese, and vanadium)
- **Surface Water** - Exceedance of one VOC (bromodichloromethane), two total metals (arsenic and manganese) and one dissolved metal (manganese)
- **Sediment** - Exceedance of one SVOC (benzo(a)pyrene)

Based on the results of the human health risk screening, surface soil, subsurface soil, and groundwater were recommended for further assessment. The risk screening concluded that exposure to surface water or sediment is unlikely to result in any unacceptable human health risks because of the spatial distribution of the detected constituents and the maximum detected concentrations of the constituents. Dioxins and furans did not exceed human health risk screening criteria and were not recommended for further assessment in the SI. It was later

SAP Worksheet #10—Problem Definition (continued)

decided that it was premature to eliminate any analyses in the RI stage of investigation, given the nature of the site.

The ecological risk screening was performed to determine whether the chemicals detected in site media might pose a potentially unacceptable risk to ecological receptors. There is viable habitat at the site, and ecological receptors could be exposed to chemicals in site surface soil, sediment, and surface water. Although ecological receptors are unlikely to come in direct contact with groundwater, the *in situ* groundwater data also were evaluated for potential ecological risk because chemicals in the groundwater can discharge to site surface water. The results of the two-step ecological risk screening process are summarized below:

- **Surface Soil** - Exceedance of 19 SVOCs (2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, carbazole, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, and bis(2-ethylhexyl)phthalate), 3 pesticides (4,4′-DDE, 4,4′-DDT, and methoxychlor), 1 explosive (perchlorate), and 8 inorganics (arsenic, copper, lead, mercury, nickel, selenium, vanadium, and zinc)
- ***In Situ* Groundwater** - Exceedance of three pesticides (4,4′-DDD, 4,4′-DDT, and heptachlor epoxide), one explosive (perchlorate), seven total inorganics (arsenic, barium, beryllium, cobalt, copper, iron, and manganese) and four dissolved inorganics (arsenic, barium, copper, and manganese)
- **Surface Water** - Exceedance of five total metals (aluminum, barium, iron, lead, and manganese) and three dissolved metals (barium, iron, and manganese)
- **Sediment** - Exceedance of 14 SVOCs (acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene), 1 PCB (Aroclor-1260), 4 pesticides (endrin aldehyde, endrin ketone, metholychlor, and alpha-chlordane), 1 explosive (perchlorate), and 1inorganic (mercury)

Based on the results of the ecological risk screening, surface soil and sediment were recommended for further assessment. The screening results suggested that the chemicals detected in groundwater either are not migrating to surface water or are not persisting in surface water and therefore do no warrant further consideration for ecological risk. In addition, the screening results suggested that the inorganics detected in surface water likely are related to background conditions and do not warrant further consideration for ecological risk. The risk screening results indicated a potentially unacceptable risk to mammals from dioxin and furan compounds in the ash material; however, the risk estimate was driven by high detection limits, and the sum of the detected congeners did not exceed the screening value. Therefore, it was concluded that the potential risk is probably overestimated and an unacceptable risk is unlikely.

Although not recommended for further assessment in the SI, ash was recommended for further assessment, based on IHIRT discussion of the SI findings.

SAP Worksheet #10—Problem Definition (continued)

Conceptual Site Model

A CSM for Site 66 was developed to present a three-dimensional representation of the waste material (i.e., source area), potential migration pathways, exposure routes, and receptors (Figure 3). Additional information is presented in the SI report (CH2M HILL, 2008) and summarized below.

Waste material sources

- Anthropogenic material, such as construction debris, metal scrap, lead flooring, scrap wood, asphalt, and laboratory bottles; ash

Potential migration pathways

- Leaching of constituents from waste material or ash as a result of infiltration of precipitation and subsequent downward migration to groundwater
- Leaching of constituents from waste material in direct contact with groundwater
- Runoff of constituents from surface soil, surface waste material, or ash into surface water bodies.

Potential receptors

- For current human health exposure scenarios:
  - Adult and adolescent trespassers/visitors exposed to constituents of potential concern (COPCs) in surface soil and ash through incidental ingestion, dermal contact, and inhalation of particulate and volatile emissions
  - Adult and adolescent trespassers/visitors exposed to COPCs in sediment through incidental ingestion, dermal contact, and inhalation of particulate and volatile emissions. (The SI risk screening concluded that it is unlikely exposure to sediment would result in any unacceptable human health risks; however, these pathways will be re-evaluated if the RI data show higher or different chemical detections in this medium than the SI data.)
- For future human health exposure scenarios:
  - Industrial workers, construction workers, adult and child residents, and adult and adolescent trespassers/visitors exposed to COPCs in surface and subsurface soil and ash through incidental ingestion, dermal contact, and inhalation of particulate and volatile emissions
  - Adult and child residents exposed to COPCs in groundwater used as a potable supply through ingestion, dermal contact, and inhalation of volatiles while showering
  - Construction workers exposed to COPCs in groundwater through dermal contact and inhalation of volatiles
  - Industrial workers and adult and child residents exposed to COPCs in indoor air from vapor intrusion from groundwater through a future building foundation through inhalation.

SAP Worksheet #10—Problem Definition (continued)

  - Industrial workers, construction workers, adult and child residents, and adult and adolescent trespassers/visitors exposed to COPCs in sediment through incidental ingestion and dermal contact. (The SI risk screening concluded that it is unlikely exposure to sediment would result in any unacceptable human health risks; however, these pathways will be re-evaluated if the RI data show higher or different chemical detections in this medium than the SI data.)

- For ecological exposure scenarios:
  - Soil invertebrates exposed to COPCs in the surface soil through dermal contact and ingestion.
  - Benthic invertebrates exposed to COPCs in the sediment through dermal contact and ingestion.
  - Upper–trophic-level receptors (i.e., carnivorous birds and mammals) exposed to COPCs accumulated in the tissues of soil invertebrates, benthic invertebrates, small mammals, amphibians, fish, or reptiles exposed to COPCs in site media.

Geology/ Site Soil Conditions

NSF-IH

The surficial geology of NSF-IH comprises Cretaceous fluviodeltic, Tertiary marine, and Quaternary fluvial deposits, which include the Cretaceous Upper Patapsco Formation, the Tertiary Aquia Formation, and the Quaternary deposits of the Potomac River System. The upland is an erosional remnant of the Upper Patapsco Formation capped by a thin layer of Tertiary Aquia Formation. The Quaternary sediments make up the majority of the surficial exposures and are generally thickest in the lower relief areas.

The U.S. Geological Survey reports that the early Potomac River cut paleochannels across the Indian Head Peninsula during the Quaternary Period. A paleochannel is evident where Quaternary deposits form a belt along the northeast end and the southeastern part of the facility. The southern section of the paleochannel extends across the entire southern region of the facility. Portions of these units subsequently have been eroded by the current Potomac River and Mattawoman Creek systems.

Site 66

Three distinct units were identified at Site 66 during the SI:

- **Ash** is composed of dark gray to black to grayish black, loose, fine to very fine silty sand-sized particles. Ash piles were observed to be at various locations within the site boundary. Ash was also observed at varying depths and thicknesses in 4 of the 10 DPT borings completed during the SI.

- **Fill** at Site 66 consists of yellowish brown to grayish brown sand, silt, and clay mixed with varying amounts of debris. The subsurface debris encountered in soil borings included concrete, brick, gravel, cinder, charred wood, pieces of wood, and ash. Sample recovery was generally poor because the material was loose or soft. Because of low sample recovery and boring refusal at buried debris, the extent and thickness of the waste materials are currently unknown.

SAP Worksheet #10—Problem Definition (continued)

- **Soil** at Site 66 consists mostly of silt, clay, and sand. The surface soil (0 to 6 inches belowground surface [bgs]) was observed to be generally dark brown to very dark brown silt that is generally loose, contains organic material in the form of roots and leaves, and may contain little to some sand. Large chunks of waste debris at the site are typically buried or partially buried by the surface soil, but in general, small particles of waste do not appear to be disseminated within this unit. The subsurface lithology consists of mottled, yellowish brown and gray silt and clay interbedded with thin lenses or layers of poorly graded fine sand. The silt and clay tend to have medium to low plasticity and are medium stiff to hard. The characteristics of these silt and clay soils are similar in nature to native soils encountered elsewhere across NSF-IH.

Site Hydrology

Three principal waterways are located in the immediate vicinity of NSF-IH: the Potomac River, Mattawoman Creek, and Chicamuxen Creek. A number of natural drainage channels on the installation receive rapid flow during intense summer storms, but usually flow intermittently with discharges from storm and industrial sewers. These natural drainage channels tend to flow toward Mattawoman Creek, the lowest hydraulic point in the area (Naval Energy and Environment Support Activity, 1992).

Topography at Site 66 is gently to steeply sloping. Surface water flows to several surface water bodies across the site (associated with the unnamed creek) which eventually discharge to Mattawoman Creek.

Hydrogeology

NSF-IH

The shallow, water-bearing zones (water table aquifer) of the facility are controlled by the shallow soil deposits. In general, the water table appears to be between 7 and 10 feet bgs within the Quaternary sediment belt. Lithologies of the water-bearing zones are usually restricted to silty and sandy clay zones. A thin layer of the Tertiary deposits overlie the Upper Patapsco confining unit along the upland. Soils in this area are very stiff, with lithologies ranging from silt to silty clays. A marker bed on top of the Upper Patapsco Formation, an iron-cemented reddish sand unit, was encountered in three borings in the upland area at depths ranging from 30 to 40 feet. Interception of this unit indicated the Upper Patapsco confining unit. It also indicated that the Patapsco aquifer would be the uppermost aquifer. The Patapsco aquifer is estimated to be more than 100 feet bgs in the upland area (Hiortdahl, 1993).

Data collected during Phase I and Phase II of the NSF-IH SI (Ensafe/Allen and Hoshall, 1994) generally indicated that the inorganic quality of the water table aquifer is poor. Analytical results of groundwater samples indicate elevated concentrations of total dissolved solids in the water table aquifer, suggesting that water from the surficial zones is not suitable as a potable water source. The water table aquifer is not used as a potable water source on the peninsula (Hiortdahl, 1993).

Site 66

The static water table at Site 66 ranges from approximately 1.5 feet bgs (IH66SB08) to 10.0 feet bgs (IH66SB10) as measured during the SI (Figure 4). This groundwater level range corresponds to an approximate elevation range of 7.4 feet amsl (IH66SB07) to 20.8 feet amsl (IH66SB10).

SAP Worksheet #10—Problem Definition (continued)

Based on this, shallow groundwater flows to the east and southwest toward the unnamed creek.

Problem Statement

Based on historical information, including analytical data, a source of CERCLA-related release(s) exists at Site 66. While historical data indicate release(s) have contaminated surrounding media, the nature and extent (and associated human health and ecological risks) have not been sufficiently delineated. Further, the limits (both horizontal and vertical) of the source area (i.e., waste material) have not been delineated.

Based on this problem statement, the objectives of the Site 66 RI are to characterize the nature and extent of site-related contamination in site media; assess whether chemical constituents have been released to soil, groundwater, or sediment at concentrations that pose potentially unacceptable risk to human health or the environment for current or future land use (by collecting data suitable for conducting an HHRA and ERA); and to define the horizontal and vertical extent of buried waste material at the site. The data collected during the SI were used to streamline the media to be investigated during the RI. However, based on the heterogeneity of the waste material observed at Site 66 (construction debris, lead flooring, ash material, laboratory bottles and other containers, etc.), the IHIRT decided that is was too early in the process to eliminate specific constituents from further analysis (see Worksheet 9-1a). The analytical data collected during the SI will be used, as appropriate, along with the RI data to conduct a baseline HHRA and ERA to assess whether the concentrations of constituents detected in the soil, groundwater, sediment, or ash materials present potentially unacceptable human health or ecological risks.

The results of the RI will be presented in a report for use by the IHIRT to make a management decision for the path forward for Site 66. The three possible management decision outcomes are to: 1) perform an interim removal action of the waste materials present at the site; (2) conduct a feasibility study based on calculated unacceptable human health or ecological risks (as applicable) in one or more environmental media at the site; and (3) remove the site from further study and recommend no further action under CERCLA based on the absence of unacceptable human health or ecological risks. In addition, the results of the RI may indicate additional study is warranted prior to making any of these management decisions.

The environmental questions/problems to be addressed by the Site 66 RI are:

1. **What is the nature and extent of contamination in the surface and subsurface soil, including ash, within and outside the current Site 66 boundary?**

   Twenty collocated surface soil and subsurface soil samples will be collected from locations outside the current site boundary to supplement the soil data collected from locations within the site boundary during the SI. The proposed sample locations were placed to provide an even distribution of samples across and outside of the site boundary where samples were not previously collected. In addition, four surface soil samples will be collected from locations within the current site boundary to augment the ecological risk data set. The surface soil and subsurface soil samples will be analyzed for VOCs, SVOCs, pesticides, PCBs, metals, dioxins/ furans, and explosives (including nitroglycerin, nitroguanidine, and perchlorate) as detailed in Worksheet 11. Proposed soil sample locations are shown on Figure 5.

SAP Worksheet #10—Problem Definition (continued)

Six samples will be collected from the ash-like material at Site 66 to supplement the ash data collected during the SI. Three samples will be collected from the locations sampled during the SI and will be analyzed for TAL metals (SI ash samples were analyzed only for dioxins and furans). Three additional samples will be collected from the ash material and analyzed for dioxins, furans, and TAL metals. Proposed ash sample locations are shown on Figure 5.

2. What is the nature and extent of contamination in the shallow groundwater at Site 66?

Five monitoring wells will be installed at Site 66 at locations based on site hydrogeology, *in situ* groundwater analytical results from the SI (CH2M HILL, 2008), and IHIRT discussion:

One well will be installed hydrogeologically upgradient of the site, two wells within the current site boundary, and two wells hydrogeologically downgradient of the site. Groundwater samples will be collected from the monitoring wells and analyzed for VOCs, SVOCs, pesticides, PCBs, metals, dioxins/ furans, and explosives (including nitroglycerin, nitroguanidine, and perchlorate), as detailed in Worksheet 11. Proposed monitoring well locations are shown on Figure 6.

3. What is the extent of sediment contamination within and downstream of the current Site 66 boundary?

Ten sediment samples will be collected from within and downstream of the current site boundary to supplement the existing sediment data collected during the SI. Six sediment samples will be collected from the unnamed creek within the current site boundary, and four sediment samples will be collected from the unnamed creek from locations between the southern boundary of Site 66 and the northern boundary of Site 11. The sediment samples will be analyzed for VOCs, SVOCs, pesticides, PCBs, metals, dioxins/furans, and explosives (including nitroglycerin, nitroguanidine, and perchlorate). Proposed sample locations are shown on Figure 7.

4. What is the extent and thickness of the buried waste material within and outside of the current Site 66 boundary?

Fourteen subsurface soil borings will be completed within the waste areas; each boring will be advanced from ground surface to native soil. The subsurface soil at each soil boring location will be characterized in the field to complete a physical description of subsurface materials, waste thickness, and stratigraphy based on visual observations. Contrary to the SI sampling, if poor recovery or refusal is encountered, multiple offsets and attempts will be made to complete the boring through to native soil. No analytical samples will be collected from these soil boring locations. Proposed boring locations are shown on Figure 5.

5. Do the concentrations of constituents detected in the soil, groundwater, sediment, or ash material present unacceptable human health or ecological risk?

The analytical data collected during the RI and the SI (as appropriate) will be used to conduct a baseline HHRA and ERA to assess whether the concentrations of constituents detected in the soil, groundwater, sediment, or ash materials present potentially unacceptable human health or ecological risks.

SAP Worksheet #10—Problem Definition (continued)

The baseline HHRA will follow current EPA risk assessment methodology and will consist of the following five components, as well as a section summarizing the results of the HHRA:

- Data evaluation/hazard identification—Data will be screened against human health risk-based criteria, such as current EPA regional screening levels (RSLs), and COPCs will be identified as those constituents that exceed the risk-based criteria.
- Exposure assessment—Receptors, exposure pathways, exposure parameters (i.e., ingestion rate), and exposure point concentrations will be identified. It is anticipated they will be those presented in the CSM.
- Toxicity assessment—Toxicity values for the COPCs identified in the data evaluation will be identified.
- Risk characterization—The previous steps will be combined to estimate potential risks to receptors.
- Uncertainty evaluation—Sources of uncertainty in the risk assessment will be identified, and potential effects on calculated risk will be determined.

An SERA (Steps 1 and 2) and, if warranted, the first step of the baseline ERA (Step 3A) will be prepared for Site 66 in general accordance with Navy ERA guidance. The SERA will be conducted as described in Appendix A.

6. Do the constituent concentrations in the soil, groundwater, sediment, or ash material warrant further action?

If the results of the baseline HHRA or the ERA indicate that an unacceptable potential risk exists at Site 66, the IHIRT will discuss the results and decide on the path forward. This path forward might include an interim action or feasibility study.

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SAP Worksheet #11—PQOs/Systematic Planning Process Statements

This section presents the PQOs for the Site 66 RI in the format specified by the UFP-SAP guidance.

Who will use the data?

The data will be used by the IHIRT (Navy, EPA Region III, MDE) to make decisions about the path forward for Site 66. CH2M HILL will use the data to prepare an RI report, which will document the field activities, analytical results, nature and extent of contamination, and baseline HHRA and/or ERA results for the data.

Within each organization, the data may be used by human health risk assessors, ecological risk assessors, and/or PMs. Other technical disciplines within each organization may use the data as well. Chemists will use the data to evaluate overall data quality with respect to subcontracted laboratories. Geologists and hydrogeologists may use the data to gain better understanding of subsurface soil quality and fill unit groundwater conditions contributing to contaminant fate and transport mechanisms. Engineers may use the data in designing removal actions or remedial systems in the future, if warranted.

Analytical data for IDW will be collected to characterize the borehole cuttings and other materials generated during the field sampling event. CH2M HILL and the IDW disposal contractor will use the data to classify the materials and select the appropriate methods for transportation and offsite disposal/treatment.

What are the PALs?

- **HHRA—**Concentrations of constituents detected in the surface soil, subsurface soil, ash, and groundwater samples collected during the Site 66 RI field event will be compared to the current RSLs to identify COPCs. RSLs for noncarcinogenic constituents will be divided by 10 to account for exposure to more than one constituent that affects the same target organ. The concentrations of constituents detected in groundwater also will be compared to the EPA maximum contaminant levels (MCL)[1]. Therefore, EPA RSLs (adjusted as described above) will be the PALs for the human health risk-based screening of analytical data to assess potential risks to human health (see Worksheet 15). If constituent concentrations exceed the RSL the constituent will be identified as a COPC for the site.
- **ERA—**The PALs for the ERA are described in Appendix A.

What will the data be used for?

The data will be used to answer the following questions, as described in Worksheet 10:

- What is the nature and extent of contamination in the surface and subsurface soil, including ash, within and outside the current Site 66 boundary?
- What is the nature and extent of contamination in the shallow groundwater at Site 66?

[1] Although shallow groundwater is not considered a suitable drinking water source under current land use conditions, it may be considered a potential future drinking water source. CERCLA identifies MCLs as criteria protective of human health for potential drinking water sources. Therefore, MCLs are appropriate for use as PALs for groundwater.

SAP Worksheet #11—PQOs/Systematic Planning Process Statements (continued)

- What is the extent of sediment contamination within and downstream of the current Site 66 boundary?
- What is the extent and thickness of the buried waste material within and outside the current Site 66 boundary?
- Do the concentrations of constituents detected in soil, groundwater, sediment, or ash material present unacceptable human health or ecological risk?
- What further actions, if any, are needed?

What types of data are needed?

Samples of soil, ash, sediment, and groundwater will be collected during the Site 66 RI field sampling event. All samples will be analyzed by an offsite laboratory. All samples will be collected in accordance with the NSF-IH Master Plans (TetraTech, 2004) and the SOPs listed on Worksheet 21 and presented in Appendix B. Because the potential past CERCLA-related activities associated with the site are unknown (i.e., all potential types of waste disposed), a broad range of constituent analyses is warranted as follows:

- **Soil** samples will be analyzed for TCL VOCs, SVOCs, pesticides, PCBs, TAL metals (including mercury and cyanide), dioxins/furans, and explosives (including nitroglycerin, nitroguanidine, and perchlorate).
- **Ash** samples will be analyzed for dioxins/furans at three sample locations and TAL metals at all six ash sampling locations.
- **Groundwater** samples will be analyzed for TCL VOCs, SVOCs, pesticides, PCBs, TAL metals and dissolved metals (including cyanide), dioxins/furans, and explosives (including nitroglycerin, nitroguanidine, and perchlorate).
- **Sediment** samples will be analyzed for TCL VOCs, SVOCs, pesticides, PCBs, TAL metals (including cyanide), dioxins/furans, and explosives (including nitroglycerin, nitroguanidine, and perchlorate).

How "good" must the data be to support the environmental decision?

This UFP-SAP is for an RI; therefore, the data quality must be adequate to evaluate the nature and extent of contamination and associated risks to allow management decisions for the site to be made with confidence. Ensuring that data are adequate for this purpose is done by using appropriate analytical protocols, validating the resulting data, including QA/QC samples to verify proper sampling and analysis protocol, and performing a data quality evaluation (DQE) to assess the availability and usability of the data for the intended purpose. Each of these is further discussed below:

- **Appropriate Analytical Protocol** – See Worksheets 15, 19, 23, 24, 25, 28, and 30.

SAP Worksheet #11—PQOs/Systematic Planning Process Statements (continued)

- **Data Validation** – See Worksheets 34, 35, and 36. Validation of data increases the level of confidence in a data set for a particular data use. The particular type and level of validation necessary to achieve acceptable confidence is subjective, and the appropriate type and level of data validation is not an absolute. Rather, the level of validation is data use- and data user-specific. For this RI data set, analyses for potential contaminants will be validated by an independent, third-party data validator against QA/QC limits established in this UFP-SAP and taking guidance from the validation criteria outlined by EPA. The validation criteria and guidance documents are listed in Worksheet 36. These documents will help the validator create a thorough and systematic approach to the validation process. The data validator will also recalculate 10 percent of the results from the raw laboratory data, which may identify laboratory errors in identification or quantification, if present.
- **QA/QC Samples** – During the RI, QA/QC samples will be collected with the various media samples as a check on sampling and analytical protocol. Like data validation, the appropriate type and quantity of QA/QC samples is not an absolute. For this RI, field duplicates will be collected at a frequency of 1 per 10 field samples per sample matrix. Field duplicates help assess sample collection techniques (i.e., representativeness of the sampling procedure), heterogeneity of the samples due to the nature of the site (i.e., unregulated dump), and laboratory precision. Matrix spike/matrix spike duplicates (MS/MSDs) are collected at a frequency of 1 pair per 20 field samples per sample matrix. The frequency is such that there is one MS/MSD pair per laboratory analytical batch. MS/MSD samples are often required by the analytical method and/or data validation guidance. Equipment blanks are collected at a frequency of 1 per day per type of decontaminated equipment. Equipment blanks help assess equipment decontamination techniques and identify when contamination may have been carried over from one sample location to another. It is important to maintain this equipment blank frequency because it is important to not associate too many locations with the potentially contaminated equipment blank. Trip blanks are collected at a frequency of 1 per cooler containing volatiles. Trip blanks accompany the empty sample containers while stored at the laboratory or shipped to the site, and while containers are full and shipped back to the laboratory. Trip blanks are useful for assessing whether any contamination occurs during times when the samples are not directly supervised.
- **DQE** – To support the environmental decision, each result must be available to and usable by the project team. All data sets will undergo a DQE before using the data to make site-specific determinations. The terms data availability and data usability and the DQE process in general are described in Worksheet 37.

How much data should be collected (number of samples for each analytical group, matrix, and concentration)?

One surface soil and one subsurface soil sample will be collected from each of 20 sample locations during the Site 66 RI. Additionally, 4 surface soil samples will be collected, for a total of 24 surface soil and 20 subsurface soil samples. Six ash samples, 10 sediment samples, and 5 groundwater samples also will be collected. The data will be of the quantity, as agreed upon by the IHIRT (see Worksheets 9-1a and 9-1b), and quality necessary to characterize the

SAP Worksheet #11—PQOs/Systematic Planning Process Statements (continued)

constituents in the soil, ash, sediment, and groundwater at Site 66 and complete the human health and ecological risk assessments. More detail concerning the number of samples and sampling locations are provided in Worksheets 17, 18, and 19.

Worksheet 15 presents target compound or analyte lists, PALs, and quantitation limits (QLs) and identifies where QLs are higher than PALs. Analytical methods were chosen to achieve QLs at or lower than PALs to the extent possible using readily available and accepted methods. Method SW-846 8270-selective ion monitoring (SIM) was chosen to detect lower concentrations of selected SVOC compounds (particularly the polycyclic aromatic hydrocarbons); method SW-846 6020 was chosen to detect lower concentrations of selected metals; and method SW-846 1613 was chosen to detect lower concentrations of dioxins and furans. Although in some instances QLs exceed PALs, this does not prevent conclusions from being drawn with respect to the objectives of the RI for the following reasons: (1) The samples collected are being analyzed for constituent groups as opposed to a specific analyte. There is no single or small group of known constituents suspected to have been released at Site 66. Analyzing for analyte groups is appropriate for making nature and extent determinations. Even if a particular analyte has a QL greater than a screening level, there are sufficient other analytes in the same constituent group that would likely be detected in the event of a release and whose QLs are less than the screening values. As such, conclusions about nature and extent and associated risks at the site likely can be made with sufficient confidence. If evaluation of the resulting overall dataset suggest there may be constituents of interest that may influence site-specific determinations, the potential effects on the site-specific evaluations and additional data needs, if warranted, will be discussed in the RI report.

(2) Even though some QLs are greater than their respective PALs, method detection limits (MDLs) are closer to and may be less that the applicable PALs. The laboratory will report a constituent result if detected at a concentration greater than its MDL; such a result would be reported as estimated because it is less than the QL.

(3) Some PALs are less than the respective QLs and MDLs. For purposes of this project, non-detects for such analytes will not be considered PAL exceedances.

Although the groundwater PALs are based on the lower of the tap water RSLs (adjusted, as appropriate) and the federal MCLs, the RSL is generally lower than the MCL for any particular analyte. However, it is ultimately the MCL that would likely be established as the remediation level, if warranted. Therefore, where QLs are greater than the tap water RSLs, the MCLs are taken into consideration when identifying the appropriate analytical methodology.

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

- See Worksheets 14, 18, and 19 and Figures 5, 6, and 7.
- Sampling will be performed during the Site 66 RI field sampling event, tentatively scheduled to begin in February 2010.
- All sampling will be performed in general accordance with the procedures described in the NSF-IH Master Plans (TetraTech, 2004) and the SOPs listed on Worksheet 21 and provided in Appendix B.

SAP Worksheet #11—PQOs/Systematic Planning Process Statements (continued)

Who will collect and generate the data? How will the data be reported?

- The CH2M HILL field team will collect the samples during the Site 66 RI field sampling event.
- The samples will be shipped via overnight courier to an offsite Navy-approved laboratory under subcontract to CH2M HILL for analysis. The laboratory will hold a current Naval Facilities Envineering Service Center (NFESC) evaluation letter for applicable analysis.
- All chemical data generated will be submitted to CH2M HILL. Once received and reviewed by CH2M HILL, all chemical data will be submitted to a third-party data validator under subcontract to CH2M HILL for validation.
- Field data, such as field screening results (i.e., photoionization detector [PID] readings) and field observations will also be collected by CH2M HILL during the Site 66 RI field sampling event. These data are qualitative and semi-quantitative (i.e., screening) in nature and therefore will not undergo validation.
- All chemical and field data will be reported in a Site 66 RI report, which will be submitted to the Navy as a preliminary draft for review before distribution to EPA and MDE for review and approval. The final approved report will be placed in the administrative record and will be publicly available.

How will the data be archived?

Data will be archived according to procedures dictated by the Navy CLEAN program/contract. All analytical data will be uploaded into a centralized database used for Navy projects. Additionally, the data will be uploaded into the Naval Installation Information Solution database. At the end of the project, paper copies of archived laboratory data and validation reports will be returned to the Navy.

PQOs listed in the form of if/then qualitative and quantitative statements.

If the lateral extent of the buried waste materials outside the current site boundary is not sufficiently delineated by the initial soil borings (i.e., waste materials are observed in the soil borings), additional soil borings will be completed until the lateral extent of buried waste materials is delineated.

If the data are sufficient to characterize the nature and extent of potential site contaminants, an HHRA and an ERA will be conducted to evaluate risks posed by site-related contamination. Because the evaluation of data adequacy is at least partially subjective, it will be based on professional judgment and concurred upon by the Navy, EPA, and MDE.

If the human health and ecological risks for Site 66 are found to be acceptable, recommendations will be made for the site based on any other applicable non-risk requirements. The Navy, EPA, and MDE will evaluate current site conditions and recommendations to assess future action and make the final decision.

SAP Worksheet #11—PQOs/Systematic Planning Process Statements (continued)

If the human health or ecological risks are found to be unacceptable, or if other relevant information is identified that suggests additional investigation or action is warranted (e.g., MCL exceedances), the Navy, EPA, and MDE will discuss the results and make a risk management decision to select the appropriate path forward. This path forward will be additional investigation, an interim action, or feasibility study.

Potentially unacceptable human health and ecological risks will be determined as follows:

HHRA

If the maximum detected concentration of a constituent exceeds the PAL for that constituent/medium, the constituent will be classified as a COPC.

If a constituent is not detected in any of the samples or is detected at concentrations less than the PAL, it will not be retained as a COPC.

Both reasonable maximum exposure and central tendency exposure exposure point concentrations will be calculated for COPCs. If the reasonable maximum exposure risk evaluation for an exposure pathway results in a risk above 1×10^{-4}, or a hazard index above 1.0, the risk/hazard will be considered unacceptable and a central tendency exposure risk evaluation and uncertainty analysis will be performed, which includes comparison of risk-driving constituents to background concentrations and other analyses.

ERA

Please see Appendix A.

SAP Worksheet #12-1—Measurement Performance Criteria Table

Matrix: Surface Soil, Subsurface Soil, Sediment

Analytical Group: VOC

Concentration Level: Low (SW-846 8260B)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
MS	VOC	One per 20 field samples	Refer to Worksheet 28-1	Refer to Worksheet 28-1	A
MSD	VOC	One per 20 field samples	Refer to Worksheet 28-1	Refer to Worksheet 28-1	A
Field Duplicate	VOC	One per 10 field samples	Precision	%RPD ≤ 30%	S & A
Equipment Rinsate Blank	VOC	One per day	Bias / Contamination	No analyte detected > 1/2 QL. For common laboratory contaminants > QL	S
Field Blank	VOC	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Trip Blank	VOC	One per cooler	Bias / Contamination	Same as equipment rinsate blank	S & A
Temperature Blank	VOC	One per cooler	Accuracy / Representativeness	2-6°C	S

[1]If information varies within an analytical group, separate by individual analyte.

DOD QSM: Department of Defense Quality Systems Manual for Environmental Laboratories January 2006, Version 3.

SAP Worksheet #12-2—Measurement Performance Criteria Table

Matrix: Surface Soil, Subsurface Soil, and Sediment

Analytical Group: SVOC

Concentration Level: Low (SW-846 8270C), SIM (SW-846 8270C-SIM)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Low (SW-846 8270C)					
MS	SVOC	One per 20 field samples	Refer to Worksheet 28-2	Refer to Worksheet 28-2	A
MSD	SVOC	One per 20 field samples	Refer to Worksheet 28-2	Refer to Worksheet 28-2	A
Field Duplicate	SVOC	One per 10 field samples	Precision	%RPD ≤ 30%	S & A
Equipment Rinsate Blank	SVOC	One per day	Bias / Contamination	No analyte detected > 1/2 QL. For common laboratory contaminants > QL	S
Field Blank	SVOC	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Temperature Blank	SVOC	One per cooler	Accuracy / Representativeness	2-6°C	S

SAP Worksheet #12-2—Measurement Performance Criteria Table (continued)

Matrix: Surface Soil, Subsurface Soil, and Sediment

Analytical Group: SVOC

Concentration Level: Low (SW-846 8270C), SIM (SW-846 8270C-SIM)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
SIM (SW-846 8270C-SIM)					
MS	SVOC	One per 20 field samples	Refer to Worksheet 28-3	Refer to Worksheet 28-3	A
MSD	SVOC	One per 20 field samples	Refer to Worksheet 28-3	Refer to Worksheet 28-3	
Field Duplicate	SVOC	One per 10 field samples	Precision	%RPD ≤ 30%	S & A
Equipment Rinsate Blank	SVOC	One per day	Bias / Contamination	No analyte detected > 1/2 QL. For common laboratory contaminants > QL	S
Field Blank	SVOC	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Temperature Blank	SVOC	One per cooler	Accuracy / Representativeness	2-6°C	S

[1]If information varies within an analytical group, separate by individual analyte.

SAP Worksheet #12-3—Measurement Performance Criteria Table

Matrix: Surface Soil, Subsurface Soil, and Sediment

Analytical Group: PEST/PCB

Concentration Level: Low (SW-846 8081A, 8082)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
MS	PEST/PCB	One per 20 field samples	Accuracy / Bias	DOD QSM limits including the DOD QSM marginal exceedance criteria. Please refer to Worksheet 15.	A
MSD	PEST/PCB	One per 20 field samples	Accuracy / Bias / Precision	Same as MS and RPD ≤ 50%.	A
Field Duplicate	PEST/PCB	One per 10 field samples	Precision	%RPD ≤ 30%	S & A
Equipment Rinsate Blank	PEST/PCB	One per day	Bias / Contamination	No analyte detected > 1/2 QL	S
Field Blank	PEST/PCB	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Temperature Blank	PEST/PCB	One per cooler	Accuracy / Representativeness	2-6°C	S

[1]If information varies within an analytical group, separate by individual analyte.

SAP Worksheet #12-4—Measurement Performance Criteria Table

Matrix: Surface Soil, Subsurface Soil, Sediment, and Ash

Analytical Group: METAL

Concentration Level: Low (SW-846 6010B, 6020, 7471A, 9012B)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Metals (SW-846 6010B)					
MS	METAL	One per 20 field samples	Refer to Worksheet 28-4	Refer to Worksheet 28-4	A
MSD	METAL	One per 20 field samples	Refer to Worksheet 28-4	Refer to Worksheet 28-4	A
Field Duplicate	METAL	One per 10 field samples	Precision	%RPD ≤ 30%	S & A
Equipment Rinsate Blank	METAL	One per day	Bias / Contamination	No analyte detected > 1/2 PQL	S
Field Blank	METAL	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Metals (SW-846 6020)					
MS	METAL	One per 20 field samples	Refer to Worksheet 28-4	Refer to Worksheet 28-4	A

SAP Worksheet #12-4—Measurement Performance Criteria Table (continued)

Matrix: Surface Soil, Subsurface Soil, Sediment, and Ash

Analytical Group: METAL

Concentration Level: Low (SW-846 6010B, 6020, 7471A, 9012B)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
MSD	METAL	One per 20 field samples	Refer to Worksheet 28-4	Refer to Worksheet 28-4	A
Field Duplicate	METAL	One per 10 field samples	Precision	%RPD ≤ 30%	S & A
Equipment Rinsate Blank	METAL	One per day	Bias / Contamination	No analyte detected > 1/2 PQL	S
Field Blank	METAL	One per week	Bias / Contamination	Same as equipment rinseate blank	S
Mercury (SW-846 7471A)					
MS	METAL	One per 20 field samples	Accuracy / Bias	Recovery ± 25 % of true value if sample < 4x spike value	A
MSD	METAL	One per 20 field samples	Accuracy / Bias / Precision	Same as MS and RPD ≤ 20%	A
Field Duplicate	METAL	One per 10 field samples	Precision	%RPD ≤ 30%	S & A
Equipment Rinsate Blank	METAL	One per day	Bias / Contamination	No analyte detected > 1/2 PQL	S

SAP Worksheet #12-4—Measurement Performance Criteria Table (continued)

Matrix: Surface Soil, Subsurface Soil, Sediment, and Ash

Analytical Group: METAL

Concentration Level: Low (SW-846 6010B, 6020, 7471A, 9012B)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Field Blank	METAL	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Cyanide (SW-846 9012B)					
MS	METAL	One per 20 field samples	Refer to Worksheet 28-4	Refer to Worksheet 28-4	A
Field Duplicate	METAL	One per 10 field samples	Precision	%RPD ≤30%	S & A
Equipment Rinsate Blank	METAL	One per day	Bias / Contamination	No analyte detected > 1/2 PQL	S
Field Blank	METAL	One per week	Bias / Contamination	Same as equipment rinsate blank	S

[1]If information varies within an analytical group, separate by individual analyte.

SAP Worksheet #12-5—Measurement Performance Criteria Table

Matrix: Surface Soil, Subsurface Soil, and Sediment

Analytical Group: EXPLO

Concentration Level: Low (SW-846 8330M, IAPP, 6850)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Nitroaromatics/Nitroamines + Nitroglycerin (SW-846 8330M)					
MS	EXPLO	One per 20 field samples	Refer to Worksheet 28-5	Refer to Worksheet 28-5	A
MSD	EXPLO	One per 20 field samples	Refer to Worksheet 28-5	Refer to Worksheet 28-5	A
Field Duplicate	EXPLO	One per 10 field samples	Precision	%RPD ≤30%	S & A
Equipment Rinsate Blank	EXPLO	One per day	Bias / Contamination	No analyte detected > 1/2 PQL	S
Field Blank	EXPLO	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Temperature Blank	PEST/PCB	One per cooler	Accuracy / Representativeness	2-6°C	S

SAP Worksheet #12-5—Measurement Performance Criteria Table (continued)

Matrix: Surface Soil, Subsurface Soil, and Sediment

Analytical Group: EXPLO

Concentration Level: Low (SW-846 8330M, IAPP, 6850)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Nitroguanidine (IAPP)					
MS	EXPLO	One per 20 field samples	Refer to Worksheet 28-5	Refer to Worksheet 28-5	A
MSD	EXPLO	One per 20 field samples	Refer to Worksheet 28-5	Refer to Worksheet 28-5	A
Field Duplicate	EXPLO	One per 10 field samples	Precision	%RPD ≤30%	S & A
Equipment Rinsate Blank	EXPLO	One per day	Bias / Contamination	No analyte detected > 1/2 PQL	S
Field Blank	EXPLO	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Temperature Blank	PEST/PCB	One per cooler	Accuracy / Representativeness	2-6°C	S
Perchlorate (SW-846 6850)					
MS	EXPLO	One per 20 field samples	Refer to Worksheet 28-5	Refer to Worksheet 28-5	A
MSD	EXPLO	One per 20 field samples	Refer to Worksheet 28-5	Refer to Worksheet 28-5	A

SAP Worksheet #12-5—Measurement Performance Criteria Table (continued)

Matrix: Surface Soil, Subsurface Soil, and Sediment

Analytical Group: EXPLO

Concentration Level: Low (SW-846 8330M, IAPP, 6850)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Field Duplicate	EXPLO	One per 10 field samples	Precision	%RPD ≤30%	S & A
Equipment Rinsate Blank	EXPLO	One per day	Bias / Contamination	No analyte detected > 1/2 PQL	S
Field Blank	EXPLO	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Temperature Blank	PEST/PCB	One per cooler	Accuracy / Representativeness	2-6°C	S

[1]If information varies within an analytical group, separate by individual analyte.

SAP Worksheet #12-6—Measurement Performance Criteria Table

Matrix: Sediment

Analytical Group: WCHEM

Concentration Level: not applicable (N/A) (SW-846 9045C), Low (Lloyd Kahn)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Temperature Blank	WCHEM	One per cooler	Accuracy / Representativeness	2-6°C	S

[1]If information varies within an analytical group, separate by individual analyte.

SAP Worksheet #12-7—Measurement Performance Criteria Table

Matrix: Sediment

Analytical Group: GRAINSIZE

Concentration Level: N/A (ASTM D422)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
N/A	GRAINSIZE	N/A	N/A	N/A	N/A

[1]If information varies within an analytical group, separate by individual analyte.

N/A: Field QC samples are not applicable to GRAINSIZE.

SAP Worksheet #12-8—Measurement Performance Criteria Table

Matrix: Groundwater

Analytical Group: VOC

Concentration Level: Low (SW-846 8260B)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
MS	VOC	One per 20 field samples	Refer to Worksheet 28-8	Refer to Worksheet 28-8	A
MSD	VOC	One per 20 field samples	Refer to Worksheet 28-8	Refer to Worksheet 28-8	A
Field Duplicate	VOC	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	VOC	One per day	Bias / Contamination	No analyte detected > 1/2 QL. For common laboratory contaminants > QL	S
Field Blank	VOC	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Trip Blank	VOC	One per cooler	Bias / Contamination	Same as equipment rinsate blank	S & A
Temperature Blank	VOC	One per cooler	Accuracy / Representativeness	2-6°C	S

[1]If information varies within an analytical group, separate by individual analyte.

SAP Worksheet #12-9—Measurement Performance Criteria Table

Matrix: Groundwater

Analytical Group: SVOC

Concentration Level: Low (SW-846 8270C), SIM (SW-846 8270C-SIM)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Low (SW-846 8270C)					
MS	SVOC	One per 20 field samples	Refer to Worksheet 28-9	Refer to Worksheet 28-9	A
MSD	SVOC	One per 20 field samples	Refer to Worksheet 28-9	Refer to Worksheet 28-9	A
Field Duplicate	SVOC	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	SVOC	One per day	Bias / Contamination	No analyte detected > 1/2 QL. For common laboratory contaminants > QL	S
Field Blank	SVOC	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Temperature Blank	SVOC	One per cooler	Accuracy / Representativeness	2-6°C	S

SAP Worksheet #12-9—Measurement Performance Criteria Table (continued)

Matrix: Groundwater

Analytical Group: SVOC

Concentration Level: Low (SW-846 8270C), SIM (SW-846 8270C-SIM)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
SIM (SW-846 8270C-SIM)					
MS	SVOC	One per 20 field samples	Refer to Worksheet 28-9	Refer to Worksheet 28-9	A
MSD	SVOC	One per 20 field samples	Accuracy / Bias / Precision	Same as MS and RPD ≤ 50%	A
Field Duplicate	SVOC	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	SVOC	One per day	Bias / Contamination	No analyte detected > 1/2 QL. For common laboratory contaminants > QL	S
Field Blank	SVOC	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Temperature Blank	SVOC	One per cooler	Accuracy / Representativeness	2-6°C	S

[1]If information varies within an analytical group, separate by individual analyte.

SAP Worksheet #12-10—Measurement Performance Criteria Table

Matrix: Groundwater

Analytical Group: PEST/PCB

Concentration Level: Low (SW-846 8081A, 8082)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
MS	PEST/PCB	One per 20 field samples	Refer to Worksheet 28-10	Refer to Worksheet 28-10	A
MSD	PEST/PCB	One per 20 field samples	Refer to Worksheet 28-10	Refer to Worksheet 28-10	A
Field Duplicate	PEST/PCB	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	PEST/PCB	One per day	Bias / Contamination	No analyte detected > 1/2 QL	S
Field Blank	PEST/PCB	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Temperature Blank	PEST/PCB	One per cooler	Accuracy / Representativeness	2-6°C	S

[1]If information varies within an analytical group, separate by individual analyte.

SAP Worksheet #12-11—Measurement Performance Criteria Table

Matrix: Groundwater

Analytical Group: METAL

Concentration Level: Low (SW-846 6010B, 6020 7470A, 9012B)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Metals (SW-846 6010B)					
MS	METAL	One per 20 field samples	Refer to Worksheet 28-11	Refer to Worksheet 28-11	A
MSD	METAL	One per 20 field samples	Refer to Worksheet 28-11	Refer to Worksheet 28-11	A
Field Duplicate	METAL	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	METAL	One per day	Bias / Contamination	No analyte detected > 1/2 QL	S
Field Blank	METAL	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Metals (SW-846 6020)					
MS	METAL	One per 20 field samples	Refer to Worksheet 28-11	Refer to Worksheet 28-11	A
MSD	METAL	One per 20 field samples	Refer to Worksheet 28-11	Refer to Worksheet 28-11	A

SAP Worksheet #12-11—Measurement Performance Criteria Table (continued)

Matrix: Groundwater

Analytical Group: METAL

Concentration Level: Low (SW-846 6010B, 6020 7470A, 9012B)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Field Duplicate	METAL	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	METAL	One per day	Bias / Contamination	No analyte detected > 1/2 QL	S
Field Blank	METAL	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Mercury (SW-846 7470A)					
MS	METAL	One per 20 field samples	Refer to Worksheet 28-11	Refer to Worksheet 28-11	A
MSD	METAL	One per 20 field samples	Refer to Worksheet 28-11	Refer to Worksheet 28-11	A
Field Duplicate	METAL	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	METAL	One per day	Bias / Contamination	No analyte detected > 1/2 QL	S
Field Blank	METAL	One per week	Bias / Contamination	Same as equipment rinsate blank	S

SAP Worksheet #12-11—Measurement Performance Criteria Table (continued)

Matrix: Groundwater

Analytical Group: METAL

Concentration Level: Low (SW-846 6010B, 6020 7470A, 9012B)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Cyanide (SW-846 9012B)					
MS	METAL	One per 20 field samples	Refer to Worksheet 28-11	Refer to Worksheet 28-11	A
Field Duplicate	METAL	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	METAL	One per day	Bias / Contamination	No analyte detected > 1/2 QL	S
Field Blank	METAL	One per week	Bias / Contamination	Same as equipment rinsate blank	S

[1]If information varies within an analytical group, separate by individual analyte.

SAP Worksheet #12-12—Measurement Performance Criteria Table

Matrix: Groundwater

Analytical Group: FMETAL

Concentration Level: Low (SW-846 6010B, 6020 7470A)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Metals (SW-846 6010B)					
MS	FMETAL	One per 20 field samples	Refer to Worksheet 28-12	Refer to Worksheet 28-12	A
MSD	FMETAL	One per 20 field samples	Refer to Worksheet 28-12	Refer to Worksheet 28-12	A
Field Duplicate	FMETAL	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	FMETAL	One per day	Bias / Contamination	No analyte detected > 1/2 QL	S
Field Blank	FMETAL	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Metals (SW-846 6020)					
MS	FMETAL	One per 20 field samples	Refer to Worksheet 28-12	Refer to Worksheet 28-12	A
MSD	FMETAL	One per 20 field samples	Refer to Worksheet 28-12	Refer to Worksheet 28-12	A

SAP Worksheet #12-12—Measurement Performance Criteria Table (continued)

Matrix: Groundwater

Analytical Group: FMETAL

Concentration Level: Low (SW-846 6010B, 6020 7470A)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Field Duplicate	FMETAL	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	FMETAL	One per day	Bias / Contamination	No analyte detected > 1/2 QL	S
Field Blank	FMETAL	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Mercury (SW-846 7470A)					
MS	FMETAL	One per 20 field samples	Refer to Worksheet 28-12	Refer to Worksheet 28-12	A
MSD	FMETAL	One per 20 field samples	Refer to Worksheet 28-12	Refer to Worksheet 28-12	A
Field Duplicate	FMETAL	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	FMETAL	One per day	Bias / Contamination	No analyte detected > 1/2 QL	S
Field Blank	FMETAL	One per week	Bias / Contamination	Same as equipment rinsate blank	S

[1]If information varies within an analytical group, separate by individual analyte.

SAP Worksheet #12-13—Measurement Performance Criteria Table

Matrix: Groundwater

Analytical Group: EXPLO

Concentration Level: Low (SW-846 8330M, IAPP, 6850)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Nitroaromatics/Nitroamines + Nitroglycerin (SW-846 8330M)					
MS	EXPLO	One per 20 field samples	Refer to Worksheet 28-13	Refer to Worksheet 28-13	A
MSD	EXPLO	One per 20 field samples	Refer to Worksheet 28-13	Refer to Worksheet 28-13	A
Field Duplicate	EXPLO	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	EXPLO	One per day	Bias / Contamination	No analyte detected > 1/2 QL	S
Field Blank	EXPLO	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Temperature Blank	PEST/PCB	One per cooler	Accuracy / Representativeness	2-6°C	S

SAP Worksheet #12-13—Measurement Performance Criteria Table (continued)

Matrix: Groundwater

Analytical Group: EXPLO

Concentration Level: Low (SW-846 8330M, IAPP, 6850)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Nitroguanidine (IAPP)					
MS	EXPLO	One per 20 field samples	Refer to Worksheet 28-13	Refer to Worksheet 28-13	A
MSD	EXPLO	One per 20 field samples	Refer to Worksheet 28-13	Refer to Worksheet 28-13	A
Field Duplicate	EXPLO	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	EXPLO	One per day	Bias / Contamination	No analyte detected > 1/2 QL	S
Field Blank	EXPLO	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Temperature Blank	PEST/PCB	One per cooler	Accuracy / Representativeness	2-6°C	S
Perchlorate (SW-846 6850)					
MS	EXPLO	One per 20 field samples	Refer to Worksheet 28-13	Refer to Worksheet 28-13	A
MSD	EXPLO	One per 20 field samples	Refer to Worksheet 28-13	Refer to Worksheet 28-13	A

SAP Worksheet #12-13—Measurement Performance Criteria Table (continued)

Matrix: Groundwater

Analytical Group: EXPLO

Concentration Level: Low (SW-846 8330M, IAPP, 6850)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Field Duplicate	EXPLO	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	EXPLO	One per day	Bias / Contamination	No analyte detected > 1/2 QL	S
Field Blank	EXPLO	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Temperature Blank	PEST/PCB	One per cooler	Accuracy / Representativeness	2-6°C	S

[1]If information varies within an analytical group, separate by individual analyte.

SAP Worksheet #12-14—Measurement Performance Criteria Table

Matrix: Groundwater

Analytical Group: WCHEM

Concentration Level: Medium (EPA 130.2)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Temperature Blank	WCHEM	One per cooler	Accuracy / Representativeness	2-6°C	S

[1]If information varies within an analytical group, separate by individual analyte.

SAP Worksheet #12-15—Measurement Performance Criteria Table

Matrix: Surface Soil, Subsurface Soil, Sediment, Ash

Analytical Group: DIOXIN

Concentration Level: Low (SW-846 8290A)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
MS	DIOXIN	One per 20 field samples	Refer to Worksheet 28-15	Refer to Worksheet 28-15	A
MSD	DIOXIN	One per 20 field samples	Refer to Worksheet 28-15	Refer to Worksheet 28-15	A
Field Duplicate	DIOXIN	One per 10 field samples	Precision	%RPD ≤30%	S & A
Equipment Rinsate Blank	DIOXIN	One per day	Bias / Contamination	< 1/2QL	S
Field Blank	DIOXIN	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Temperature Blank	DIOXIN	One per cooler	Accuracy / Representativeness	2-6°C	S

[1]If information varies within an analytical group, separate by individual analyte.

SAP Worksheet #12-16—Measurement Performance Criteria Table

Matrix: Groundwater
Analytical Group: DIOXIN
Concentration Level: Low (SW-846 8290A)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group[1]	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
MS	DIOXIN	One per 20 field samples	Refer to Worksheet 28-16	Refer to Worksheet 28-16	A
MSD	DIOXIN	One per 20 field samples	Refer to Worksheet 28-16	Refer to Worksheet 28-16	A
Field Duplicate	DIOXIN	One per 10 field samples	Precision	%RPD ≤20%	S & A
Equipment Rinsate Blank	DIOXIN	One per day	Bias / Contamination	< 1/2QL	S
Field Blank	DIOXIN	One per week	Bias / Contamination	Same as equipment rinsate blank	S
Temperature Blank	DIOXIN	One per cooler	Accuracy / Representativeness	2-6°C	S

[1]If information varies within an analytical group, separate by individual analyte.

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SAP Worksheet #13—Secondary Data Criteria and Limitations Table

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
2008 Soil, *in situ* groundwater, ash, surface water, and sediment data	CH2M HILL. *Site 66 – Turkey Run Disposal Area Site Investigation Report*. November 2008.	CH2M HILL, soil, *in situ* groundwater, ash, surface water, and sediment data, 2008	Data will be used to assist the placement of RI sample locations. Additionally, data will be evaluated as part of the risk assessments during the RI	*In situ* groundwater data will not be included in the HHRA data set since it is not reproducible, making it not suitable to assess risk
Sediment	CH2M HILL. *Final Remedial Investigation Report, Sites 11, 13, 17, 21, and 25, Naval District Washington, Indian Head, Indian Head, Maryland*. 2004.	CH2M HILL, sediment data, 2000	Data will be used to assist the placement of RI sample locations.	None

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SAP Worksheet #14—Summary of Project Tasks

Project Logistics

In general, work will be performed by workers in Level D personal protective equipment (PPE), which includes hard hat, safety glasses, safety-toed boots, and hearing protection. Optional PPE includes the use of Tyvek® coveralls. Upgrades to higher levels of PPE are discussed in the HASP, provided as Appendix C.

Sampling activities are expected to be performed during normal working hours, except under specific arrangement with NSF-IH for after-hours or weekend activities.

Pre-Mobilization Tasks

- Procure subcontractors
- Schedule field and support staff and conduct field kickoff meeting
- Obtain dig permit from NSF-IH

Field Investigation Tasks

- **Third-Party Utility Clearance**

  CH2M HILL will identify and mark all sample locations. CH2M HILL will coordinate utility clearance with Miss Utility of Maryland and the base. A third-party utility clearance subcontractor (TBD) will conduct utility clearance for a 15-foot radius around each borehole location, if possible, so that boreholes can be easily relocated in the event that refusal is encountered at a proposed location. Clearance will be performed before conducting any intrusive work and in accordance with SOP B.1.

- **Monitoring Well Installation**

  With support from a drilling subcontractor (TBD), CH2M HILL will install five permanent monitoring wells; one upgradient of the site, two within the site boundary, and two downgradient of the site. Monitoring wells will be installed using HSA methods and in accordance with SOP B.2. Split-spoon samples will be collected at 2-foot intervals during advancement of the soil borings for lithological information according to SOP B.6.

  Monitoring wells will be constructed of 2-inch (inner–diameter) Schedule 40 polyvinyl chloride with a 10-foot, 0.01-inch slotted polyvinyl chloride screen and a stick-up finish. Actual depth of monitoring wells may be changed in accordance with field observations made by the field geologist during monitoring well installation activities.

- **Monitoring Well Survey**

  With support from a surveying subcontractor (TBD), CH2M HILL will survey the five permanent monitoring wells at the site. Well locations (northing, easting, elevation) will be recorded and loaded into the geographic information system (GIS) database. Well surveys will be conducted in accordance with SOP B.3.

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

- **Surface and subsurface soil sampling for chemical analysis**

  With support from a DPT subcontractor (TBD), CH2M HILL will collect 20 collocated surface and subsurface soil samples, as specified on Worksheet 17 and shown on Figure 5. Sampling protocols will follow SOP B.4 referenced in Worksheet 21. Four additional surface soil samples will be collected from the locations shown in Figure 5. Sampling protocols will follow SOP B.5. All soil samples will be logged for lithology according to SOP B.6. Appropriate QA/QC samples will be collected as specified on Worksheet 20.

- **Ash sampling for chemical analysis**

  CH2M HILL will collect six grab ash samples from the ground surface at Site 66 according to SOP B.5. Ash sample locations are shown on Figure 5.

- **Soil borings for lithology**

  DPT borings will be advanced within and outside of the fill boundary to native soil to determine fill thickness and extent of fill. Fourteen borings will be advanced; proposed locations are shown on Figure 5.

- **Groundwater sampling for chemical analysis**

  CH2M HILL will collect groundwater samples from the five newly installed monitoring wells, as specified on Worksheet 17. Sampling protocols will follow SOP B.7, referenced in Worksheet 21. Appropriate QA/QC samples will be collected as specified on Worksheet 20.

- **Sediment sampling for chemical analysis**

  CH2M HILL will collect 10 grab sediment samples as shown on Figure 7. Sampling protocols will follow SOP B.8, referenced in Worksheet 21.

- **Surveying**

  All soil, ash, and sediment sample locations will be located using a global positioning system in accordance with applicable SOPs referenced on Worksheet 21.

- **Documentation**

  Detailed field observations will be recorded in a field notebook in accordance with applicable SOPs referenced on Worksheet 21.

- **Decontamination**

  All non-disposable sampling equipment will be decontaminated before sampling activities at each location in accordance with applicable SOPs referenced on Worksheet 21.

- **IDW**

  IDW soil, purge water, and decontamination rinse water will be placed in metal drums and sampled for waste characterization parameters in accordance with applicable SOPs referenced on Worksheet 21.

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

Analyses and Testing Tasks

The analytical laboratory will process and prepare samples for analyses and analyze all samples for specified analytes as noted on Worksheet 18. The laboratory will provide all sample results in a Level IV data package, which includes all laboratory QC forms and raw data. Please refer to Worksheet 29a.

Quality Control Tasks

- SOPs for field and laboratory activities will be implemented.
- QC samples will be collected as described on Worksheet 20.

Secondary Data

Secondary data (Worksheet 13) provided by CH2M HILL has been incorporated into the site history narrative, and will be used for risk assessment and risk management purposes, as appropriate.

Data Validation, Review, and Management Tasks

- Database setup and management.
- Data validation will be performed by a third-party subcontractor to CH2M HILL as described on Worksheets 35 and 36.
- A data usability assessment will be performed as described on Worksheet 37.
- Validated data will be incorporated into CH2M HILL's data warehouse and basewide GIS in accordance with the NSF-IH Master Plans.

Documentation and Reporting

- Detailed field observations will be recorded in a field notebook in accordance with applicable SOPs referenced on Worksheet 21.
- The field work, data analyses and data evaluation will be described in Site 66 RI report.

Data Tracking, Storage, Archiving, Retrieval and Security

- Records will be tracked, maintained, and archived by the EIS (see organization chart on Worksheet 5) as described on Worksheet 29

Assessment/Audit Tasks

- See Worksheets 31 and 32.

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SAP Worksheet #15-1—Reference Limits and Evaluation Table

Matrix: Surface Soil, Subsurface Soil, and Sediment
Analytical Group: VOC

Analyte	CAS Number	RSLs Residential Soil Adjusted (µg/kg)	SS ERA Screening Level (µg/kg)	RSLs Res Soil X 10 for SD Adjusted (µg/kg)	SD ERA Screening Level (µg/kg)	PAL[1] (µg/kg)	Project Quantitation Limit (PQL) Goal[2] (µg/kg)	Laboratory-specific[3] QLs (µg/kg)	MDLs (µg/kg)	LCL (%)	UCL (%)	RPD (%)
Dichlorodifluoromethane (Freon-12)	75-71-8	19000	NC	190000	NC	19000	9500	10	0.28	35	135	≤ 30 %
Chloromethane	74-87-3	12000	NC	120000	NC	12000	6000	10	0.44	50	130	≤ 30 %
Vinyl chloride	75-01-4	60	300	600	NC	60	30	10	0.35	60	125	≤ 30 %
Bromomethane	74-83-9	790	NC	7900	NC	790	395	10	0.64	30	160	≤ 30 %
Chloroethane	75-00-3	1500000	NC	2200000	NC	1500000	750000	10	0.15	40	155	≤ 30 %
Trichlorofluoromethane(Freon-11)	75-69-4	80000	NC	800000	NC	80000	40000	10	0.48	25	185	≤ 30 %
1,1-Dichloroethene	75-35-4	25000	NC	250000	31	31	15.5	5	0.59	65	135	≤ 30 %
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	76-13-1	940000	NC	940000	NC	940000	470000	5	0.32	83*	137	≤ 30 %
Acetone	67-64-1	6100000	NC	61000000	NC	6100000	3050000	25	5.1	20	160	≤ 30 %
Carbon disulfide	75-15-0	67000	NC	260000	0.851	0.851	0.851	5	0.56	45	160	≤ 30 %
Methyl acetate	79-20-9	7800000	NC	29000000	NC	7800000	3900000	9	2.74	85*	129	≤ 30 %
Methylene chloride	75-09-2	11000	300	110000	NC	300	150	25	7.93	55	140	≤ 30 %
trans-1,2-Dichloroethene	156-60-5	11000	300	110000	NC	300	150	5	0.38	65	135	≤ 30 %
Methyl-tert-butyl ether (MTBE)	1634-04-4	39000	NC	390000	NC	39000	19500	5	1.06	58*	157	≤ 30 %
1,1-Dichloroethane	75-34-3	3400	300	34000	NC	300	150	6	1.67	75	125	≤ 30 %
cis-1,2-Dichloroethene	156-59-2	78000	300	780000	NC	300	150	5	0.32	65	125	≤ 30 %
2-Butanone	78-93-3	2800000	NC	28000000	NC	2800000	1400000	25	4.1	30	160	≤ 30 %
Chloroform	67-66-3	300	300	3000	NC	300	150	5	0.28	70	125	≤ 30 %
1,1,1-Trichloroethane	71-55-6	680000	300	680000	30.2	30.2	15.1	5	0.38	70	135	≤ 30 %
Cyclohexane	110-82-7	120000	100	120000	NC	100	50	5	0.32	87*	133	≤ 30 %
Carbon tetrachloride	56-23-5	250	300	2500	64.2	64.2	32.1	5	0.61	65	135	≤ 30 %
Benzene	71-43-2	1100	100	11000	NC	100	50	5	0.46	75	125	≤ 30 %
1,2-Dichloroethane	107-06-2	450	870000	4500	NC	450	225	5	0.31	70	135	≤ 30 %
Trichloroethene	79-01-6	2800	300	28000	96.9	96.9	48.45	5	0.37	75	125	≤ 30 %
Methylcyclohexane	108-87-2	NC	NC	NC	NC	N/A	5	5	0.53	80*	123	≤ 30 %
1,2-Dichloropropane	78-87-5	930	300	9300	NC	300	150	5	0.26	70	120	≤ 30 %
Bromodichloromethane	75-27-4	280	450000	2800	NC	280	140	5	0.45	70	130	≤ 30 %
cis-1,3-Dichloropropene	10061-01-5	1700	300	17000	NC	300	150	5	0.2	70	125	≤ 30 %
4-Methyl-2-pentanone	108-10-1	530000	100000	3200000	NC	100000	50000	25	3.44	45	145	≤ 30 %
Toluene	108-88-3	500000	100	930000	NC	100	50	5	0.46	70	125	≤ 30 %
trans-1,3-Dichloropropene	10061-02-6	1700	300	17000	NC	300	150	5	0.49	65	125	≤ 30 %
1,1,2-Trichloroethane	79-00-5	1100	300	11000	1240	300	150	5	0.67	60	125	≤ 30 %
Tetrachloroethene	127-18-4	570	300	5700	468	300	150	5	1.23	65	140	≤ 30 %
2-Hexanone	591-78-6	530000	NC	3200000	NC	530000	265000	25	3.81	45	145	≤ 30 %
Dibromochloromethane	124-48-1	700	NC	7000	NC	700	350	5	0.51	65	130	≤ 30 %
1,2-Dibromoethane	106-93-4	34	5000	340	NC	34	17	5	0.39	70	125	≤ 30 %
Chlorobenzene	108-90-7	31000	100	310000	8.42	8.42	8.42	5	0.38	75	125	≤ 30 %

SAP Worksheet #15-1—Reference Limits and Evaluation Table (continued)

Matrix: Surface Soil, Subsurface Soil, and Sediment

Analytical Group: VOC

Analyte	CAS Number	RSLs Residential Soil Adjusted (µg/kg)	SS ERA Screening Level (µg/kg)	RSLs Res Soil X 10 for SD Adjusted (µg/kg)	SD ERA Screening Level (µg/kg)	PAL[1] (µg/kg)	Project Quantitation Limit (PQL) Goal[2] (µg/kg)	Laboratory-specific[3]				
Ethylbenzene	100-41-4	5700	100	57000	1100	100	50	5	0.52	75	125	≤ 30 %
Xylene, total	1330-20-7	60000	100	300000	25.2	25.2	25.2	15	0.25	90*	118	≤ 30 %
Styrene	100-42-5	650000	100	1000000	NC	100	50	5	0.51	75	125	≤ 30 %
Bromoform	75-25-2	61000	1147000	610000	654	654	327	5	0.45	55	135	≤ 30 %
Isopropylbenzene	98-82-8	220000	NC	310000	NC	220000	110000	5	0.4	75	130	≤ 30 %
1,1,2,2-Tetrachloroethane	79-34-5	590	300	5900	1360	300	150	5	0.33	55	130	≤ 30 %
1,3-Dichlorobenzene	541-73-1	NC	20000	NC	4430	4430	2215	5	0.39	70	125	≤ 30 %
1,4-Dichlorobenzene	106-46-7	2600	20000	26000	599	599	299.5	5	0.44	70	125	≤ 30 %
1,2-Dichlorobenzene	95-50-1	200000	100	220000	16.5	16.5	8.25	5	0.4	75	120	≤ 30 %
1,2-Dibromo-3-chloropropane	96-12-8	5.6	NC	56	NC	5.6	5.6	5	1.53	40	135	≤ 30 %
1,2,4-Trichlorobenzene	120-82-1	8700	100	87000	2100	100	50	5	0.79	65	130	≤ 30 %

Shading indicates cells where the laboratory-specific QL is greater than the screening level, but the MDL is still less than the screening level. Please refer to Worksheet 11.

NC: No screening level for this compound.
µg/kg: micrograms per kilogram
LCL: lower confidence level
UCL: upper confidence level
[1]The PAL is the lower of RSLs Residential Soil Adjusted, SS ERA Screening Level, RSLs Res Soil X 10 for SD Adjusted, and SD ERA Screening Level.
[2]The PQL Goal is 1/2 the PAL, the PAL, or the laboratory-specific QL, as applicable.
[3]Limits are DOD QSM v.3 unless specified otherwise (when a DOD QSM limit does not exist).
*Katahdin in-house statistically-derived limits (when a DOD QSM limit does not exist).

SAP Worksheet #15-2—Reference Limits and Evaluation Table

Matrix: Surface Soil, Subsurface Soil, and Sediment

Analytical Group: SVOC (Combined list between SW-846 8270C and SW-846 8270C-SIM)

Analyte	CAS Number	Concentration Range[3]	RSLs Residential Soil Adjusted (µg/kg)	SS ERA Screening Level (µg/kg)	RSLs Res Soil X 10 for SD Adjusted (µg/kg)	SD ERA Screening Level (µg/kg)	PAL[1] (µg/kg)	PQL Goal[2] (µg/kg)	Laboratory-specific[4]				
									QLs (µg/kg)	MDLs (µg/kg)	LCL (%)	UCL (%)	RPD (%)
Benzaldehyde	100-52-7	Low	780000	NC	1900000	NC	780000	390000	360	119.97	10*	123	≤ 30 %
Phenol	108-95-2	SIM	1800000	100	18000000	420	100	100	100	6.07	40	100	≤ 30 %
bis(2-Chloroethyl)ether	111-44-4	SIM	190	NC	1900	NC	190	95	20	1.67	40	105	≤ 30 %
2-Chlorophenol	95-57-8	SIM	39000	100	390000	31.2	31.2	31.2	100	5.32	45	105	≤ 30 %
2-Methylphenol	95-48-7	SIM	310000	100	3100000	12	12	12	100	8.53	40	105	≤ 30 %
2,2'-Oxybis(1-chloropropane)	108-60-1	Low	3500	NC	35000	NC	3500	1750	330	88.51	20	115	≤ 30 %
Acetophenone	98-86-2	Low	780000	NC	2300000	NC	780000	390000	540	177.68	59*	102	≤ 30 %
4-Methylphenol	106-44-5	SIM	31000	100	310000	670	100	100	100	9.91	40	105	≤ 30 %
n-Nitroso-di-n-propylamine	621-64-7	SIM	69	NC	690	NC	69	34.5	20	1.85	40	115	≤ 30 %
Hexachloroethane	67-72-1	Low	6100	NC	61000	1027	1027	513.5	330	96.26	35	110	≤ 30 %
Nitrobenzene	98-95-3	SIM	4400	2260	44000	21	21	21	20	4.83	40	115	≤ 30 %
Isophorone	78-59-1	Low	510000	NC	5100000	NC	510000	255000	330	74.75	45	110	≤ 30 %
2-Nitrophenol	88-75-5	Low	39000	NC	390000	NC	39000	19500	510	166.6	40	110	≤ 30 %
2,4-Dimethylphenol	105-67-9	SIM	120000	100	1200000	29	29	29	20	3.24	30	105	≤ 30 %
bis(2-Chloroethoxy)methane	111-91-1	Low	18000	NC	180000	NC	18000	9000	330	96.02	45	110	≤ 30 %
2,4-Dichlorophenol	120-83-2	SIM	18000	100	180000	117	100	50	20	2.18	45	110	≤ 30 %
Naphthalene	91-20-3	SIM	3900	100	39000	176	100	50	20	2.57	40	105	≤ 30 %
4-Chloroaniline	106-47-8	Low	2400	20000	24000	NC	2400	1200	360	119.2	10	100	≤ 30 %
Hexachlorobutadiene	87-68-3	SIM	6100	NC	61000	1.3	1.3	1.3	20	2.31	40	115	≤ 30 %
Caprolactam	105-60-2	Low	3100000	NC	31000000	NC	3100000	1550000	440	144.42	30*	140	≤ 30 %
4-Chloro-3-methylphenol	59-50-7	Low	39000	NC	390000	NC	39000	19500	500	165.8	45	115	≤ 30 %
2-Methylnaphthalene	91-57-6	SIM	31000	NC	310000	20.2	20.2	20.2	20	2.21	45	105	≤ 30 %
Hexachlorocyclopentadiene	77-47-4	SIM	37000	100	370000	NC	100	50	20	1.54	23*	107	≤ 30 %
2,4,6-Trichlorophenol	88-06-2	SIM	6100	100	61000	213	100	100	100	3.25	45	110	≤ 30 %
2,4,5-Trichlorophenol	95-95-4	SIM	610000	100	6100000	213	100	100	100	2.54	50	110	≤ 30 %
1,1-Biphenyl	92-52-4	Low	260000	600	260000	1220	600	300	330	73.37	50*	113	≤ 30 %
2-Chloronaphthalene	91-58-7	Low	210000	1000	210000	NC	1000	500	330	86.64	45	105	≤ 30 %
2-Nitroaniline	88-74-4	Low	18000	NC	180000	NC	18000	9000	820	75.07	45	120	≤ 30 %
Dimethyl phthalate	131-11-3	SIM	NC	2000	NC	71	71	35.5	20	1.43	50	110	≤ 30 %
2,6-Dinitrotoluene	606-20-2	Low	6100	NC	61000	NC	6100	3050	330	78.76	50	110	≤ 30 %
Acenaphthylene	208-96-8	SIM	340000	100	3400000	5.9	5.9	5.9	20	1.22	45	105	≤ 30 %
3-Nitroaniline	99-09-2	Low	NC	NC	NC	NC	N/A	820	820	93.82	25	110	≤ 30 %
Acenaphthene	83-32-9	SIM	340000	100	3400000	6.7	6.7	6.7	20	1.45	45	110	≤ 30 %
2,4-Dinitrophenol	51-28-5	Low	12000	20000	120000	NC	12000	6000	1200	376.76	15	130	≤ 30 %
4-Nitrophenol	100-02-7	SIM	4400	100	44000	NC	100	100	100	7.98	15	140	≤ 30 %
Dibenzofuran	132-64-9	Low	7800	NC	78000	415	415	415	330	78.67	50	105	≤ 30 %
2,4-Dinitrotoluene	121-14-2	SIM	1600	NC	16000	41.6	41.6	41.6	21	6.99	50	115	≤ 30 %
Diethylphthalate	84-66-2	Low	4900000	1000	49000000	603	603	603	330	79.74	50	115	≤ 30 %

SAP Worksheet #15-2—Reference Limits and Evaluation Table (continued)

Matrix: Surface Soil, Subsurface Soil, and Sediment

Analytical Group: SVOC (Combined list between SW-846 8270C and SW-846 8270C-SIM)

Analyte	CAS Number	Concentration Range[3]	RSLs Residential Soil Adjusted (µg/kg)	SS ERA Screening Level (µg/kg)	RSLs Res Soil X 10 for SD Adjusted (µg/kg)	SD ERA Screening Level (µg/kg)	PAL[1] (µg/kg)	PQL Goal[2] (µg/kg)	Laboratory-specific[4]				
Fluorene	86-73-7	SIM	230000	100	2300000	77.4	77.4	38.7	20	3.15	50	110	≤ 30 %
4-Chlorophenyl-phenylether	7005-72-3	Low	31000	NC	310000	NC	31000	15500	330	77.86	45	110	≤ 30 %
4-Nitroaniline	100-01-6	Low	24000	NC	240000	NC	24000	12000	820	134.05	35	115	≤ 30 %
4,6-Dinitro-2-methylphenol	534-52-1	SIM	610	NC	6100	NC	610	610	310	100.21	30	135	≤ 30 %
n-Nitrosodiphenylamine	86-30-6	Low	99000	200	990000	2680	200	100	660	218.6	50	115	≤ 30 %
4-Bromophenyl-phenylether	101-55-3	Low	NC	NC	NC	1230	1230	615	330	84.57	45	115	≤ 30 %
Hexachlorobenzene	118-74-1	SIM	300	1000000	3000	20	20	20	20	1.79	45	120	≤ 30 %
Atrazine	1912-24-9	SIM	2100	0.05	21000	6.62	0.05	0.05	20	0.99	55**	135	≤ 30 %
Pentachlorophenol	87-86-5	SIM	3000	1730	30000	504	504	252	100	13.74	25	120	≤ 30 %
Phenanthrene	85-01-8	SIM	1700000	100	17000000	204	100	50	20	1.77	50	110	≤ 30 %
Anthracene	120-12-7	SIM	1700000	100	17000000	57.2	57.2	28.6	20	1.24	55	105	≤ 30 %
Carbazole	86-74-8	Low	NC	NC	NC	1800	1800	900	340	111.09	45	115	≤ 30 %
Di-n-butylphthalate	84-74-2	Low	610000	200000	6100000	6470	6470	3235	330	100.8	55	110	≤ 30 %
Fluoranthene	206-44-0	SIM	230000	100	2300000	423	100	50	20	1.76	55	115	≤ 30 %
Pyrene	129-00-0	SIM	170000	100	1700000	195	100	50	20	2.1	45	125	≤ 30 %
Butylbenzylphthalate	85-68-7	Low	260000	NC	2600000	10900	10900	5450	330	92.91	50	125	≤ 30 %
3,3'-Dichlorobenzidine	91-94-1	SIM	1100	NC	11000	127	127	63.5	20	2.98	10	130	≤ 30 %
Benzo(a)anthracene	56-55-3	SIM	150	100	1500	108	100	50	20	1.93	50	110	≤ 30 %
Chrysene	218-01-9	SIM	15000	100	150000	166	100	50	20	1.73	55	110	≤ 30 %
bis(2-Ethylhexyl)phthalate	117-81-7	SIM	35000	NC	350000	180	180	180	100	31.98	45	125	≤ 30 %
Di-n-octylphthalate	117-84-0	SIM	NC	NC	NC	61	61	61	140	46.49	40	130	≤ 30 %
Benzo(b)fluoranthene	205-99-2	SIM	150	100	1500	27.2	27.2	27.2	20	2.44	45	115	≤ 30 %
Benzo(k)fluoranthene	207-08-9	SIM	1500	100	15000	27.2	27.2	27.2	20	3.1	45	125	≤ 30 %
Benzo(a)pyrene	50-32-8	SIM	15	100	150	150	15	15	20	3.29	50	110	≤ 30 %
Indeno(1,2,3-cd)pyrene	193-39-5	SIM	150	100	1500	17	17	17	20	1.85	40	120	≤ 30 %
Dibenz(a,h)anthracene	53-70-3	SIM	15	100	150	33	15	15	20	1.84	40	125	≤ 30 %
Benzo(g,h,i)perylene	191-24-2	SIM	170000	100	1700000	170	100	50	20	1.95	40	125	≤ 30 %

Shading indicates cells where the laboratory-specific QL is greater than the screening level, but the MDL is still less than the screening level. Please refer to Worksheet 11.

Shading indicates cells where the laboratory-specific QL and MDL are greater than the screening level. Please refer to Worksheet 11.

NC: No screening level for this compound.

[1]The PAL is the lower of RSLs Residential Soil Adjusted, SS ERA Screening Level, RSLs Res Soil X 10 for SD Adjusted, and SD ERA Screening Level.

[2]The PQL Goal is 1/2 the PAL, the PAL, or the laboratory=specific QL, as applicable.

[3]The SIM list is chosen to best achieve the PQL goal and also based on laboratory capability (compound must have an established QL/MDL).

[4]Limits are DOD QSM v.3 unless specified otherwise (when a DOD QSM limit does not exist).

*Katahdin in-house statistically-derived limits (when a DOD QSM limit does not exist).

**Nominal limits (no DOD QSM limit and no statistically-generated limit).

SAP Worksheet #15-3—Reference Limits and Evaluation Table

Matrix: Surface Soil, Subsurface Soil, and Sediment

Analytical Group: PEST/PCB

Analyte	CAS Number	RSLs Residential Soil Adjusted (µg/kg)	SS ERA Screening Level (µg/kg)	RSLs Res Soil X 10 for SD Adjusted (µg/kg)	SD ERA Screening Level (µg/kg)	PAL[1] (µg/kg)	PQL[2] (µg/kg)	Laboratory-specific[3]				
								QLs (µg/kg)	MDLs (µg/kg)	LCL (%)	UCL (%)	RPD (%)
alpha-BHC	319-84-6	77	100000	770	6	6	3	1.7	0.46	60	125	≤ 30 %
beta-BHC	319-85-7	270	100000	2700	5	5	2.5	1.7	0.38	60	125	≤ 30 %
delta-BHC	319-86-8	270	100000	2700	6400	270	135	1.7	0.33	55	130	≤ 30 %
gamma-BHC (Lindane)	58-89-9	520	100	5200	2.37	2.37	1.185	1.7	0.46	60	125	≤ 30 %
Heptachlor	76-44-8	110	1000	1100	68	68	34	1.7	0.47	50	140	≤ 30 %
Aldrin	309-00-2	29	100	290	2	2	2	1.7	0.41	45	140	≤ 30 %
Heptachlor epoxide	1024-57-3	53	100	530	2.47	2.47	2.47	1.7	0.44	65	130	≤ 30 %
Endosulfan I	959-98-8	37000	NC	370000	2.9	2.9	2.9	1.7	0.4	15	135	≤ 30 %
Dieldrin	60-57-1	30	100	300	1.9	1.9	1.9	3.3	0.38	65	125	≤ 30 %
4,4'-DDE	72-55-9	1400	100	14000	3.16	3.16	3.16	3.3	0.37	70	125	≤ 30 %
Endrin	72-20-8	1800	100	18000	2.22	2.22	2.22	3.3	0.38	60	135	≤ 30 %
Endosulfan II	33213-65-9	37000	NC	370000	14	14	7	3.3	0.44	35	140	≤ 30 %
4,4'-DDD	72-54-8	2000	100	20000	4.88	4.88	4.88	3.3	0.42	30	135	≤ 30 %
Endosulfan sulfate	1031-07-8	37000	NC	370000	5.4	5.4	5.4	3.3	0.45	60	135	≤ 30 %
4,4'-DDT	50-29-3	1700	100	17000	4.16	4.16	4.16	3.3	0.42	45	140	≤ 30 %
Methoxychlor	72-43-5	31000	100	310000	18.7	18.7	9.35	17	0.48	55	145	≤ 30 %
Endrin ketone	53494-70-5	1800	100	18000	3	3	3	3.3	0.9	65	135	≤ 30 %
Endrin aldehyde	7421-93-4	1800	100	18000	2.22	2.22	2.22	3.3	0.35	35	145	≤ 30 %
alpha-Chlordane	5103-71-9	1600	100	16000	3.24	3.24	3.24	1.7	0.47	65	120	≤ 30 %
gamma-Chlordane	5103-74-2	1600	224	16000	2800	224	112	1.7	0.45	65	125	≤ 30 %
Toxaphene	8001-35-2	440	NC	4400	1	1	1	43	14	N/A	N/A	N/A
Aroclor-1016	12674-11-2	390	100	3900	59.8	59.8	29.9	17	5.23	40	140	≤ 30 %
Aroclor-1221	11104-28-2	170	100	1700	59.8	59.8	59.8	30	9.92	N/A	N/A	N/A
Aroclor-1232	11141-16-5	170	100	1700	59.8	59.8	29.9	20	6.64	N/A	N/A	N/A
Aroclor-1242	53469-21-9	220	100	2200	59.8	59.8	29.9	17	3.78	N/A	N/A	N/A
Aroclor-1248	12672-29-6	220	100	2200	59.8	59.8	29.9	29	9.54	N/A	N/A	N/A
Aroclor-1254	11097-69-1	110	100	1100	59.8	59.8	29.9	21	6.86	N/A	N/A	N/A
Aroclor-1260	11096-82-5	220	100	2200	59.8	59.8	29.9	17	3.26	60	130	≤ 30 %

Shading indicates cells where the laboratory-specific QL is greater than the screening level, but the MDL is still less than the screening level. Please refer to Worksheet 11.

NC: No screening level for this compound.

[1]The PAL is the lower of RSLs Residential Soil Adjusted, SS ERA Screening Level, RSLs Res Soil X 10 for SD Adjusted, and SD ERA Screening Level.

[2]The PQL Goal is 1/2 the PAL, the PAL, or the laboratory-specific QL, as applicable.

[3]Limits are DOD QSM v.3.

SAP Worksheet #15-4—Reference Limits and Evaluation Table

Matrix: Surface Soil, Subsurface Soil, Sediment, and Ash

Analytical Group: METAL (includes combined list between SW-846 6010B and 6020, includes mercury by 7471A, includes cyanide by 9012B)

Analyte	CAS Number	Concentration Range[3]	RSLs Residential Soil Adjusted (µg/kg)	SS ERA Screening Level (µg/kg)	RSLs Res Soil X 10 for SD Adjusted (µg/kg)	SD ERA Screening Level (µg/kg)	PAL[1] (µg/kg)	PQL[2] (µg/kg)	Laboratory-specific	
									QLs (µg/kg)	MDLs (µg/kg)
Aluminum	7429-90-5	Low	7700	50	77000	25500	50	50	30	2.87
Antimony	7440-36-0	Low	3.1	78	31	2	2	1	0.8	0.099
Arsenic	7440-38-2	ICP-MS	0.39	18	3.9	9.8	0.39	0.39	0.5	0.151
Barium	7440-39-3	Low	1500	330	15000	500	330	165	0.5	0.0606
Beryllium	7440-41-7	Low	16	40	160	NC	16	8	0.5	0.00947
Cadmium	7440-43-9	Low	7	32	70	0.99	0.99	0.99	1	0.00657
Calcium	7440-70-2	Low	NUT	NUT	NUT	NUT	N/A	7	7	2.09
Chromium	7440-47-3	ICP-MS	280	0.4	2800	43.4	0.4	0.4	0.5	0.153
Cobalt	7440-48-4	ICP-MS	2.3	13	23	50	2.3	1.15	0.1	0.00582
Copper	7440-50-8	Low	310	70	3100	31.6	31.6	15.8	2.5	0.0945
Iron	7439-89-6	Low	5500	200	55000	20000	200	100	10	1.28
Lead	7439-92-1	Low	400	120	400	35.8	35.8	17.9	0.5	0.136
Magnesium	7439-95-4	Low	NUT	NUT	NUT	NUT	N/A	5	5	0.92
Manganese	7439-96-5	Low	180	220	1800	460	180	90	0.5	0.0794
Mercury	7439-97-6	Low	2.3	0.1	23	0.18	0.1	0.05	0.04	0.00224
Nickel	7440-02-0	Low	150	38	1500	22.7	22.7	11.35	4	0.0327
Potassium	7440-09-7	Low	NUT	NUT	NUT	NUT	N/A	100	100	5.26
Selenium	7782-49-2	ICP-MS	39	0.52	390	2	0.52	0.52	0.5	0.117
Silver	7440-22-4	ICP-MS	39	560	390	1	1	0.5	0.1	0.00923
Sodium	7440-23-5	Low	NUT	NUT	NUT	NUT	N/A	100	100	3.89
Thallium	7440-28-0	ICP-MS	0.51	1	5.1	NC	0.51	0.255	0.2	0.0149
Vanadium	7440-62-2	ICP-MS	39	2	390	57	2	1	0.5	0.0998
Zinc	7440-66-6	Low	2300	120	23000	121	120	60	2.5	0.115
Cyanide	57-12-5	Low	160	0.3	1600	0.1	0.1	0.05	1	0.222

Shading indicates cells where the laboratory-specific QL is greater than the screening level, but the MDL is still less than the screening level. Please refer to Worksheet 11.

NUT: No screening level for this compound because it is a nutrient.

[1]The PAL is the lower of RSLs Residential Soil Adjusted, SS ERA Screening Level, RSLs Res Soil X 10 for SD Adjusted, and SD ERA Screening Level.

[2]The PQL Goal is 1/2 the PAL, the PAL, or the laboratory-specific QL, as applicable.

[3]The ICP-MS list is chosen to best achieve the PQL goal and also based on laboratory capability (analyte must have an established QL/MDL).

SAP Worksheet #15-5—Reference Limits and Evaluation Table

Matrix: Surface Soil, Subsurface Soil and Sediment
Analytical Group: EXPLO

Analyte	CAS Number	RSLs Residential Soil Adjusted (µg/kg)	SS ERA Screening Level (µg/kg)	RSLs Res Soil X 10 for SD Adjusted (µg/kg)	SD ERA Screening Level (µg/kg)	PAL[1] (µg/kg)	PQL Goal[2] (µg/kg)	Laboratory-specific[3]				
								QLs (µg/kg)	MDLs (µg/kg)	LCL (%)	UCL (%)	RPD (%)
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	380000	NC	3800000	NC	380000	190000	100	8.6	80	115	≤ 30 %
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	5500	NC	55000	NC	5500	2750	100	6.8	70	135	≤ 30 %
1,3,5-Trinitrobenzene (1,3,5-TNB)	99-35-4	220000	2260	2200000	NC	2260	1130	100	6.7	75	125	≤ 30 %
1,3-Dinitrobenzene (1,3-DNB)	99-65-0	610	2260	6100	NC	610	305	100	6.2	80	125	≤ 30 %
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	24000	NC	240000	NC	24000	12000	100	5.4	30**	120	≤ 30 %
Nitrobenzene (NB)	98-95-3	4400	2260	44000	21	21	21	100	22	75	125	≤ 30 %
2,4,6-Trinitrotoluene (2,4,6-TNT)	118-96-7	3600	NC	36000	NC	3600	1800	100	6.7	55	140	≤ 30 %
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	19406-51-0	15000	NC	150000	NC	15000	7500	100	17	80	125	≤ 30 %
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	35572-78-2	15000	NC	150000	NC	15000	7500	100	21	80	125	≤ 30 %
2,4-Dinitrotoluene (2,4-DNT)	121-14-2	1600	NC	16000	41.6	41.6	41.6	100	15	80	125	≤ 30 %
2,6-Dinitrotoluene (2,6-DNT)	606-20-2	6100	NC	61000	NC	6100	3050	100	27	80	120	≤ 30 %
2-Nitrotoluene (2-NT)	88-72-2	2900	NC	29000	NC	2900	1450	100	12	80	125	≤ 30 %
3-Nitrotoluene (3-NT)	99-08-1	120000	NC	1200000	NC	120000	60000	100	7.9	75	120	≤ 30 %
4-Nitrotoluene (4-NT)	99-99-0	24000	NC	240000	NC	24000	12000	100	31	75	125	≤ 30 %
Nitroguanidine (NQ)	556-88-7	610000	NC	6100000	NC	610000	305000	250	20	72	121	≤ 20 %
Nitroglycerin (NG)	55-63-0	610	NC	6100	NC	610	610	800	137	30**	120	≤ 50 %
Perchlorate	14797-73-0	5500	NC	55000	NC	5500	2750	5	0.26	80	120	≤ 15 %

Shading indicates cells where the laboratory-specific QL is greater than the screening level, but the MDL is still less than the screening level. Please refer to Worksheet 11.
Shading indicates cells where the laboratory-specific QL and MDL are greater than the screening level. Please refer to Worksheet 11.

NC: No screening level for this compound.

[1]The PAL is the lower of RSLs Residential Soil Adjusted, SS ERA Screening Level, RSLs Res Soil X 10 for SD Adjusted, and SD ERA Screening Level.

[2]The PQL Goal is 1/2 the PAL, the PAL, or the laboratory-specific QL, as applicable.

[3]Limits are DOD QSM v.3 unless specified otherwise (when a DOD QSM limit does not exist).

**Nominal limits (when a DOD QSM limit does not exist and a statistically-derived limit does not exist).

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SAP Worksheet #15-6—Reference Limits and Evaluation Table

Matrix: Sediment

Analytical Group: WCHEM

Analyte	CAS Number[3]	PAL[2]	PQL Goal[2]	Laboratory-specific[1]	
				QLs	MDLs
pH	PH	N/A	N/A	N/A	N/A
TOC	TOC	N/A	400 mg/kg	400 mg/kg	45.5 mg/kg

mg/kg: milligrams per kilogram

[1]QLs and MDLs are not applicable to pH data.

[2]There are no screening levels or PALs applicable to WCHEM data. For TOC, the PQL Goal is the laboratory-specific QL.

[3]These CAS numbers are contractor-specific.

SAP Worksheet #15-7—Reference Limits and Evaluation Table

Matrix: Sediment

Analytical Group: GRAINSIZE

Analyte	CAS Number[3]	PAL[2] (percent)	PQL Goal[2] (percent)	Laboratory-specific	
				QLs (percent)	MDLs (percent)
GS03 Sieve 3" (75 mm)	SIEVE75.0	N/A	N/A	N/A	N/A
GS05 Sieve 2" (50 mm)	SIEVE50.0	N/A	N/A	N/A	N/A
GS06 Sieve 1.5" (37.5 mm)	SIEVE37.5	N/A	N/A	N/A	N/A
GS07 Sieve 1" (25.0 mm)	SIEVE25.0	N/A	N/A	N/A	N/A
GS08 Sieve 0.75" (19.0 mm)	SIEVE19.0	N/A	N/A	N/A	N/A
GS10 Sieve 0.375" (9.5 mm)	SIEVE9.5	N/A	N/A	N/A	N/A
Sieve No. 004 (4.75 mm)	SIEVE4.75	N/A	N/A	N/A	N/A
Sieve No. 010 (2.00 mm)	SIEVE2.0	N/A	N/A	N/A	N/A
Sieve No. 020 (850 um)	SIEVE850	N/A	N/A	N/A	N/A
Sieve No. 040 (425 um)	SIEVE425	N/A	N/A	N/A	N/A
Sieve No. 060 (250 um)	SIEVE250	N/A	N/A	N/A	N/A
Sieve No. 080 (180 um)	SIEVE180	N/A	N/A	N/A	N/A
Sieve No. 100 (150 um)	SIEVE150	N/A	N/A	N/A	N/A
Sieve No. 200 (75um)	SIEVE75	N/A	N/A	N/A	N/A
Gravel (%)	GRAVEL	N/A	N/A	N/A	N/A
Sand (%)	14808-60-7	N/A	N/A	N/A	N/A
Coarse Sand (%)	COARSESAND	N/A	N/A	N/A	N/A
Medium Sand (%)	MEDIUMSAND	N/A	N/A	N/A	N/A
Fine Sand (%)	FINESAND	N/A	N/A	N/A	N/A
Fines (%)	FINES	N/A	N/A	N/A	N/A

[1]QLs and MDLs are not applicable to GRAINSIZE data.

[2]There are no screening levels or PALs applicable to GRAINSIZE data. The PQL Goal is not applicable.

[3]These CAS numbers are contractor-specific.

SAP Worksheet #15-8—Reference Limits and Evaluation Table

Matrix: Groundwater and Aqueous (blanks)

Analytical Group: VOC

Analyte	CAS Number	RSLs Tap Water Adjusted (µg/L)	MCL-Groundwater (µg/L)	PAL[1] (µg/L)	PQL Goal[2] (µg/L)	Laboratory-specific[3]				
						QLs (µg/L)	MDLs (µg/L)	LCL (%)	UCL (%)	RPD (%)
Dichlorodifluoromethane (Freon-12)	75-71-8	39	NC	39	19.5	2	0.35	30	155	≤ 20 %
Chloromethane	74-87-3	19	NC	19	9.5	2	0.26	40	125	≤ 20 %
Vinyl chloride	75-01-4	0.016	2	0.016	0.016	2	0.26	50	145	≤ 20 %
Bromomethane	74-83-9	0.87	NC	0.87	0.87	2	0.33	30	145	≤ 20 %
Chloroethane	75-00-3	2100	NC	2100	1050	2	0.34	60	135	≤ 20 %
Trichlorofluoromethane(Freon-11)	75-69-4	130	NC	130	65	2	0.51	60	145	≤ 20 %
1,1-Dichloroethene	75-35-4	34	7	7	3.5	1	0.26	70	130	≤ 20 %
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	76-13-1	5900	NC	5900	2950	3	0.73	78*	132	≤ 20 %
Acetone	67-64-1	2200	NC	2200	1100	7	2.1	40	140	≤ 20 %
Carbon disulfide	75-15-0	100	NC	100	50	1	0.25	35	160	≤ 20 %
Methyl acetate	79-20-9	3700	NC	3700	1850	3	0.79	62*	137	≤ 20 %
Methylene chloride	75-09-2	4.8	5	4.8	4.8	5	0.3	55	140	≤ 20 %
trans-1,2-Dichloroethene	156-60-5	11	100	11	5.5	2	0.35	60	140	≤ 20 %
Methyl-tert-butyl ether (MTBE)	1634-04-4	12	NC	12	6	2	0.5	65	125	≤ 20 %
1,1-Dichloroethane	75-34-3	2.4	NC	2.4	1.2	1	0.22	70	135	≤ 20 %
cis-1,2-Dichloroethene	156-59-2	37	70	37	18.5	1	0.24	70	125	≤ 20 %
2-Butanone	78-93-3	710	NC	710	355	5	1.33	30	150	≤ 20 %
Chloroform	67-66-3	0.19	80	0.19	0.19	1	0.22	35	135	≤ 20 %
1,1,1-Trichloroethane	71-55-6	910	200	200	100	1	0.31	65	130	≤ 20 %
Cyclohexane	110-82-7	1300	NC	1300	650	2	0.39	60*	150	≤ 20 %
Carbon tetrachloride	56-23-5	0.2	5	0.2	0.2	2	0.36	65	140	≤ 20 %
Benzene	71-43-2	0.41	5	0.41	0.205	1	0.28	80	120	≤ 20 %
1,2-Dichloroethane	107-06-2	0.15	5	0.15	0.15	1	0.26	70	130	≤ 20 %
Trichloroethene	79-01-6	1.7	5	1.7	1.7	2	0.37	70	125	≤ 20 %
Methylcyclohexane	108-87-2	NC	NC	N/A	2	2	0.37	74*	128	≤ 20 %
1,2-Dichloropropane	78-87-5	0.39	5	0.39	0.39	1	0.3	75	125	≤ 20 %
Bromodichloromethane	75-27-4	0.12	80	0.12	0.12	1	0.27	65	130	≤ 20 %
cis-1,3-Dichloropropene	10061-01-5	0.43	NC	0.43	0.43	1	0.31	70	130	≤ 20 %
4-Methyl-2-pentanone	108-10-1	200	NC	200	100	6	1.9	60	135	≤ 20 %
Toluene	108-88-3	230	1000	230	115	2	0.35	75	120	≤ 20 %
trans-1,3-Dichloropropene	10061-02-6	0.43	NC	0.43	0.43	1	0.25	55	140	≤ 20 %
1,1,2-Trichloroethane	79-00-5	0.24	5	0.24	0.24	1	0.28	75	125	≤ 20 %
Tetrachloroethene	127-18-4	0.11	5	0.11	0.11	2	0.4	45	150	≤ 20 %
2-Hexanone	591-78-6	200	NC	200	100	6	1.7	55	130	≤ 20 %
Dibromochloromethane	124-48-1	0.15	80	0.15	0.15	1	0.26	60	135	≤ 20 %
1,2-Dibromoethane	106-93-4	0.0065	0.05	0.0065	0.0065	1	0.28	80	120	≤ 20 %
Chlorobenzene	108-90-7	9.1	100	9.1	4.55	1	0.25	80	120	≤ 20 %

SAP Worksheet #15-8—Reference Limits and Evaluation Table (continued)

Matrix: Groundwater and Aqueous (blanks)

Analytical Group: VOC

Analyte	CAS Number	RSLs Tap Water Adjusted (µg/L)	MCL-Groundwater (µg/L)	PAL[1] (µg/L)	PQL Goal[2] (µg/L)	Laboratory-specific[3]				
						QLs (µg/L)	MDLs (µg/L)	LCL (%)	UCL (%)	RPD (%)
Ethylbenzene	100-41-4	1.5	700	1.5	1.5	1	0.3	75	125	≤ 20 %
Xylene, total	1330-20-7	20	10000	20	10	3	0.26	84*	120	≤ 20 %
Styrene	100-42-5	160	100	100	50	1	0.27	65	135	≤ 20 %
Bromoform	75-25-2	8.5	80	8.5	4.25	2	0.37	70	130	≤ 20 %
Isopropylbenzene	98-82-8	68	NC	68	34	2	0.36	75	125	≤ 20 %
1,1,2,2-Tetrachloroethane	79-34-5	0.067	NC	0.067	0.067	1	0.3	65	130	≤ 20 %
1,3-Dichlorobenzene	541-73-1	NC	NC	N/A	2	2	0.34	75	125	≤ 20 %
1,4-Dichlorobenzene	106-46-7	0.43	75	0.43	0.43	1	0.28	75	125	≤ 20 %
1,2-Dichlorobenzene	95-50-1	37	600	37	18.5	1	0.29	70	120	≤ 20 %
1,2-Dibromo-3-chloropropane	96-12-8	0.00032	0.2	0.00032	0.00032	2	0.64	50	130	≤ 20 %
1,2,4-Trichlorobenzene	120-82-1	0.82	70	0.82	0.82	2	0.34	65	135	≤ 20 %

Shading indicates cells where the laboratory-specific QL is greater than the screening level, but the MDL is still less than the screening level. Please refer to Worksheet 11.

Shading indicates cells where the laboratory-specific QL and MDL are greater than the screening level. Please refer to Worksheet 11.

µg/L: micrograms per liter

NC: No screening level for this compound.

[1]The PAL is the lower of RSLs Tap Water Adjusted or MCL-Groundwater.

[2]The PQL Goal is 1/2 the PAL, the PAL, or the laboratory-specific QL, as applicable.

[3]Limits are DOD QSM v.3 unless specified otherwise (when a DOD QSM limit does not exist).

*Katahdin in-house statistically-derived limits (when a DOD QSM limit does not exist).

SAP Worksheet #15-9—Reference Limits and Evaluation Table

Matrix: Groundwater and Aqueous (blanks)

Analytical Group: SVOC (Combined list between SW-846 8270C and SW-846 8270C-SIM)

Analyte	CAS Number	Concentration Range[3]	RSLs Tap Water Adjusted (µg/L)	MCL-Groundwater (µg/L)	PAL[1] (µg/L)	PQL Goal[2] (µg/L)	Laboratory-specific[4] QLs (µg/L)	MDLs (µg/L)	LCL (%)	UCL (%)	RPD (%)
Benzaldehyde	100-52-7	Low	370	NC	370	185	10	2.92	10*	77	≤ 30 %
Phenol	108-95-2	Low	1100	NC	1100	550	10	1.92	0	115	≤ 30 %
bis(2-Chloroethyl)ether	111-44-4	SIM	0.012	NC	0.012	0.012	0.20	0.0407	35	110	≤ 30 %
2-Chlorophenol	95-57-8	Low	18	NC	18	18	11	3.44	35	105	≤ 30 %
2-Methylphenol	95-48-7	Low	180	NC	180	90	13	4.04	40	110	≤ 30 %
2,2'-Oxybis(1-chloropropane)	108-60-1	SIM	0.32	NC	0.32	0.32	0.40	0.121	25	130	≤ 30 %
Acetophenone	98-86-2	Low	370	NC	370	185	12	3.82	54*	103	≤ 30 %
4-Methylphenol	106-44-5	Low	18	NC	18	18	10	2.68	30	110	≤ 30 %
n-Nitroso-di-n-propylamine	621-64-7	SIM	0.0096	NC	0.0096	0.0096	0.30	0.0716	35	130	≤ 30 %
Hexachloroethane	67-72-1	SIM	3.7	NC	3.7	1.85	0.30	0.0726	30	100	≤ 30 %
Nitrobenzene	98-95-3	SIM	0.12	NC	0.12	0.12	0.40	0.130	45	110	≤ 30 %
Isophorone	78-59-1	Low	71	NC	71	35.5	10	1.87	10*	126	≤ 30 %
2-Nitrophenol	88-75-5	Low	18	NC	18	9	12	3.62	40	115	≤ 30 %
2,4-Dimethylphenol	105-67-9	Low	73	NC	73	36.5	12	3.74	30	110	≤ 30 %
bis(2-Chloroethoxy)methane	111-91-1	Low	11	NC	11	5.5	10	2.45	45	105	≤ 30 %
2,4-Dichlorophenol	120-83-2	Low	11	NC	11	5.5	13	4.01	50	105	≤ 30 %
Naphthalene	91-20-3	SIM	0.14	NC	0.14	0.14	0.20	0.0640	40	100	≤ 30 %
4-Chloroaniline	106-47-8	Low	0.34	NC	0.34	0.34	10	1.67	15	110	≤ 30 %
Hexachlorobutadiene	87-68-3	SIM	0.86	NC	0.86	0.43	0.30	0.0871	25	105	≤ 30 %
Caprolactam	105-60-2	Low	1800	NC	1800	900	10	0.400	15*	35	≤ 30 %
4-Chloro-3-methylphenol	59-50-7	Low	18	NC	18	18	10	2.57	45	110	≤ 30 %
2-Methylnaphthalene	91-57-6	Low	15	NC	15	15	10	2.06	45	105	≤ 30 %
Hexachlorocyclopentadiene	77-47-4	Low	22	50	22	11	10	1.24	10*	106	≤ 30 %
2,4,6-Trichlorophenol	88-06-2	SIM	3.7	NC	3.7	1.85	1.0	0.120	50	115	≤ 30 %
2,4,5-Trichlorophenol	95-95-4	Low	370	NC	370	185	25	4.22	50	110	≤ 30 %
1,1-Biphenyl	92-52-4	Low	180	NC	180	90	10	1.75	49*	112	≤ 30 %
2-Chloronaphthalene	91-58-7	Low	290	NC	290	145	10	2.10	50	105	≤ 30 %
2-Nitroaniline	88-74-4	SIM	11	NC	11	5.5	0.40	0.118	50	115	≤ 30 %
Dimethyl phthalate	131-11-3	Low	NC	NC	N/A	10	10	0.79	25	125	≤ 30 %
2,6-Dinitrotoluene	606-20-2	SIM	3.7	NC	3.7	1.85	0.30	0.0703	50	115	≤ 30 %
Acenaphthylene	208-96-8	Low	220	NC	220	110	10	1.48	50	105	≤ 30 %
3-Nitroaniline	99-09-2	Low	NC	NC	N/A	25	25	1.39	20	125	≤ 30 %
Acenaphthene	83-32-9	Low	220	NC	220	110	10	1.68	45	110	≤ 30 %
2,4-Dinitrophenol	51-28-5	SIM	7.3	NC	7.3	3.65	1.0	0.243	15	140	≤ 30 %
4-Nitrophenol	100-02-7	SIM	0.12	NC	0.12	0.12	1.0	0.235	0	125	≤ 30 %
Dibenzofuran	132-64-9	SIM	3.7	NC	3.7	1.85	0.30	0.0682	55	105	≤ 30 %
2,4-Dinitrotoluene	121-14-2	SIM	0.22	NC	0.22	0.22	0.20	0.0352	50	120	≤ 30 %
Diethylphthalate	84-66-2	Low	2900	NC	2900	1450	10	1.10	40	125	≤ 30 %

SAP Worksheet #15-9—Reference Limits and Evaluation Table (continued)

Matrix: Groundwater and Aqueous (blanks)

Analytical Group: SVOC (Combined list between SW-846 8270C and SW-846 8270C-SIM)

Analyte	CAS Number	Concentration Range[3]	RSLs Tap Water Adjusted (µg/L)	MCL-Groundwater (µg/L)	PAL[1] (µg/L)	PQL Goal[2] (µg/L)	Laboratory-specific[4]				
							QLs (µg/L)	MDLs (µg/L)	LCL (%)	UCL (%)	RPD (%)
Fluorene	86-73-7	Low	150	NC	150	75	10	1.11	50	110	≤ 30 %
4-Chlorophenyl-phenylether	7005-72-3	Low	18	NC	18	18	10	1.39	50	110	≤ 30 %
4-Nitroaniline	100-01-6	SIM	3.4	NC	3.4	1.7	0.20	0.0647	35	120	≤ 30 %
4,6-Dinitro-2-methylphenol	534-52-1	SIM	0.37	NC	0.37	0.37	2.0	0.500	40	130	≤ 30 %
n-Nitrosodiphenylamine	86-30-6	Low	14	NC	14	7	10	1.86	50	110	≤ 30 %
4-Bromophenyl-phenylether	101-55-3	Low	NC	NC	N/A	10	10	1.28	50	115	≤ 30 %
Hexachlorobenzene	118-74-1	SIM	0.042	1	0.042	0.042	0.20	0.0554	50	110	≤ 30 %
Atrazine	1912-24-9	SIM	0.29	3	0.29	0.29	0.20	0.0378	30**	150	≤ 30 %
Pentachlorophenol	87-86-5	SIM	0.56	1	0.56	0.56	1.0	0.333	40	115	≤ 30 %
Phenanthrene	85-01-8	Low	1100	NC	1100	550	10	0.94	50	115	≤ 30 %
Anthracene	120-12-7	Low	1100	NC	1100	550	10	1.41	55	110	≤ 30 %
Carbazole	86-74-8	Low	NC	NC	N/A	10	10	1.33	50	115	≤ 30 %
Di-n-butylphthalate	84-74-2	Low	370	NC	370	185	10	1.22	55	115	≤ 30 %
Fluoranthene	206-44-0	Low	150	NC	150	75	10	1.26	55	115	≤ 30 %
Pyrene	129-00-0	Low	110	NC	110	55	10	1.5	50	130	≤ 30 %
Butylbenzylphthalate	85-68-7	Low	35	NC	35	17.5	10	1.5	45	115	≤ 30 %
3,3'-Dichlorobenzidine	91-94-1	SIM	0.15	NC	0.15	0.15	0.20	0.0564	20	110	≤ 30 %
Benzo(a)anthracene	56-55-3	SIM	0.029	NC	0.029	0.029	0.20	0.0460	55	110	≤ 30 %
Chrysene	218-01-9	SIM	2.9	NC	2.9	1.45	0.20	0.0360	55	110	≤ 30 %
bis(2-Ethylhexyl)phthalate	117-81-7	SIM	4.8	6	4.8	2.4	2.0	0.498	40	125	≤ 30 %
Di-n-octylphthalate	117-84-0	Low	NC	NC	N/A	10	10	2.3	35	135	≤ 30 %
Benzo(b)fluoranthene	205-99-2	SIM	0.029	NC	0.029	0.029	0.3	0.089	45	120	≤ 30 %
Benzo(k)fluoranthene	207-08-9	SIM	0.29	NC	0.29	0.29	0.2	0.049	45	125	≤ 30 %
Benzo(a)pyrene	50-32-8	SIM	0.0029	0.2	0.0029	0.0029	0.2	0.066	55	110	≤ 30 %
Indeno(1,2,3-cd)pyrene	193-39-5	SIM	0.029	NC	0.029	0.029	0.2	0.052	45	125	≤ 30 %
Dibenz(a,h)anthracene	53-70-3	SIM	0.0029	NC	0.0029	0.0029	0.3	0.07	40	125	≤ 30 %
Benzo(g,h,i)perylene	191-24-2	Low	110	NC	110	55	10	1.84	40	125	≤ 30 %

Shading indicates cells where the laboratory-specific QL is greater than the screening level, but the MDL is still less than the screening level. Please refer to Worksheet 11.

Shading indicates cells where the laboratory-specific QL and MDL are greater than the screening level. Please refer to Worksheet 11.

NC: No screening level for this compound.

[1]The PAL is the lower of RSLs Tap Water Adjusted or MCL-Groundwater.

[2]The PQL Goal is 1/2 the PAL, the PAL, or the laboratory-specific QL, as applicable.

[3]The SIM list is chosen to best achieve the PQL goal and also based on laboratory capability (compound must have an established QL/MDL).

[4]Limits are DOD QSM v.3 unless specified otherwise (when a DOD QSM limit does not exist).

*Katahdin in-house statistically-derived limits (when a DOD QSM limit does not exist).

**Nominal limits (when a DOD QSM limit does not exist and there is no statistically-determined limit).

SAP Worksheet #15-10—Reference Limits and Evaluation Table

Matrix: Groundwater and Aqueous (blanks)
Analytical Group: PEST/PCB

Analyte	CAS Number	RSLs Tap Water Adjusted (µg/L)	MCL-Groundwater (µg/L)	PAL[1] (µg/L)	PQL Goal[2] (µg/L)	Laboratory-specific[3]				
						QLs (µg/L)	MDLs (µg/L)	LCL (%)	UCL (%)	RPD (%)
alpha-BHC	319-84-6	0.011	NC	0.011	0.011	0.05	0.0061	60	130	≤ 30 %
beta-BHC	319-85-7	0.037	NC	0.037	0.037	0.05	0.0079	65	125	≤ 30 %
delta-BHC	319-86-8	0.037	NC	0.037	0.037	0.05	0.0044	45	135	≤ 30 %
gamma-BHC (Lindane)	58-89-9	0.061	0.2	0.061	0.061	0.05	0.0058	25	135	≤ 30 %
Heptachlor	76-44-8	0.015	0.4	0.015	0.015	0.05	0.014	40	130	≤ 30 %
Aldrin	309-00-2	0.004	NC	0.004	0.004	0.05	0.015	25	140	≤ 30 %
Heptachlor epoxide	1024-57-3	0.0074	0.2	0.0074	0.0074	0.05	0.0064	60	130	≤ 30 %
Endosulfan I	959-98-8	22	NC	22	11	0.05	0.0058	50	110	≤ 30 %
Dieldrin	60-57-1	0.0042	NC	0.0042	0.0042	0.1	0.0042	60	130	≤ 30 %
4,4'-DDE	72-55-9	0.2	NC	0.2	0.1	0.1	0.0069	35	140	≤ 30 %
Endrin	72-20-8	1.1	2	1.1	0.55	0.1	0.0033	55	135	≤ 30 %
Endosulfan II	33213-65-9	22	NC	22	11	0.1	0.0064	30	130	≤ 30 %
4,4'-DDD	72-54-8	0.28	NC	0.28	0.14	0.1	0.012	25	150	≤ 30 %
Endosulfan sulfate	1031-07-8	22	NC	22	11	0.1	0.0036	55	135	≤ 30 %
4,4'-DDT	50-29-3	0.2	NC	0.2	0.1	0.1	0.0052	45	140	≤ 30 %
Methoxychlor	72-43-5	18	40	18	9	0.5	0.013	55	150	≤ 30 %
Endrin ketone	53494-70-5	1.1	2	1.1	0.55	0.1	0.0024	75	125	≤ 30 %
Endrin aldehyde	7421-93-4	1.1	2	1.1	0.55	0.1	0.0041	55	135	≤ 30 %
alpha-Chlordane	5103-71-9	0.19	NC	0.19	0.095	0.05	0.0098	65	125	≤ 30 %
gamma-Chlordane	5103-74-2	0.19	NC	0.19	0.095	0.05	0.0080	60	125	≤ 30 %
Toxaphene	8001-35-2	0.061	3	0.061	0.061	1	0.058	N/A	N/A	N/A
Aroclor-1016	12674-11-2	0.26	0.5	0.26	0.26	0.5	0.16	25	145	≤ 30 %
Aroclor-1221	11104-28-2	0.0068	0.5	0.0068	0.0068	1.3	0.40	N/A	N/A	N/A
Aroclor-1232	11141-16-5	0.0068	0.5	0.0068	0.0068	0.5	0.12	N/A	N/A	N/A
Aroclor-1242	53469-21-9	0.034	0.5	0.034	0.034	0.5	0.12	N/A	N/A	N/A
Aroclor-1248	12672-29-6	0.034	0.5	0.034	0.034	0.5	0.08	N/A	N/A	N/A
Aroclor-1254	11097-69-1	0.034	0.5	0.034	0.034	0.5	0.092	N/A	N/A	N/A
Aroclor-1260	11096-82-5	0.034	0.5	0.034	0.034	0.5	0.13	30	145	≤ 30 %

(yellow) Shading indicates cells where the laboratory-specific QL is greater than the screening level, but the MDL is still less than the screening level. Please refer to Worksheet 11.

(orange) Shading indicates cells where the laboratory-specific QL and MDL are greater than the screening level. Please refer to Worksheet 11.

NC: No screening level for this compound.

[1]The PAL is the lower of RSLs Tap Water Adjusted or MCL-Groundwater.

[2]The PQL Goal is 1/2 the PAL, the PAL, or the laboratory=specific QL, as applicable.

[3]Limits are DOD QSM v.3.

SAP Worksheet #15-11—Reference Limits and Evaluation Table

Matrix: Groundwater and Aqueous (blanks)

Analytical Group: METAL and FMETAL (includes combined list between SW-846 6010B and 6020, includes mercury by 7470A, includes cyanide by 9012B)

Analyte[4]	CAS Number	Concentration Range[3]	RSLs Tap Water Adjusted (µg/L)	MCL-Groundwater (µg/L)	PAL[1] (µg/L)	PQL Goal[2] (µg/L)	Laboratory-specific	
							QLs (ug/L) µ	MDLs (µg/L)
Aluminum	7429-90-5	Low	3700	NC	3700	1850	300	12.5
Antimony	7440-36-0	ICP-MS[3]	1.5	6	1.5	1.5	1	0.140
Arsenic	7440-38-2	ICP-MS	0.045	10	0.045	0.045	5	1.48
Barium	7440-39-3	Low	730	2000	730	365	5	0.354
Beryllium	7440-41-7	ICP-MS	7.3	4	4	2	1	0.06
Cadmium	7440-43-9	ICP-MS	1.8	5	1.8	1.8	1	0.0454
Calcium	7440-70-2	Low	NUT	NUT	N/A	50	50	6.84
Chromium	7440-47-3	ICP-MS	11	100	11	5.5	3	0.3
Cobalt	7440-48-4	ICP-MS	1.1	NC	1.1	1.1	1	0.08
Copper	7440-50-8	Low	150	1300	150	75	25	0.704
Iron	7439-89-6	Low	2600	NC	2600	1300	100	5.17
Lead	7439-92-1	Low	NC	15	15	7.5	5	1.02
Magnesium	7439-95-4	Low	NUT	NUT	N/A	50	50	9.39
Manganese	7439-96-5	Low	88	NC	88	44	5	0.667
Mercury	7439-97-6	Low	1.1	2	1.1	0.55	0.2	0.021
Nickel	7440-02-0	Low	73	NC	73	73	40	0.244
Potassium	7440-09-7	Low	NUT	NUT	N/A	1000	1000	95
Selenium	7782-49-2	Low	18	50	18	18	10	3.03
Silver	7440-22-4	Low	18	NC	18	18	15	0.787
Sodium	7440-23-5	Low	NUT	NUT	N/A	1000	1000	21.7
Thallium	7440-28-0	ICP-MS	0.24	2	0.24	0.24	2	0.114
Vanadium	7440-62-2	ICP-MS	18	NC	18	9	5	0.685
Zinc	7440-66-6	Low	1100	NC	1100	550	25	1.73
Cyanide[4]	57-12-5	Low	73	200	73	36.5	0.12	0.004

Shading indicates cells where the laboratory-specific QL is greater than the screening level, but the MDL is still less than the screening level. Please refer to Worksheet 11.

Shading indicates cells where the laboratory-specific QL and MDL are greater than the screening level. Please refer to Worksheet 11.

NC: No screening level for this compound.

NUT: No screening level for this compound because it is a nutrient.

N/A: Not applicable

[1]The PAL is the lower of RSLs Tap Water Adjusted or MCL-Groundwater.

[2]The PQL Goal is 1/2 the PAL, the PAL, or the laboratory-specific QL, as applicable.

[3]The ICP-MS list is chosen to best achieve the PQL goal and also based on laboratory capability (analyte must have an established QL/MDL).

[4]Cyanide is not analyzed with the filtered metals.

SAP Worksheet #15-12—Reference Limits and Evaluation Table

Matrix: Groundwater and Aqueous (blanks)

Analytical Group: EXPLO

Analyte	CAS Number	RSLs Tap Water Adjusted (µg/L)	MCL-Groundwater (µg/L)	PAL[1] (µg/L)	PQL Goal[2] (µg/L)	Laboratory-specific[3]				
						QLs (µg/L)	MDLs (µg/L)	LCL (%)	UCL (%)	RPD (%)
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	180	NC	180	90	1	0.043	80	115	≤ 30 %
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	0.61	NC	0.61	0.61	1	0.046	50	160	≤ 30 %
1,3,5-Trinitrobenzene (1,3,5-TNB)	99-35-4	110	NC	110	55	1	0.04	65	140	≤ 30 %
1,3-Dinitrobenzene (1,3-DNB)	99-65-0	0.37	NC	0.37	0.37	1	0.045	45	160	≤ 30 %
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	15	NC	15	7.5	1	0.06	30**	120	≤ 30 %
Nitrobenzene (NB)	98-95-3	0.12	NC	0.12	0.12	1	0.07	50	140	≤ 30 %
2,4,6-Trinitrotoluene (2,4,6-TNT)	118-96-7	1.8	NC	1.8	1.8	1	0.064	20	175	≤ 30 %
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	19406-51-0	7.3	NC	7.3	3.65	1	0.053	55	155	≤ 30 %
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	35572-78-2	7.3	NC	7.3	3.65	1	0.038	50	155	≤ 30 %
2,4-Dinitrotoluene (2,4-DNT)	121-14-2	0.22	NC	0.22	0.22	1	0.052	60	135	≤ 30 %
2,6-Dinitrotoluene (2,6-DNT)	606-20-2	3.7	NC	3.7	1.85	1	0.056	60	135	≤ 30 %
2-Nitrotoluene (2-NT)	88-72-2	0.31	NC	0.31	0.31	1	0.071	45	135	≤ 30 %
3-Nitrotoluene (3-NT)	99-08-1	73	NC	73	36.5	1	0.062	50	130	≤ 30 %
4-Nitrotoluene (4-NT)	99-99-0	4.2	NC	4.2	2.1	1	0.06	50	130	≤ 30 %
Nitroguanidine (NQ)	556-88-7	370	NC	370	185	20	9.67	73	117	≤ 15 %
Nitroglycerin (NG)	55-63-0	0.37	NC	0.37	0.37	4	0.34	30**	120	≤ 30 %
Perchlorate	14797-73-0	2.6	NC	2.6	1.3	0.5	0.082	80	120	≤ 15 %

Shading indicates cells where the laboratory-specific QL is greater than the screening level, but the MDL is still less than the screening level. Please refer to Worksheet 11.

NC: No screening level for this compound.

N/A: Not applicable

[1]The PAL is the lower of RSLs Tap Water Adjusted or MCL-Groundwater.

[2]The PQL Goal is 1/2 the PAL, the PAL, or the laboratory-specific QL, as applicable.

[3]Limits are DOD QSM v.3 unless specified otherwise (when a DOD QSM limit does not exist).

**Nominal limits (when a DOD QSM limit does not exist and a statistically-derived limit does not exist).

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SAP Worksheet #15-13—Reference Limits and Evaluation Table

Matrix: Groundwater

Analytical Group: WCHEM

Analyte	CAS Number[3]	PAL[2]	PQL Goal[2]	Laboratory-specific[1]	
				QLs	MDLs
Hardness	HARDNESS	N/A	5000 ug/L	5000 µg/L	1630 µg/L

N/A: Not applicable

[1]QLs and MDLs are not applicable to hardness data.

[2]There are no screening levels or PALs applicable to WCHEM data. For hardness, the PQL goal is the laboratory-specific QL.

[3]These CAS numbers are contractor-specific.

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SAP Worksheet #15-14—Reference Limits and Evaluation Table

Matrix: Surface Soil, Subsurface Soil, Sediment, and Ash

Analytical Group: DIOXIN

Analyte	CAS Number	RSLs Residential Soil Adjusted (ng/kg)	SS ERA Screening Level (ng/kg)	RSLs Res Soil X 10 for SD Adjusted (ng/kg)	SD ERA Screening Level (ng/kg)	PAL[1] (ng/kg)	PQL Goal[2] (ng/kg)	Laboratory-specific[4]				
								QLs (ng/kg)	EDLs (ng/kg)[3]	LCL (%)	UCL (%)	RPD (%)
2,3,7,8-TCDD (dioxin)	1746-01-6	4.5	1000	45	0.85	0.85	0.85	1.0	0.0588	79	128	≤ 25 %
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	40321-76-4	4.5	NC	45	NC	4.5	4.5	2.5	0.0482	78	126	≤ 25 %
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	39227-28-6	45	NC	450	NC	45	22.5	2.5	0.0466	71	130	≤ 25 %
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	57653-85-7	45	NC	450	NC	45	22.5	2.5	0.0425	80	128	≤ 25 %
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	19408-74-3	45	NC	450	NC	45	22.5	2.5	0.0447	70	130	≤ 25 %
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	3582246-9	NC	NC	NC	NC	N/A	2.5	2.5	0.0479	70	130	≤ 25 %
Octachlorodibenzo-p-dioxin	3268-87-9	NC	NC	NC	NC	N/A	5.0	5.0	0.0695	80	130	≤ 20 %
2,3,7,8-Tetrachlorodibenzofuran	51207-31-9	NC	NC	NC	NC	N/A	1.0	1.0	0.0562	73	126	≤ 20 %
1,2,3,7,8-Pentachlorodibenzofuran	57117-41-6	NC	NC	NC	NC	N/A	2.5	2.5	0.0396	71	130	≤ 20 %
2,3,4,7,8-Pentachlorodibenzofuran	57117-31-4	NC	NC	NC	NC	N/A	2.5	2.5	0.0388	72	121	≤ 20 %
1,2,3,4,7,8-Hexachlorodibenzofuran	70648-26-9	45	NC	450	NC	45	22.5	2.5	0.0340	74	129	≤ 20 %
1,2,3,6,7,8-Hexachlorodibenzofuran	57117-44-9	45	NC	450	NC	45	22.5	2.5	0.0335	73	128	≤ 20 %
1,2,3,7,8,9-Hexachlorodibenzofuran	72918-21-9	45	NC	450	NC	45	22.5	2.5	0.0418	70	130	≤ 20 %
2,3,4,6,7,8-Hexachlorodibenzofuran	60851-34-5	45	NC	450	NC	45	22.5	2.5	0.0367	71	125	≤ 20 %
1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4	450	NC	4500	NC	450	225	2.5	0.0377	70	130	≤ 20 %
1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7	450	NC	4500	NC	450	225	2.5	0.0500	78	130	≤ 20 %
Octachlorodibenzofuran	39001-02-0	NC	NC	NC	NC	N/A	5.0	5.0	0.0644	70	130	≤ 20 %
Total tetrachlorodibenzo-p-dioxin	41903-57-5	NC	NC	NC	NC	N/A	1.0	1.0	0.0590	N/A	N/A	N/A
Total pentachlorodibenzo-p-dioxin	36088-22-9	NC	NC	NC	NC	N/A	2.5	2.5	0.0480	N/A	N/A	N/A
Total hexachlorodibenzo-p-dioxin	34465-46-8	NC	NC	NC	NC	N/A	2.5	2.5	0.0430	N/A	N/A	N/A
Total heptachlorodibenzo-p-dioxin	37871-00-4	NC	NC	NC	NC	N/A	2.5	2.5	0.0480	N/A	N/A	N/A
Total tetrachlorodibenzofuran	55722-27-5	NC	NC	NC	NC	N/A	1.0	1.0	0.0560	N/A	N/A	N/A
Total pentachlorodibenzofuran	30402-15-4	NC	NC	NC	NC	N/A	2.5	2.5	0.0400	N/A	N/A	N/A
Total hexachlorodibenzofuran	55684-94-1	NC	NC	NC	NC	N/A	2.5	2.5	0.0340	N/A	N/A	N/A
Total heptachlorodibenzofuran	38998-75-3	NC	NC	NC	NC	N/A	2.5	2.5	0.0380	N/A	N/A	N/A

Shading indicates cells where the laboratory-specific QL is greater than the screening level, but the Estimated Detection Limit (EDL) is still less than the screening level. Please refer to Worksheet 11.

NC: No screening level for this compound.

N/A: Not applicable

[1]The PAL is the lower of RSLs Residential Soil Adjusted, SS ERA Screening Level, RSLs Res Soil X 10 for SD Adjusted, and SD ERA Screening Level.

[2]The PQL Goal is 1/2 the PAL, the PAL, or the laboratory-specific QL, as applicable.

[3]HRMS methods (such as SW-846 8290A) typically do not use the MDL for reporting purposes. Instead, results are flagged if they are less than the QL but greater than the EDL. The EDL is calculated by multiplying 2.5 times the baseline noise in the retention time range for each congener in each sample.

[4]Limits are Columbia Analytical Services, Inc.-Houston in-house statistically-derived limits.

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

Matrix: Groundwater, Aqueous (blanks)

Analytical Group: DIOXIN

Analyte	CAS Number	RSLs Tap Water Adjusted (pg/L)	MCL-Groundwater (pg/L)	PAL[1] (pg/L)	PQL Goal[2] (pg/L)	Laboratory-specific[4] QLs (pg/L)	EDLs (pg/L)[3]	LCL (%)	UCL (%)	RPD (%)
2,3,7,8-TCDD (dioxin)	1746-01-6	0.52	30	0.52	0.52	10	0.805	79	130	≤ 25 %
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	40321-76-4	0.52	60	0.52	0.52	25	0.770	79	123	≤ 25 %
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	39227-28-6	5.2	300	5.2	5.2	25	0.773	83	130	≤ 25 %
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	57653-85-7	5.2	300	5.2	5.2	25	0.637	80	128	≤ 25 %
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	19408-74-3	5.2	300	5.2	5.2	25	0.695	70	130	≤ 25 %
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	3582246-9	NC	NC	N/A	25	25	0.719	76	122	≤ 25 %
Octachlorodibenzo-p-dioxin	3268-87-9	NC	NC	N/A	50	50	0.917	70	126	≤ 20 %
2,3,7,8-Tetrachlorodibenzofuran	51207-31-9	NC	300	300	150	10	1.23	80	126	≤ 20 %
1,2,3,7,8-Pentachlorodibenzofuran	57117-41-6	NC	600	600	300	25	0.580	79	124	≤ 20 %
2,3,4,7,8-Pentachlorodibenzofuran	57117-31-4	NC	60	60	30	25	0.564	73	122	≤ 20 %
1,2,3,4,7,8-Hexachlorodibenzofuran	70648-26-9	5.2	300	5.2	5.2	25	0.492	78	123	≤ 20 %
1,2,3,6,7,8-Hexachlorodibenzofuran	57117-44-9	5.2	300	5.2	5.2	25	0.456	75	128	≤ 20 %
1,2,3,7,8,9-Hexachlorodibenzofuran	72918-21-9	5.2	300	5.2	5.2	25	0.571	70	130	≤ 20 %
2,3,4,6,7,8-Hexachlorodibenzofuran	60851-34-5	5.2	300	5.2	5.2	25	0.521	70	123	≤ 20 %
1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4	52	3000	52	26	25	0.511	74	118	≤ 20 %
1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7	52	3000	52	26	25	0.667	70	130	≤ 20 %
Octachlorodibenzofuran	39001-02-0	NC	NC	N/A	50	50	0.916	72	130	≤ 20 %
Total tetrachlorodibenzo-p-dioxin	41903-57-5	NC	NC	N/A	10	10	0.805	N/A	N/A	N/A
Total pentachlorodibenzo-p-dioxin	36088-22-9	NC	NC	N/A	25	25	0.770	N/A	N/A	N/A
Total hexachlorodibenzo-p-dioxin	34465-46-8	NC	NC	N/A	25	25	0.637	N/A	N/A	N/A
Total heptachlorodibenzo-p-dioxin	37871-00-4	NC	NC	N/A	25	25	0.719	N/A	N/A	N/A
Total tetrachlorodibenzofuran	55722-27-5	NC	NC	N/A	10	10	1.23	N/A	N/A	N/A
Total pentachlorodibenzofuran	30402-15-4	NC	NC	N/A	25	25	0.564	N/A	N/A	N/A
Total hexachlorodibenzofuran	55684-94-1	NC	NC	N/A	25	25	0.456	N/A	N/A	N/A
Total heptachlorodibenzofuran	38998-75-3	NC	NC	N/A	25	25	0.511	N/A	N/A	N/A

Shading indicates cells where the laboratory-specific QL is greater than the screening level, but the EDL is still less than the screening level. Please refer to Worksheet 11.

Shading indicates cells where the laboratory-specific QL and EDL are greater than the screening level. Please refer to Worksheet 11.

NC: No screening level for this compound.

N/A: Not applicable

[1]The PAL is the lower of RSLs Tap Water Adjusted or MCL-Groundwater.

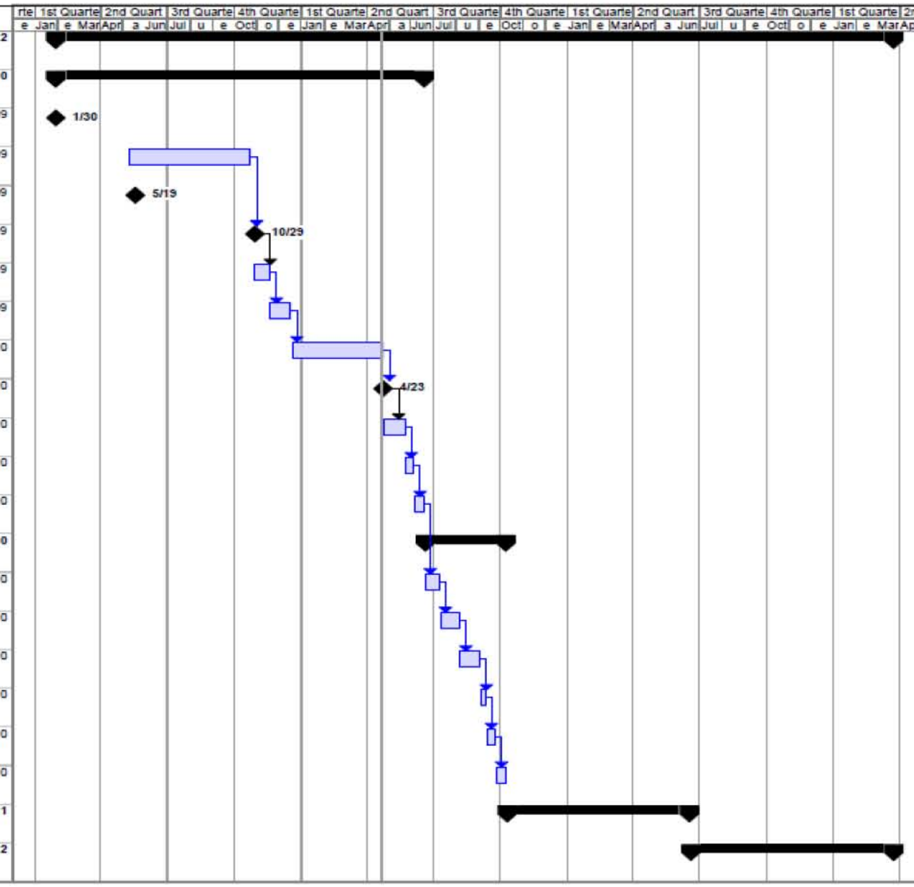
[2]The PQL Goal is 1/2 the PAL, the PAL, or the laboratory-specific QL, as applicable.

[3]HRMS methods (such as SW-846 8290A) typically do not use the MDL for reporting purposes. Instead, results are flagged if they are less than the QL but greater than the EDL. The EDL is calculated by multiplying 2.5 times the baseline noise in the retention time range for each congener in each sample.

[4]Limits are Columbia Analytical Services, Inc.-Houston in-house statistically-derived limits.

SAP Worksheet #16—Project Schedule/Timeline Table

ID		Task Name	Duration	Start	Finish
1		**Site 66 RI/FS Project**	**821 days**	**Fri 1/30/09**	**Fri 3/23/12**
2		**UFP-SAP Work Plan**	**361 days**	**Fri 1/30/09**	**Fri 6/18/10**
3		NTP	0 days	Fri 1/30/09	Fri 1/30/09
4		Pre-Draft UFP-SAP	24 wks	Mon 5/11/09	Fri 10/23/09
5		Site Visit w/IHIRT	0 days	Tue 5/19/09	Tue 5/19/09
6		Submit	0 days	Thu 10/29/09	Thu 10/29/09
7		Navy Review	21 edays	Thu 10/29/09	Thu 11/19/09
8		RTC	4 wks	Fri 11/20/09	Thu 12/17/09
9		Draft UFP-SAP (Navy chemist ok)	18 wks	Mon 12/21/09	Fri 4/23/10
10		Submit	0 days	Fri 4/23/10	Fri 4/23/10
11		Navy & Regulatory Review	30 edays	Fri 4/23/10	Sun 5/23/10
12		RTC (includes team concurrence)	2 wks	Mon 5/24/10	Fri 6/4/10
13		Final UFP-SAP	2 wks	Mon 6/7/10	Fri 6/18/10
14		**Fieldwork**	**80 days**	**Mon 6/21/10**	**Fri 10/8/10**
15		Plan	15 days	Mon 6/21/10	Fri 7/9/10
16		Perform	4 wks	Mon 7/12/10	Fri 8/6/10
17		Lab Analysis	28 edays	Fri 8/6/10	Fri 9/3/10
18		QC Check	1 wk	Mon 9/6/10	Fri 9/10/10
19		Data Validation	2 wks	Mon 9/13/10	Fri 9/24/10
20		QC Check and Load Data	2 wks	Mon 9/27/10	Fri 10/8/10
21		**RI Report**	**180 days**	**Mon 10/11/10**	**Fri 6/17/11**
31		**FS Report**	**200 days**	**Mon 6/20/11**	**Fri 3/23/12**



Project: Site 66 Schedule 0509
Date: Wed 4/21/10

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

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SAP Worksheet #17—Sampling Design and Rationale

Matrix	Depth of Samples	Analysis	Method	Number of Samples	Rationale	Sampling Strategy
Surface Soil	0 – 6 inches	VOC	SW-846 8260B w/ EnCores	24	Based on professional judgment and IHIRT agreement, twenty surface soil samples will be collected outside the current site boundary, and four surface soil samples will be collected within the site boundary to provide an even distribution of sample stations across the previously uncharacterized area. The distribution of samples along with the broad suite of analytes will delineate the extent of constituents outside the current site boundary and will provide additional data for the HHRA and ERA.	Twenty surface soil samples will be collected using a DPT rig. Samples will be collected directly from the sampling sleeve. Four additional surface soil samples will be collected using traditional sampling methods.
		SVOC	SW-846 8270C and 8270C-SIM	24		
		PEST/PCBs	SW-846 8081A and 8082	24		
		METAL	SW-846 6010B, 6020, 7471A, and 9012B	24		
		DIOXIN	SW-846 8290A	24		
		EXPLO	SW-846 8330, IAPP, and 6850	24		
Subsurface Soil	Sample interval above groundwater table or suspect soil (i.e., staining, elevated PID reading), if encountered	VOC	SW-846 8260B w/ EnCores	20	Based on professional judgment and IHIRT agreement, twenty subsurface soil samples will be collected outside the current site boundary to provide an even distribution of sample stations across the previously uncharacterized area. The distribution of samples along with the broad suite of analytes will delineate the extent of constituents outside the current site boundary and will provide additional data for the HHRA and ERA.	Twenty surface soil samples will be collected using a DPT rig. Samples will be collected directly from the sampling sleeve. Borings will be extended into native soil (if waste material is encountered) and will be logged for stratigraphy.
		SVOC	SW-846 8270C and 8270C-SIM	20		
		PEST/PCBs	SW-846 8081A and 8082	20		
		METAL	SW-846 6010B, 6020, 7471A, and 9012B	20		
		DIOXIN	SW-846 8290A	20		
		EXPLO	SW-846 8330, IAPP, and 6850	20		

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

Matrix	Depth of Samples	Analysis	Method	Number of Samples	Rationale	Sampling Strategy
Ash	0 – 6 inches	METAL	SW-846 6010B, 6020, 7471A, and 9012B	6	Ash samples will be collected to supplement SI data and more fully characterize the nature of the ash material at the site. Based on professional judgment and IHIRT agreement, two samples will be collected from each of the three identified ash piles at the site; one sample per ash pile from the locations sampled during the SI to for additional analysis for TAL metals (SI ash samples were analyzed only for dioxins and furans), and one additional sample per ash pile for dioxins, furans, and TAL metals. These data will be used to assess potential human health and ecological risks related to the ash material.	Samples will be collected from the previously delineated ash piles within the site boundary.
		DIOXIN	SW-846 8290A	3		

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

Matrix	Depth of Samples	Analysis	Method	Number of Samples	Rationale	Sampling Strategy
Groundwater	Permanent monitoring wells will be screened in the shallow aquifer at the direction of a qualified field geologist. Samples will be collected at the middle of the monitoring well screen.	VOC	SW-846 8260B	5	Based on professional judgment and IHIRT agreement, five monitoring wells will be installed. The upgradient well location will provide a basis to determine if constituents detected at Site 66 are site-related or may be entering the site from an upgradient source. The two site wells will help to characterize the groundwater within Site 66. The two downgradient wells will help to determine if potential site constituents are exiting the site. The groundwater samples will be analyzed for a comprehensive list of analytes because sampling of site groundwater is limited to the SI data. Monitoring well data will be used to conduct an HHRA.	Groundwater will be sampled following well installation and development. Wells will be sampled using low-flow methods.
		SVOC	SW-846 8270C and 8270C-SIM	5		
		PEST/PCBs	SW-846 8081A and 8082	5		
		METAL	SW-846 6010B, 6020, 7471A, and 9012B	5		
		FMETAL	SW-846 6010B, 6020, and 7471A	5		
		DIOXIN	SW-846 8290A	5		
		EXPLO	SW-846 8330, IAPP, and 6850	5		

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

Matrix	Depth of Samples	Analysis	Method	Number of Samples	Rationale	Sampling Strategy
Sediment	0 – 6 inches	VOC	SW-846 8260B no EnCores	10	Based on professional judgment and IHIRT agreement six sediment samples will be collected within the current Site 66 boundary to provide additional characterization of site sediment and an even distribution of sample stations across the previously uncharacterized area. Four samples will be collected downstream towards the northern extent of Site 11 to delineate the downstream extent of contamination outside the current Site 66 boundary and an even distribution of sample stations across the previously uncharacterized area between Site 66 and Site 11. Sediment samples will be analyzed for a comprehensive list of analytes to supplement previous sediment investigations at Site 66 and Site 11 and to provide additional data for use in the ERA.	Grab samples will be collected from shallow sediments using decontaminated sampling equipment
		SVOC	SW-846 8270C and 8270C-SIM	10		
		PEST/PCBs	SW-846 8081A and 8082	10		
		METAL	SW-846 6010B, 6020, 7471A, and 9012B	10		
		DIOXIN	SW-846 8290A	10		
		EXPLO	SW-846 8330, IAPP, and 6850	10		

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

Sampling Location / ID Number	Matrix	Depth (units)1	Analytical Group (See Worksheet #19)	Number of Samples (identify field duplicates)	Sampling (Field) SOP Reference (see Appendix B)
IS66DP22 / IS66SS220001	surface soil	0 - 6 inches	VOCs, SVOCs, pesticides, PCBs, metals (including cyanide), explosives (including nitroglycerin, nitroguanidine, and perchlorate), dioxins/furans	1	B.5
IS66DP22 / IS66SB22XXXX	subsurface soil	TBD		1	B.4
IS66DP22 / IS66SS22P0001	surface soil	0 - 6 inches		1 (duplicate)	B.5
IS66DP22 / IS66SB22PXXXX	subsurface soil	TBD		1 (duplicate)	B.4
IS66DP23 / IS66SS230001	surface soil	0 - 6 inches		1	B.5
IS66DP23 / IS66SB23XXXX	subsurface soil	TBD		1	B.4
IS66DP24 / IS66SS240001	surface soil	0 - 6 inches		1	B.5
IS66DP24 / IS66SB24XXXX	subsurface soil	TBD		1	B.4
IS66DP25 / IS66SS250001	surface soil	0 - 6 inches		1	B.5
IS66DP25 / IS66SB25XXXX	subsurface soil	TBD		1	B.4
IS66DP26 / IS66SS260001	surface soil	0 - 6 inches		1	B.5
IS66DP26 / IS66SB26XXXX	subsurface soil	TBD		1	B.4
IS66DP27 / IS66SS270001	surface soil	0 - 6 inches		1	B.5
IS66DP27 / IS66SB27XXXX	subsurface soil	TBD		1	B.4
IS66DP28 / IS66SS280001	surface soil	0 - 6 inches		1	B.5
IS66DP28 / IS66SB28XXXX	subsurface soil	TBD		1	B.4
IS66DP29 / IS66SS290001	surface soil	0 - 6 inches		1	B.5
IS66DP29 / IS66SB29XXXX	subsurface soil	TBD		1	B.4
IS66DP30 / IS66SS300001	surface soil	0 - 6 inches		1	B.5
IS66DP30 / IS66SB30XXXX	subsurface soil	TBD		1	B.4
IS66DP31 / IS66SS310001	surface soil	0 - 6 inches		1	B.5
IS66DP31 / IS66SB31XXXX	subsurface soil	TBD		1	B.4
IS66DP32 / IS66SS320001	surface soil	0 - 6 inches		1	B.5
IS66DP32 / IS66SB32XXXX	subsurface soil	TBD		1	B.4

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

Sampling Location / ID Number	Matrix	Depth (units)1	Analytical Group (See Worksheet #19)	Number of Samples (identify field duplicates)	Sampling (Field) SOP Reference (see Appendix B)
IS66DP32 / IS66SS32P0001	surface soil	0 - 6 inches		1 (duplicate)	B.5
IS66DP32 / IS66SB32PXXXX	subsurface soil	TBD		1 (duplicate)	B.4
IS66DP33 / IS66SS330001	surface soil	0 - 6 inches		1	B.5
IS66DP33 / IS66SB33XXXX	subsurface soil	TBD		1	B.4
IS66DP34 / IS66SS340001	surface soil	0 – 6 inches		1	B.5
IS66DP34 / IS66SB34XXXX	subsurface soil	TBD		1	B.4
IS66DP35 / IS66SS350001	surface soil	0 - 6 inches		1	B.5
IS66DP35 / IS66SB35XXXX	subsurface soil	TBD		1	B.4
IS66DP36 / IS66SS360001	surface soil	0 - 6 inches		1	B.5
IS66DP36 / IS66SB36XXXX	subsurface soil	TBD		1	B.4
IS66DP37 / IS66SS370001	surface soil	0 - 6 inches		1	B.5
IS66DP37 / IS66SB37XXXX	subsurface soil	TBD		1	B.4
IS66DP38 / IS66SS380001	surface soil	0 - 6 inches		1	B.5
IS66DP38 / IS66SB38XXXX	subsurface soil	TBD		1	B.4
IS66DP39 / IS66SS390001	surface soil	0 - 6 inches		1	B.5
IS66DP39 / IS66SB39XXXX	subsurface soil	TBD		1	B.4
IS66DP40 / IS66SS400001	surface soil	0 - 6 inches		1	B.5
IS66DP40 / IS66SB40XXXX	subsurface soil	TBD		1	B.4
IS66DP41 / IS66SS410001	surface soil	0 - 6 inches		1	B.5
IS66DP41 / IS66SB41XXXX	subsurface soil	TBD		1	B.4
IS66SO42 / IS66SS420001	surface soil	0 - 6 inches		1	B.5
IS66SO42 / IS66SS42P0001				1 (duplicate)	
IS66SO43 / IS66SS430001				1	
IS66SO44 / IS66SS440001				1	

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

Sampling Location / ID Number	Matrix	Depth (units)1	Analytical Group (See Worksheet #19)	Number of Samples (identify field duplicates)	Sampling (Field) SOP Reference (see Appendix B)
IS66SO45 / IS66SS450001				1	
IS66ASH04 / IS66AH04	ash	0 - 6 inches	Metals, dioxins/furans	1	B.5
IS66ASH04 / IS66AH04P				1 (duplicate)	
IS66ASH05 / IS66AH05				1	
IS66ASH06 / IS66AH06				1	
IS66ASH07 / IS66AH07			Metals	1	
IS66ASH08 / IS66AH08				1	
IS66ASH09 / IS66AH09				1	
IS66MW01 / IS66GW01MMYY	groundwater	TBD	VOCs, SVOCs, pesticides, PCBs, metals (including cyanide), explosives (including nitroglycerin, nitroguanidine, and perchlorate), dioxins/furans	1	B.7
IS66MW02 / IS66GW02MMYY				1	
IS66MW03 / IS66GW03MMYY				1	
IS66MW03 / IS66GW03PMMYY				1 (duplicate)	
IS66MW04 / IS66GW04MMYY				1	
IS66MW05 / IS66GW05MMYY				1	
IS66SD06 / IS66SD06	sediment	0 - 6 inches	VOCs, SVOCs, pesticides, PCBs, metals (including cyanide), explosives (including nitroglycerin, nitroguanidine, and perchlorate), dioxins/furans	1	B.8
IS66SD06 / IS66SD06P				1 (duplicate)	
IS66SD07 / IS66SD07				1	
IS66SD08 / IS66SD08				1	
IS66SD09 / IS66SD09				1	
IS66SD10 / IS66SD10				1	
IS66SD11 / IS66SD11				1	
IS66SD12 / IS66SD12				1	
IS66SD13 / IS66SD13				1	

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

Sampling Location / ID Number	Matrix	Depth (units)1	Analytical Group (See Worksheet #19)	Number of Samples (identify field duplicates)	Sampling (Field) SOP Reference (see Appendix B)
IS66SD14 / IS66SD14				1	
IS66SD15 / IS66SD15				1	

[1] The depth intervals for subsurface soil samples will be determined in the field. Samples will be collected from the depth interval directly above the water table. The depth intervals for groundwater samples will be determined in the field, based on the observed depth to groundwater and screen placement during well installation.

SAP Worksheet #19—Analytical SOP Requirements Table

Matrix	Analytical Group	Analytical and Preparation Method / SOP Reference[1]	Containers (number, size, and type)	Sample Volume[2] (units)	Preservation Requirements (chemical, temperature, light-protected)	Maximum Holding Time[3] (preparation / analysis)
SD	VOC	SW-846 8260B, 5035 / CA-202, CA-214	1 of 4oz CWM soil jar	5 grams (g)	(4±2) °C	14 days
SS, SB	VOC	SW-846 8260B, 5035 / CA-202, CA-214	4 of 5g EnCores	5g	(4±2) °C	48 hours to freeze at laboratory / 14 days to analyze
SS, SB, SD	SVOC	SW846 8270C, 8270C-SIM, 3540C, 3550 / CA-204, CA-213, CA-512, CA-526	1 of 8oz CWM soil jar	30g	(4±2) °C	14 days / 40 days
SS, SB, SD	PEST/PCB	SW-846 8081A, 3540C, 3545A, 3550C / CA-302, CA-500, CA-524, CA-537	1 of 8oz CWM soil jar	30g	(4±2) °C	14 days / 40 days
SS, SB, SD	PEST/PCB	SW-846 8082, 3540, 3545A, 3550C / CA-302, CA-500, CA-524, CA-537	1 of 8oz CWM soil jar	30g	(4±2) °C	14 days / 40 days
SS, SB, SD	EXPLO	SW-846 8330M / CA-402	1 of 8oz CWM soil jar	10g	(4±2) °C	14 days / 40 days
SS, SB, SD	EXPLO	SW-846 8330 / WS-LC-0010	1 of 8oz CWM soil jar	20g	(4±2) °C	14 days / 40 days
SS, SB, SD	EXPLO	SW-846 6850 / WS-LC-0012	1 of 8oz CWM soil jar	10g	(4±2) °C	28 days

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

Matrix	Analytical Group	Analytical and Preparation Method / SOP Reference[1]	Containers (number, size, and type)	Sample Volume[2] (units)	Preservation Requirements (chemical, temperature, light-protected)	Maximum Holding Time[3] (preparation / analysis)
SS, SB, SD, ASH	METAL	SW-846 6010B, 3050B / CA-605, CA-608	1 of 4oz CWM soil jar	1-2g		6 months
		SW-846 6020, 3050B / CA-605, CA-627		1-2g		6 months
		SW-846 7471A / CA-611		0.6-0.8g		28 days
		SW846 9012 / SOP CA-773		10g		14 days
SD	WCHEM	SW-846 9045C / CA-709		20g		ASAP
		Lloyd Kahn / CA-741		0.2g		14 days
	GRAINSIZE	ASTM D422 / BR-GT-006	1 of 8oz CWM soil jar	500g	N/A	N/A
GW, AQ	VOC	SW-846 8260B / CA-202	3 of 40 milliliters (mL) VOA vial	40mL	HCl to pH < 2, (4±2) °C	14 days
	SVOC	SW-846 8270C, 8270C-SIM, 3510, 3520 / CA-204, CA-213, CA-502	2 of 1L amber	1 liter (L)	(4±2) °C	7 days / 40 days
	PEST/PCB	SW-846 8081A, 3510C, 3520C / CA-302, CA-515	2 of 1L amber	1L		7 days / 40 days

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

Matrix	Analytical Group	Analytical and Preparation Method / SOP Reference[1]	Containers (number, size, and type)	Sample Volume[2] (units)	Preservation Requirements (chemical, temperature, light-protected)	Maximum Holding Time[3] (preparation / analysis)
		SW-846 8082, 3510C, 3520C / CA-329, CA-515				7 days / 40 days
	EXPLO	SW-846 8330M / CA-402	2 of 1L amber	500mL		7 days / 40 days
		SW-846 8330, WS-LC-0010	2 of 1L amber	1L		7 days / 40 days
		SW-846 6850, WS-LC-0012	1 of 125mL high-density polyethylene (HDPE)	20mL		28 days
	METAL FMETAL[4]	SW-846 6010B, 3010B / CA-604, CA-608	1 of 250mL HDPE	50mL	HNO_3 to pH < 2, (4±2) °C	6 months
		SW-846 6020, 3010B / CA-604, CA-627		50mL		6 months
		SW-846 7470A / CA-615		25mL		28 days
	METAL	SW-846 9012B / CA-773	1 of 250mL HDPE	50mL	NaOH to pH > 12, (4±2) °C	14 days
GW	WCHEM	EPA 130.2 / CA-707	1 of 250mL HDPE	25mL	(4±2) °C	ASAP
SS, SB, SD, ASH	DIOXIN	SW-846 8290A / HMS-8290	1 of 8oz CWM soil jar	10g	(4±2) °C	30 days / 45 days
GW, AQ	DIOXIN	SW-846 8290A / HMS-8290	2 of 1L amber	1L	(4±2) °C	30 days (1 year if frozen) / 45 days

1Specify the appropriate reference letter or number from the Analytical SOP References table (Worksheet #23).

2Provide the minimum sample volume or mass requirement if it differs from the container volume.

3Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted.

4The field team will field-filter FMETALs so that preserved bottleware can be used.

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SAP Worksheet #20—Field QC Sample Summary Table

Matrix	Analytical Group	No. of Sampling Locations[2]	No. of Field Duplicates	No. of MS/MSDs[1]	No. of Field Blanks[4]	No. of Equip. Blanks[4]	No. of VOA Trip Blanks[4]	No. of PT Samples[3]	Total No. of Samples to Lab
SS	VOCs w/ EnCores	24	3	2	1	5	5		42
SS	SVOCs (plus SIM-SVOCs)	24	3	2	1	5			37
SS	PEST/PCBs	24	3	2	1	5			37
SS	METALs (plus 6020, Hg, and CN)	24	3	2	1	5			37
SS	EXPLOs (plus NG, NQ, and perch)	24	3	2	1	5			37
SS	DIOXINS (D/Fs)	24	3	2	1	5			37
SB	VOCs w/ EnCores	20	2	1					24
SB	SVOCs (plus SIM-SVOCs)	20	2	1					24
SB	PEST/PCBs	20	2	1					24
SB	METALs (plus 6020, Hg, and CN)	20	2	1					24
SB	EXPLOs (plus NG, NQ, and perch)	20	2	1					24
SB	DIOXINS (D/Fs)	20	2	1					24
SD	VOCs no EnCores	10	1	1		1	1		15
SD	SVOCs (plus SIM-SVOCs)	10	1	1		1			14
SD	PEST/PCBs	10	1	1		1			14
SD	METALs (plus 6020, Hg, and CN)	10	1	1		1			14
SD	EXPLOs (plus NG, NQ, and perch)	10	1	1		1			14
SD	DIOXINS (D/Fs)	10	1	1		1			14
SD	WCHEM (pH and TOC)	10							10

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

Matrix	Analytical Group	No. of Sampling Locations[2]	No. of Field Duplicates	No. of MS/MSDs[1]	No. of Field Blanks[4]	No. of Equip. Blanks[4]	No. of VOA Trip Blanks[4]	No. of PT Samples[3]	Total No. of Samples to Lab
SD	GRAINSIZE	10							10
GW	VOCs	5	1	1		2	2		12
GW	SVOCs (plus SIM-SVOCs)	5	1	1		2			10
GW	PEST/PCBs	5	1	1		2			10
GW	METALs (plus 6020, Hg, and CN)	5	1	1		2			10
GW	FMETALs (plus 6020 and Hg)	5	1	1		2			10
GW	EXPLOs (plus NG, NQ, and perch)	5	1	1		2			10
GW	DIOXINS (D/Fs)	5	1	1		2			10
GW	WCHEM (hardness)	5							5
ASH	METALs (plus 6020, Hg, and CN)	6	1	1		1			10
ASH	DIOXINS (D/Fs)	3	1	1		1			7

[1]Although the MS/MSD is not typically considered a field QC, it is included here because location determination is often established in the field.

[2]If samples will be collected at different depths at the same location, count each discrete sampling depth as a separate sampling location or station.

[3]The number of batch or project-specific proficiency testing (PT) samples is optional but highly recommended.

[4]The number of equipment blanks, field blanks, and trip blanks is based on a fundamental assumption of the number of sampling days each site will require.

SAP Worksheet #21—Project Sampling SOP References Table

Reference Number	Title, Revision Date and / or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work?	Comments
Appendix B.1	Locating and Clearing Underground Utilities; January 2008	CH2M HILL	Subcontractor Supplied	No	
Appendix B.2	General Guidance for Monitoring Well Installation; January 2008	CH2M HILL	Subcontractor Supplied	No	
Appendix B.3	Civil Surveying; January 2008	CH2M HILL	Global positioning system units	No	
Appendix B.4	Direct-Push Soil Sample Collection; January 2008	CH2M HILL	Subcontractor Supplied	No	
Appendix B.5	Shallow Soil Sampling; January 2008	CH2M HILL	Hand tools: stainless steel	No	
Appendix B.6	Logging of Soil Borings; January 2008	CH2M HILL	Pen, field book, soil color chart	No	
Appendix B.7	Groundwater Sampling from Monitoring Wells; January 2008	CH2M HILL	Groundwater sampling pumps and tubing, Horiba U-22	No	
Appendix B.8	Sediment Sampling; January 2008	CH2M HILL		No	
Appendix B.9	Decontamination of Personnel and Equipment; January 2008	CH2M HILL	For cleansing reusable samplers	No	
Appendix B.10	Sampling Contents of Tanks and Drums; January 2008	CH2M HILL	Subcontractor-Supplied	No	
Appendix B.11	Disposal of Waste Fluids and Solids; January 2008	CH2M HILL	55-gallon steel drums, labeling equipment	No	
Appendix B.12	Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, Oxidation Reduction Potential, and Temperature Using the Horiba® U-22 with Flow-through Cell; January 2008	CH2M HILL	Horiba U-22	No	
Appendix B.13	Multi RAE Photoionization Detector (PID); January 2008	CH2M HILL	Multi RAE PID	No	
Appendix B.14	Preparing Field Log Books; January 2008	CH2M HILL	N/A	No	
Appendix B.15	Packaging and Shipping Procedures for Low-Concentration Samples; January 2008	CH2M HILL	Lab-supplied coolers	No	

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

Field Equipment	Calibration Activity	Maintenance Activity	Testing/ Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Resp. Person	SOP Reference	Comments
Water quality meter	Calibration of pH, dissolved oxygen and conductivity probes	N/A	Visual Inspection	Daily	Parameter specific per model/ instruction manual	Manufacturer technical support for calibration errors	FTL	B.12	
Horiba® U-22	Calibrate probe using Horiba® U-22 Auto-Calibration Standard Solution	Check mechanical and electronic parts, verify system continuity, check battery, and clean probes. Calibration check.	Visual Inspection	Daily before use, at the end of the day, and when unstable readings occur.	Stable readings after 3 minutes pH reads 4.0 +/- 3% conductivity reads 4.49 +/- 3% turbidity reads 0 +/- 3%	Clean probe with deionized water and calibrate again. Do not use this instrument if unable to calibrate properly.	FTL	B.12	
Multi RAE PID	Calibrate using ambient air and isobutylene 100 parts per million (ppm) calibration gas	Recharge daily	Visual Inspection	Daily, before use	Ambient air reads 0.0 ppm +/- 3% Isobutylene gas reads 100 ppm +/- 3%	Follow instructions in manual to clean sensor. Do not use this instrument if unable to calibrate properly.	FTL	B.13	
Groundwater sampling pumps and tubing	N/A	N/A	Inspect pumps, tubing and air/sample line quick-connects	Regularly	Maintained in good working order per manufacturer's recommendations	Replace items	FTL	B.7	

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SAP Worksheet #23—Analytical SOP References Table

Lab SOP Number	Title, Revision Date, and / or Number	Date Last Revisited if not Revised	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?[1] (y/n)
BR-GT-006	Particle Size Analysis, 1/1/08, Rev. 5[2]		Definitive	SD / GRAINSIZE	Sieves	TestAmerica Burlington	N
CA-101	Equipment Maintenance, August, 2009, Rev. 8		N/A	N/A	All	Katahdin Analytical Services, Inc. (KAS)	N
CA-202	Analysis of VOAs by Purge and Trap GC/MS: SW-846 Method 8260, March, 2008, Rev. 9	June, 2009	Definitive	SS, SB, SD, GW, AQ / VOC	GC/MS	KAS	N
CA-204	Analysis of Semivolatile Organic Compounds by Capillary Column GC/MS: SW-846 Method 8270, April, 2009, Rev. 10		Definitive	SS, SB, SD, GW, AQ / SVOC	GC/MS	KAS	N
CA-213	Analysis of Semivolatile Organic Compounds By: SW 846 Method 8270 – Modified For Selected Ion Monitoring (SIM), April, 2009, Rev. 6		Definitive	SS, SB, SD, GW, AQ / SVOC	GC/MS	KAS	N
CA-214	Closed-System Purge-And-Trap And Extraction For Volatile Organics In Soil And Waste Samples Using SW-846 Method 5035, September, 2008, Rev. 5		Definitive	SS, SB, SD / VOC	Tekmar, Arcon, Encon	KAS	N
CA-302	Analysis of Pesticides By Gas Chromatography/Electron Capture Detector (GC/ECD): SW-846 Method 8081, February, 2009, Rev. 9		Definitive	SS, SB, SD, GW, AQ / PEST/PCB	GC/ECD	KAS	N
CA-329	Analysis Of PCBs as Total Arochlors By Gas Chromatography/Electron Capture Detector (GC/ECD): SW-846 Method 8082, May, 2009, Rev. 8		Definitive	SS, SB, SD, GW, AQ / PEST/PCB	GC/ECD	KAS	N
CA-402	Determination Of Nitroaromatics And Nitramines By HPLC Method 8330, August, 2009, Rev. 4		Definitive	SS, SB, SD, GW, AQ / EXPLO	HPLC	KAS	N
CA-500	Preparation Of Sediment/Soil Samples By Sonication Using Method 3550 For Subsequent Pesticides/PCBs Analysis, February, 2009, Rev. 6		Definitive	SS, SB, SD / PEST/PCB	Sonication	KAS	N
CA-502	Preparation Of Aqueous Samples For Extractable Semivolatile Analysis, September, 2008, Rev. 5		Definitive	GW, AQ / SVOC	Separtory Funnel / CLLE	KAS	N
CA-512	Preparation Of Sediment/Soil Samples By Sonication Using Method 3550 For Subsequent Extractable Semi-Volatiles Analysis, February, 2009, Rev. 7		Definitive	SS, SB, SD / PEST/PCB	Sonication	KAS	N
CA-515	Preparation of Aqueous Samples for Pesticides/PCBs Analysis, September, 2008, Rev. 6		Definitive	GW, AQ / PEST	Separtory Funnel / CLLE	KAS	N
CA-524	Preparation Of Sediment/Soil Samples By Soxhlet Extraction Using Method 3540 For Pesticide/PCB Analysis, August, 2009, Rev. 6		Definitive	SS, SB, SD / PEST/PCB	Soxhlet	KAS	N
CA-526	Preparation Of Sediment/Soil Samples By Soxhlet Extraction Using Method 3540 For Subsequent Extractable Semivolatile Analysis, August, 2009, Rev. 6		Definitive	SS, SB, SD / SVOA	Soxhlet	KAS	N
CA-537	Preparation of Sediment/Soil and Tissue Samples by Accelerated Solvent Extraction Using Method 3545 for Subsequent Extractable Pesticide and PCB Analysis, August, 2009, Rev. 2		Definitive	SS, SB, SD / PEST/PCB	ASE	KAS	N
CA-604	Acid Digestion of Aqueous Samples By EPA Method 3010 for ICP Analysis of Total or Dissolved Metals, May, 2009, Rev 4		Definitive	GW, AQ / METAL, FMETAL	Digestion Block	KAS	N
CA-605	Acid Digestion Of Solid Samples By USEPA Method 3050 For Metals Analysis By ICP-AES And GFAA, August, 2009, Rev. 4		Definitive	SS, SB, SD, ASH / METAL	Digestion Block	KAS	N
CA-608	Trace Metals Analysis By ICP-AES Using EPA Method 6010, February, 2009, Rev. 8		Definitive	SS, SB, SD, ASH, GW, AQ / METAL	ICP-AES	KAS	N
CA-611	Digestion And Analysis Of Solid Samples For Mercury By USEPA Method 7471, February, 2009, Rev. 5		Definitive	SS, SB, SD / METAL (Hg)	CVAA	KAS	N

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

Lab SOP Number	Title, Revision Date, and / or Number	Date Last Revisited if not Revised	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?[1] (y/n)
CA-615	Digestion And Analysis Of Aqueous Samples For Mercury By USEPA Method 7470, March, 2009, Rev. 3		Definitive	GW, AQ / METAL (Hg)	CVAA	KAS	N
CA-627	Trace Metals Analysis By ICP-MS Using USEPA Method 6020, February, 2009, Rev. 5		Definitive	SS, SB, SD, ASH, GW, AQ / METAL, FMETAL	ICP-MS	KAS	N
CA-707	Titrimetric Determination of Total Hardness by Addition of EDTA using EPA Method 130.2 and SM2340C, April, 2009, Rev. 5		Definitive	GW / WCHEM (hardness)	Titrator	KAS	N
CA-709	pH Concentration Measurements in Soil Matrices - SW 846 Method 9045, February, 2009, Rev. 6		Definitive	SD / WCHEM (pH)	pH Probe	KAS	N
CA-741	Determination of Total Organic Carbon in Solids Using the EPA Region II Lloyd Kahn Method, June, 2008, Rev. 2		Definitive	SD / WCHEM (TOC)	TOC Analyzer	KAS	N
CA-773	Colorimetric Analysis Of Total And Ammenable Cyanide Using The Automated Konelab Multiwavelength Photometric Analyzer, March, 2009, Rev. 2		Definitive	SS, SB, SD, ASH, GW, AQ / METAL (CN)	Konelab	KAS	N
HMS -8290	Analysis of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (HRGC/HRMS), 5/20/09, Rev. 7		Definitive	SS, SB, SD, ASH, GW, AQ / DIOXIN	HRGC/HRMS	Columbia Analytical Services - Houston	N
SD-902	Sample Receipt and Internal Control, May, 2009, Rev. 8		N/A	N/A	N/A	KAS	N
SD-903	Sample Disposal, May, 2009, Rev. 4		N/A	N/A	N/A	KAS	N
SMO-WET	Sample Receiving, 2/10/09, Rev. 7		N/A	N/A	N/A	Columbia Analytical Services - Houston	N
WS-LC-0010	Determination of Nitroguanidine based on Method 8330, SW-846, 4/17/09, Rev. 3.1		Definitive	SS, SB, SD, GW, AQ / EXPLO (NQ)	HPLC/UV	TestAmerica - West Sacramento	N
WS-LC-0012	Determination of Perchlorate by Liquid Chromatography Coupled with Tandem Mass Spectrometry (LC/MS/MS) by Method 6850 or 8321 Modified, 2/13/09, Rev. 5.1		Definitive	SS, SB, SD, GW, AQ / EXPLO (perch)	HPLC/MS/MS	TestAmerica - West Sacramento	N

[1]If yes, then specify the modification that has been made. Note that any analytical SOP modification made relative to project-specific needs must be reviewed and approved by the Navy QA Officer.

[2]BR-GT-006 is revisited bi-annually because particle size analysis is not specified in the DOD QSM v,3.

SAP Worksheet #24—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA[2]	SOP Reference[1]
GC/MS (SW-846 8260B)	Initial Calibration	Instrument receipt, instrument change (new column, source cleaning, etc.), when CV is out of criteria.	Six-point initial calibration for all analytes. RSD <30 for CCC's; SPCC's RFs > 0.050, %RSD < 15% for all other compounds. If % RSD > 15% 1. Linear least squares regression: r ≥ 0.995. 2. Non-linear regression: coefficient of determination (COD) r2 ≥ 0.99 (6 points for second order)	Repeat initial calibration.	Analyst, Supervisor	CA-202
	Initial Calibration Verification (second source)	Once after each initial calibration.	± 20% recovery individual compounds.	Correct problem and verify second source standard. Reanalyze initial calibration.		
	Evaluation of relative retention times (RRT)	With each sample.	RRT of each target analyte within ±0.06 RRT units.	Correct problem, then rerun ICAL.		
	Continuing Calibration	At the beginning of each 12 hour shift	1. Average RF for SPCCs: VOCs ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachloroethane; ≥ 0.1 for chloromethane, bromoform, and 1,1-dichloroethane. 2. %Difference/Drift for all target compounds and surrogates: VOCs and SVOCs ≤ 20%D (Note: D - difference when using RFs or drift when using least squares regression or non-linear calibration).	Repeat initial calibration and reanalyze all samples analyzed since the last successful calibration verification. Notify client for corrective action if there are sporadic failures.		
	BFB Tune	Prior to the ICAL and every 12 hours	Mass - Criteria	Retune and/or clean source		
			50 - 15.0-40.0% of mass 95			
			75 - 30.0-60% of mass 95			
			95 - base peak, 100% relative abundance			
			96 - 5.0-9.0% of mass 95			
			173 - less than 2.0% of mass 174			
			174 - greater than 50.0% of mass 95			
			175 - 5.0-9.0% of mass 174			
			176 - 95.0 - 101% of mass 174			
			177 - 5.0-9.0% of mass 176			

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

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA[2]	SOP Reference[1]
GC/MS (SW-846 8270C and 8270C-SIM)	Initial Calibration	Instrument receipt, instrument change (new column, source cleaning, etc.), when CV is out of criteria.	Six-point initial calibration for all analytes. RSD <30 for CCC's; SPCC's RFs > 0.050, %RSD < 15% for all other compounds. If % RSD > 15% 1. Linear least squares regression: r ≥ 0.995. 2. Non-linear regression: coefficient of determination (COD) r2 ≥ 0.99 (6 points for second order)	Repeat initial calibration.	Analyst, Supervisor	CA-204, CA-213
	Initial Calibration Verification (second source)	Once after each initial calibration.	± 20% recovery individual compounds.	Identify source of problem, correct, repeat calibration, rerun samples.		
	Evaluation of relative retention times (RRT)	With each sample.	RRT of each target analyte within ±0.06 RRT units.	Correct problem, then rerun ICAL.		
	Breakdown check (DDT Method 8270 only)	At the beginning of each 12-hour period, prior to analysis of samples.	Degradation ≤ 20% for DDT. Benzidine and pentachlorophenol should be present at their normal responses, and should not exceed a tailing factor of 2.	Correct problem then repeat breakdown check. Flagging criteria are not appropriate. No samples shall be run until degradation ≤ 20%.		
	Continuing Calibration	At the beginning of each 12 hour shift	<u>1. Average RF for SPCCs:</u> SVOCs ≥ 0.050. <u>2. %Difference/Drift for all target compounds and surrogates:</u> VOCs and SVOCs ≤ 20%D (Note: D - difference when using RFs or drift when using least squares regression or non-linear calibration).	Repeat initial calibration and reanalyze all samples analyzed since the last successful calibration verification. Notify client for corrective action if there are sporadic failures.		
	DFTPP Tune	Prior to the ICAL and every 12 hours	<u>Mass - Criteria</u> 51 30.0 to 60.0 % of mass 198 68 less than 2.0 % of mass 69 69 present 70 less than 2.0 % of mass 69 127 40.0-60.0 % of mass 198 197 less than 1.0 % of mass 198 198 base peak, 100 % relative abundance 199 5.0-9.0 % of mass 198 275 10.0-30.0 % of mass 198 365 greater than 1.0 % of mass 198 441 present, but less than mass 443 442 greater than 40% of mass 198 443 17.0-23.0 % of mass 442	Retune and/or clean source		

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

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA[2]	SOP Reference[1]
GC/ECD (SW-846 8081)	Minimum five-point initial calibration (ICAL) for all analytes	ICAL prior to sample analysis	One of the options below:Option 1: RSD for each analyte ≤ 20%;Option 2: linear least squares regression: ≥ > 0.995;Option 3: non-linear regression: coefficient of determination (COD) r2 ≥ 0.99 (6 points shall be used for second order, 7 points shall be used for third order).	Correct problem then repeat ICAL. Flagging criteria are not appropriate. Problem must be corrected. No samples may be run until ICAL has passed. Calibration may not be forced through the origin. Quantitation for multicomponent analytes such as chlordane, toxaphene, and Aroclors must be performed using a 5-point calibration. Results may not be quantitated using a single point.	Analyst, Supervisor	CA-302
	Initial Calibration Verification (second source)	Once after each initial calibration.	± 20% recovery individual compounds.	Identify source of problem, correct, repeat calibration, rerun samples.		
	Retention time window position establishment for each analyte and surrogate	Once per ICAL and at the beginning of the analytical shift.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	N/A		
	Breakdown check	Refer to Worksheet 28-3 and 28-10.				
	Continuing Calibration	After every 10 samples; If calibration curve previously analyzed, analyze daily before samples.	% D < 20%	Evaluate the samples: If the %D >+15% and sample results are <PQL, narrate. If %D >±15% only on one channel, narrate. If %D >±15% for closing CV, and is likely a result of matrix interference, narrate. Otherwise, reanalyze all samples back to last accept		
GC/ECD (SW-846 8082)	Minimum five-point initial calibration (ICAL) for all analytes	ICAL prior to sample analysis	One of the options below: Option 1: RSD for each analyte ≤ 20%; Option 2: linear least squares regression: ≥ > 0.995; Option 3: non-linear regression: coefficient of determination (COD) r2 ≥ 0.99 (6 points shall be used for second order, 7 points shall be used for third order).	Correct problem then repeat ICAL. Flagging criteria are not appropriate. Problem must be corrected. No samples may be run until ICAL has passed. Calibration may not be forced through the origin. Quantitation for multicomponent analytes such as chlordane, toxaphene, and Aroclors must be performed using a 5-point calibration. Results may not be quantitated using a single point.	Analyst, Supervisor	CA-329
	Initial Calibration Verification	Once after each initial calibration.	± 20% recovery individual compounds.	Identify source of problem, correct, repeat calibration, rerun samples.		
	Retention time window position establishment for each analyte and surrogate	Once per ICAL and at the beginning of the analytical shift.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	N/A		
	Continuing Calibration	After every 10 samples; If calibration curve previously analyzed, analyze daily before samples.	% D < 20%	Evaluate the samples: If the %D >+15% and sample results are <PQL, narrate. If %D >±15% only on one channel, narrate. If %D >±15% for closing CV, and is likely a result of matrix interference, narrate. Otherwise, reanalyze all samples back to last accept		

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

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA[2]	SOP Reference[1]
HPLC (SW-846 8330)	Initial Calibration - A minimum 5-point calibration is required.	Instrument receipt, major instrument change, when CV does not meet criteria.	5 point calibration – correlation coefficient (r) ≥ 0.995 or $(r)^2$ ≥ 0.990	Repeat Initial calibration and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst, Supervisor	CA-402
	Initial Calibration Verification (ICV)	Once after initial calibration.	85 to 115% recovery.	Identify source of problem, correct, repeat calibration, rerun samples.		
	Retention time window position establishment for each analyte and surrogate	Once per ICAL and at the beginning of the analytical shift.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	N/A		
	Continuing Calibration (CV)	After every 10 samples; If calibration curve previously analyzed, analyze daily before samples.	< 15% Difference	(1) Evaluate the samples: If the %D > +15% and sample results are < QL, narrate. If %D > ± 15% only on one channel, narrate. If %D > ± 15% and is likely a result of matrix interference, narrate. Otherwise, reanalyze all samples back to last acceptable CV.		
ICP-AES (SW-846 6010B)	Initial Calibration (one high standard and a calibration blank)	At the beginning of each day or if QC is out of criteria.	Two point calibration per manufacturer's guidelines; analytes run at their calibration levels must fall within 95-105% of True Values	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards	Analyst, Supervisor	CA-608
	Initial Calibration Verification (second source)	Once after each ICAL, prior to beginning a sample run.	Value of second source for all analytes within ±10% of true value.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL.		
	Low-level calibration check standard	Daily, after one-point ICAL.	Within ±20% of true value.	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. ICS-B: Within ±20% of true value.	Terminate analysis; locate and correct problem; reanalyze ICS, reanalyze all samples. If corrective action fails, apply Q-flag to all results for specific analytes in all samples associated with the ICS.		
	Continuing Calibration	At the beginning and end of each run sequence and every 10 samples	90-110% of True Values	Check problem, recalibrate and reanalyze any samples not bracketed by passing CCVs.		
ICP-MS (SW-846 6020)	Tune	Daily prior to calibration	Mass calibration within 0.1 amu of true value, Resolution < 0.9 amu at 10% peak height	Perform necessary equipment maintenance	Analyst, Supervisor	CA-627
	Initial Calibration (one high standard and a calibration blank)	Daily prior to sample analysis.	4 point calibration plus blank – correlation coefficient ≥ 0.995.	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards		
	Initial Calibration Verification (second source)	Once after each ICAL, prior to beginning a sample run.	Value of second source for all analytes within ±10% of true value.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL.		
	Low-level calibration check standard	Daily, after one-point ICAL.	Within ±20% of true value.	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. ICS-B: Within ±20% of true value.	Terminate analysis; locate and correct problem; reanalyze ICS, reanalyze all samples. If corrective action fails, apply Q-flag to all results for specific analytes in all samples associated with the ICS.		
	Continuing Calibration	At the beginning and end of each run sequence and every 10 samples	90-110% of True Values	Check problem, recalibrate and reanalyze any samples not bracketed by passing CCVs.		

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

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA[2]	SOP Reference[1]
CVAA (SW-846 7470A, 7471A)	Initial Calibration	At the start of each run	Correlation coefficient ≥ 0.995.	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards	Analyst, Supervisor	CA-611, CA-615
	Initial Calibration Verification (second source)	Once after each ICAL, prior to beginning a sample run.	Value of second source for all analytes within ±10% of true value.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL.		
	Continuing Calibration	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 braketted by passing CCVs. If the CCV fails high, consult with client and report samples that are <PQL.		
Konelab (SW-846 9012B)	Initial Calibration	Daily prior to sample analysis.	7 point calibration; Correlation coefficient ≥ 0.995	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards	Analyst, Supervisor	CA-773
	Distilled Standards (one high and one low)	Once per multipoint calibration.	Within ±15% of true value.	Correct problem, then repeat distilled standards. Flagging criteria are not appropriate. Problem must be corrected. No samples may run until distilled standards have passed.		
	Initial Calibration Verification (second source)	Once after each ICAL, prior to beginning a sample run.	Within ±15% of true value.	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.		
	Continuing Calibration	CV -at beginning and end of each run sequence and every 10 samples	+/- 15% of True Value	If the CCV fails high, report samples that are <PQL. Recalibrate and/or reanalyze samples back to last acceptable CCV recovery.		
pH Meter (SW-846 9045)	Daily Calibration	Each day of use	±0.05 pH units	Use new buffers, recalibrate	Analyst, Supervisor	CA-709
TOC Analyzer (Lloyd Kahn)	Initial Calibration- initially, when the daily CCV does not pass, but, no longer than every 3 months.	Correlation coefficient >/= 0.995	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards	Check instrument performance, perform corrective maintenance, recalibrate	Analyst, Supervisor	CA-741
	CCV-every 10 samples and at the end of the run	80-120% of true value for 415.1 75-125% of true value for Lloyd Kahn	If the CCV fails high, report samples that are <PQL. Recalibrate and/or reanalyze samples back to last acceptable CCV recovery.	Check instrument performance, perform corrective maintenance, recalibrate and reanalyze all samples analyzed since the last successful calibration verification.		

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

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA[2]	SOP Reference[1]
LC/MS/MS (SW-846 6850)	Minimum six-point initial calibration for target analytes, lowest concentration standard at or near the reporting limit	Initial calibration prior to sample analysis	Linear: $r^2 > 0.990$ (r>0.995), b < MDL; Quadratic: $r^2 > 0.995$	Correct problem, then repeat initial calibration	Lab Manager, Analyst	WS-LC-0012
	Second-source calibration verification	Once per five-point initial calibration	Less than 15% difference for target analytes	Correct problem, then repeat. If still fails, repeat initial calibration.		
	Daily calibration verification	Before sample analysis and every 10 samples or every 12 hours, as specified by the method, and at the end of the sequence.	Mid-range standard: Perchlorate within ±15% of the true value	Correct problem, then repeat. If still fails, repeat initial calibration		
	Initial Calibration Blank and Continuing Calibration Blank (ICB/CCB)	Following ICV/CCVs	No target analyte concentrations above ½ the reporting limit (RL).	Rerun ICB. Isolate and correct problem. Reanalyze associated samples.		
	Interference Check Standard (ICS)	Refer to Worksheet 28-5 and 28-13.				
	Limit of Detection Verification (LODV) (per batch)	Prior to sample analysis and at the end of the analytical sequence. It can be analyzed after every 10 samples in order to reduce the reanalysis rate.	Within ±30% of true value.	Correct problem and rerun LODV and all samples analyzed since last successful LODV. If a sample with perchlorate concentration at or between the LOD and RL is bracketed by a failing LODV, it must be reanalyzed. A sample with concentration above the RL can be reported. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable LODV. Flagging is only appropriate in cases where the samples cannot be reanalyzed.		
	Internal Standard	Every Calibration Standard	ICAL: IS for each standard must be within ± 50% of the average area of the ICAL. ICV, CCV: Within ± 50% of the average area of the ICAL or within ± 50% of the 1st CCV of the run, if the ICAL is not run the same day.	Evaluate the system. Reanalyze/repeat the calibration.		
HPLC/UV (SW-846 8330 (NQ))	Minimum five-point initial calibration for target analytes, lowest concentration standard at or near the reporting limit	Initial calibration prior to sample analysis	Average RF: RSD ≤ 20%; Linear: r2 > 0.990 (r>0.995), b < MDL; Quadratic: $r^2 > 0.995$	Correct problem, then repeat initial calibration	Lab Manager, Analyst	WS-LC-0010
	Second-source calibration verification	Once per five-point initial calibration	Less than 15% difference for target analytes	Correct problem, then repeat. If still fails, repeat initial calibration.		
	Daily calibration verification	Before sample analysis; after every 10 field samples and at the end of the sequence.	Less than 15% difference for target analytes	Correct problem, then repeat. If still fails, repeat initial calibration. Reanalyze all samples since last successful calibration verification		

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

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA[2]	SOP Reference[1]
HRGC/HRMS(SW-846 8290A)	Tuning	At the beginning and the end of each 12-hour period of analysis	Static resolving power ≥ 10,000 (10% valley) for identified masses per method, and lock-mass ion between lowest and highest masses for each descriptor and level of reference compound ≤ 10% full-scale deflection, per method.	Retune instrument and verify. Rerun affected samples. Flagging criteria are not appropriate. Problem must be corrected. No samples may be accepted without a valid tune.	Analyst	HMS-8290
	GC column performance check	Prior to ICAL or calibration verification. Use GC performance check solution per method.	Peak separation between 2,3,7,8-TCDD and other TCDD isomers result in a valley of ≤ 25% per method; and Identification of all first and last eluters of the eight homologue retention time windows and documentation by labeling (F/L) on the chromatogram; and Absolute retention times for switching from one homologous series to the next ≥ 10 seconds for all components of the mixture.	Correct problem then repeat column performance check. Flagging criteria are not appropriate.		
	Initial calibration (ICAL) for all analytes identified in method	ICAL prior to sample analysis, as needed by the failure of calibration verification standrard, and when a new lot is used as standard source for HRCC-3, sample fortification (IS), or recovery solutions.	Ion abundance ratios in accordance with criteria in Table 8 of the method; and S/N ratio ≥ 10 for all target analyte ions; and RSD ≤ 20% for response factors (RF) for all 17 unlabeled standards and RSD ≤ 20% for RFs for the 9 labeled IS.	Correct problem and repeat ICAL. Flagging criteria are not appropriate. Problem must be corrreted. No samples may be run until ICAL has passed. Calibration may not be forced through origin.		
	Calibration Verification	At the beginning of each 12-hour period and at the end of each analytical sequence.	Ion abundance rations in accordance with criteria in Table 8 of the method; and For unlabeled standards, RF within ±20%D of RF established in ICAL; and For labeled standards, RF within ±30%D of RF established in ICAL.	Correct problem, repeat calibration verification standard. If that fails, repeat ICAL and reanalyze all samples analyzed since the last successful CCV. End-of-run CCV: If the RF for unlabeled standards ≤ 25% RPD and the RF for labeled standards ≤ 35% RPD (relative to the RF established in the ICAL), the mean RF from the two daily CCVs must be used for quantitation of impacted samples instead of the ICAL mean RF value. If the starting and ending CCV RFs differ by more than 25% RPD for unlabeled compounds or 35% RPD for labeled compounds, the sample may be quantitated against a new initial calibraiton if it is analyzed within two hours. Otherwise reanalyze samples with positive detections if necessary. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last successful calibration verification. Problem must be corrected. Results may not be reported without a valid calibration verification. Flagging is only appropriate in cases where the samples cannot be reanlayzed.		

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

[2]Name or title of responsible person may be used.

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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[2]	SOP Reference[1]
GC/MS (VOC)	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 - Please refer to Worksheet 24.	Ion source, injector liner, column, column flow, purge lines, purge flow, trap	Prior to initial calibration and/or as necessary.	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Department Manager	CA-202
GC/MS (SVOC)	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 - Please refer to Worksheet 24.	Ion source, injector liner, column, column flow, purge lines, purge flow, trap	Prior to initial calibration and/or as necessary	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Department Manager	CA-204, CA-213
GC/ECD (PEST/PCB)	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 - Please refer to Worksheet 24.	Injector liner, septa, column, column flow.	Prior to initial calibration and/or as necessary.	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Department Manager	CA-302, CA-329
HPLC (EXPLO)	Check and sonicate pump valves as needed. Backflush column as needed. Replace analytical column or guard column as needed. Sonicate and replace solvent with every use. Replace the UV lamp as needed. Check and replace seal-pak as needed.	QC standards - Please refer to Worksheet 24.	Column flow, pressure	Prior to initial calibration and/or as necessary.	Acceptable calibration or CCV	Correct the problem and repeat calibration or CV	Analyst, Department Manager	CA-402
ICP-AES	Clean torch assembly and spray chamber when discolored or when degradation in data quality is observed. Clean nebulizer, check argon, replace peristaltic pump tubing as needed. Other maintenance specified in lab Equipment Maintenance SOP.	QC standards - Please refer to Worksheet 24.	Torch, nebulizer chamber, pump, pump tubing	Prior to initial calibration and as necessary	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Department Manager	CA-608
ICP-MS	Clean torch assembly and spray chamber when discolored or when degradation in data quality is observed. Clean nebulizer, check argon, replace peristaltic pump tubing as needed. Other maintenance specified in lab Equipment Maintenance SOP.	QC standards - Please refer to Worksheet 24.	Torch, nebulizer, spray chamber, pump tubing	Prior to initial calibration and as necessary	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Department Manager	CA-627
CVAA	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 - Please refer to Worksheet 24.	Tubing, sample probe, optical cell	Prior to initial calibration and as necessary	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Department Manager	CA-611, CA-615
Konelab (CN)	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.	QC standards - Please refer to Worksheet 24.	Reagent tubes, lamp, wash tubes, paddles, syringes, dispensing needles.	Prior to initial calibration and/or as necessary.	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Department Manager	CA-773
pH Meter	Clean probe.	QC standards - Please refer to Worksheet 24.	Probe	As necessary	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Department Manager	CA-709
TOC Analyzer	Check level of dilution water, drain vessel water, humidifier water, autosampler rinse water, and phosphoric acid vessel and fill as needed. Replace oxygen cylinder.	QC standards - Please refer to Worksheet 24.	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
LC/MS/MS (perch)	Replace columns as needed, check eluent reservoirs.	Sensitivity check - Please refer to Worksheet 24.	Instrument performance and sensitivity	Daily or as needed	CCV pass criteria	Recalibrate	TestAmerica Chemist	WS-LC-0012
HPLC/UV (NQ)	Replace columns as needed, check eluent reservoirs.	Sensitivity check - Please refer to Worksheet 24.	Instrument performance and sensitivity	Daily or as needed	CCV pass criteria	Recalibrate	TestAmerica Chemist	WS-LC-0009
Waters Autospec	Complete inspection, repair, and service by manufacturer.	N/A	All parts	Annually	N/A	N/A	Waters Service Agent	HMS-8290

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

[2]Name or title of responsible person may be used.

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SAP Worksheet #26—Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): FTL (TBD)/CH2M HILL
Sample Packaging (Personnel/Organization): Sample Processor or Field Team Member (TBD)/CH2M HILL
Coordination of Shipment (Personnel/Organization): Sample Processor or Field Team Member (TBD)/CH2M HILL
Type of Shipment/Carrier: Overnight/FedEx
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Receipt Personnel/Katahdin Analytical Services, Inc.; Sample Receipt Personnel/ Columbia Analytical Services, Inc. -Houston. All analytical fractions except DIOXIN will be shipped directly to Katahdin Analytical Services, Inc. DIOXIN will be shipped to Columbia Analytical Services, Inc.-Houston.
Sample Custody and Storage (Personnel/Organization): Sample Receipt Personnel/Katahdin Analytical Services, Inc.; Sample Receipt Personnel/ Columbia Analytical Services, Inc.-Houston
Sample Preparation (Personnel/Organization): Extractions Personnel/Katahdin Analytical Services, Inc.; Extractions Personnel/ Columbia Analytical Services, Inc.-Houston
Sample Determinative Analysis (Personnel/Organization): Analyst/Katahdin Analytical Services, Inc.; Analyst/ Columbia Analytical Services, Inc.-Houston
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): 90
Sample Extract/Digestate Storage (No. of days from extraction/digestion): Extracts may be disposed of 90 days after extraction.
Biological Sample Storage (No. of days from sample collection): N/A
SAMPLE DISPOSAL
Personnel/Organization: Environmental Health and Safety Officer/ Katahdin Analytical Services, Inc.; Environmental Health and Safety Officer/ Columbia Analytical Services, Inc. -Houston
Number of Days from Analysis: Samples may be disposed of 90 days after report mail date.

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SAP Worksheet #27—Sample Custody Requirements Table

Sample Labeling:

Sample labels will include, at a minimum, client name, site, sample ID, date/time collected, analysis group or method, preservative, and sampler's initials. Labels will be taped to the jar to ensure that they do not separate.

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, as outlined above. Samples will be cushioned with packaging material and placed into coolers containing enough ice to keep the samples below 4°C until they are received by the laboratory. The chain of custody (CoC) will be completed by the FTL or other designated field team member and will be placed into the cooler. Coolers will be shipped to the laboratory via FedEx, with the airbill number indicated on the CoC (to relinquish custody). Upon delivery, the laboratory will log in each cooler and report the status of the samples.

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

See the analytical laboratory SOPs: SD-902 "Sample Receipt and Internal Control", SD-903 "Sample Disposal", and SMO-WET "Sample Receiving" for details on sample handling.

Sample Identification Procedures:

Upon opening the cooler, the receiving clerk signs the CoC and then takes the temperature using the temperature blank (if absent, then a sample container or infrared thermometer is used). The sample containers in the cooler are unpacked and checked against the client's CoC, and any discrepancies or breakage is noted on the CoC. Next, if any water samples require preservative, the clerk will check the pH values to see if they are in the acceptable pH range. The clerk will deliver the CoC (and any other paperwork; such as temperature or pH QA notice, to the PM for laboratory information management system (LIMS) entry and client contact (if needed).

The field logbook will identify the sample ID with the location, depth, date/time collected, and the parameters requested. The laboratory will assign each field sample a laboratory sample ID based on information in the CoC. The laboratory will send sample log-in forms to EIS to check sample IDs and parameters are correct.

CoC Procedures:

CoCs 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 CoC also will have the sampler's name and signature. The CoC 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 LIMS database for each sample.

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SAP Worksheet #28-1—Laboratory QC Samples Table

Matrix: SS, SB, SD
Analytical Group: VOC
Analytical Method / SOP Reference: SW-846 8260B / CA-202

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected > 1/2 QL. For common laboratory contaminants > QL	Investigate source of contamination. Rerun method blank prior to analysis of samples if possible. Evaluate the samples and associated QC: if blank results are above QL, report sample results which are < QL or > 10X the blank concentration. Reanalyze blank and samples >QL and < 10X the blank.	Analyst, Supervisor, QA Manager	Accuracy/bias- Contamination	No analyte detected > 1/2 QL. For common laboratory contaminants > QL
LCS	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or laboratory statistically derived limits. Please refer to Worksheet 15.	Evaluate and reanalyze if possible. If an MS/MSD was performed in the same 12 hour clock and acceptable narrate. If the LCS recoveries are high but the sample results are <QL narrate. Otherwise reprep and reanalyze.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or laboratory statistically derived limits. Please refer to Worksheet 15.	CA will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met. If both the LCS and MS/MSD are unacceptable reprep the samples and QC.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike Duplicate	Same as MS	Same as MS and RPD ≤ 30%	Same as MS.	Analyst, Supervisor, QA Manager	Accuracy/bias & Precision	Same as MS and RPD ≤ 30%
Internal Standards (IS)	Each field and QC sample	RT ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard	Reanalyze affected samples	Analyst	Accuracy	RT ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard
Surrogates	4 Per Sample	DoD QSM: 4-Bromofluorobenzene - 85-120% Toluene-d8 - 85-115% KAS Statisically-derived: Dibromofluoromethane - 67-118% 1,2-Dichloroethane-d4 - 55-148%	Reanalyze if sample volume is available and within hold time. Otherwise, contact client.	Analyst, Supervisor, QA Manager	Accuracy/bias	4-Bromofluorobenzene - 85-120% Toluene-d8 - 85-115% Dibromofluoromethane - 67-118% 1,2-Dichloroethane-d4 - 55-148%

DoD QSM: Department of Defense Quality Systems Manual for Environmental Laboratories April 2009, Version 4.1. Statistically-derived limits are used when DoD QSM limits do not exist.

SAP Worksheet #28-2—Laboratory QC Samples Table

Matrix: SS, SB, SD

Analytical Group: SVOC

Analytical Method / SOP Reference: SW-846 8270C, 8270C-SIM / CA-204, CA-213

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Low (SW-846 8270C)						
Method Blank	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected > 1/2 QL. For common laboratory contaminants > QL	Investigate source of contamination. Evaluate the samples and associated QC: if blank results are above QL, report sample results which are < QL or > 10X the blank concentration. Reprep and analyze method blank and all samples processed with the contaminated blank.	Analyst, Supervisor, QA Manager	Accuracy/bias- Contamination	No analyte detected > 1/2 QL. For common laboratory contaminants > QL
LCS	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria[1] or laboratory statistically derived limits. Please refer to Worksheet 15.	Evaluate and reanalyze if possible. If an MS/MSD was extracted in the same extraction batch and acceptable narrate. If the LCS recoveries are high but the sample results are <QL narrate. Otherwise reprep and reanalyze	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria[1].
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or laboratory statistically derived limits. Please refer to Worksheet 15.	CA will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met. If both the LCS and MS/MSD are unacceptable reprep the samples and QC.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike Duplicate	Same as MS.	Same as MS and RPD ≤ 30%	Same as MS.	Analyst, Supervisor, QA Manager	Accuracy/bias & Precision	Same as MS and RPD ≤ 30%
Surrogates	6 Per Sample	DoD QSM: 2-Fluorobiphenyl - 45-105% Terphenyl-d14 - 30-125% 2,4,6-Tribromophenol - 35-125% 2-Fluorophenol - 35-105% Nitrobenzene-d5 - 40-110% Phenol-d5/d6 - 140-100%	Reanalyze if sample volume is available and within hold time. Otherwise, contact client.	Analyst, Supervisor, QA Manager	Accuracy/bias	2-Fluorobiphenyl - 45-105% Terphenyl-d14 - 30-125% 2,4,6-Tribromophenol - 35-125% 2-Fluorophenol - 35-105% Nitrobenzene-d5 - 40-110% Phenol-d5/d6 - 140-100%
Internal Standards (IS)	Each field and QC sample	RT ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard	Reanalyze affected samples	Analyst	Accuracy	RT ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard

SAP Worksheet #28-2—Laboratory QC Samples Table (continued)

Matrix: SS, SB, SD
Analytical Group: SVOC
Analytical Method / SOP Reference: SW-846 8270C, 8270C-SIM / CA-204, CA-213

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
SIM (SW-846 8270C-SIM)						
Method Blank	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected > 1/2 QL. For common laboratory contaminants > QL	Investigate source of contamination. Evaluate the samples and associated QC: if blank results are above QL, report sample results which are < QL or > 10X the blank concentration. Reprep and analyze method blank and all samples processed with the contaminated blank.	Analyst, Supervisor, QA Manager	Accuracy/bias- Contamination	No analyte detected > 1/2 QL. For common laboratory contaminants > QL
LCS	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria[1] or laboratory statistically derived limits. Please refer to Worksheet 15.	Evaluate and reanalyze if possible. If an MS/MSD was extracted in the same extraction batch and acceptable narrate. If the LCS recoveries are high but the sample results are <QL narrate. Otherwise reprep and reanalyze	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria[1].
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or nominal limits. Please refer to Worksheet 15.	CA will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met. If both the LCS and MS/MSD are unacceptable reprep the samples and QC.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike Duplicate	Same as MS.	Same as MS and RPD ≤ 30%	See above	Analyst, Supervisor, QA Manager	Accuracy/bias & Precision	Same as MS and RPD ≤ 30%
Surrogates	4 Per Sample	KAS Statisically-derived: 2-Methylnaphthalene-d10 - 33-125% Fluorene-d10 - 53-136% Pyrene-d10 - 16-162% Nominal: 2,4-Dibromophenol - 30-150%	Reanalyze if sample volume is available and within hold time. Otherwise, contact client.	Analyst, Supervisor, QA Manager	Accuracy/bias	KAS Statisically-derived: 2-Methylnaphthalene-d10 - 33-125% Fluorene-d10 - 53-136% Pyrene-d10 - 16-162% Nominal: 2,4-Dibromophenol - 30-150%
Internal Standards (IS)	Each field and QC sample	RT ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard	Reanalyze affected samples	Analyst	Accuracy	RT ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard

DoD QSM: Department of Defense Quality Systems Manual for Environmental Laboratories April 2009, Version 4.1 . Statistically-derived limits are used when DoD QSM limits do not exist.

1. The following analytes may not exceed their LCS control limits, even marginally: 2-methylnaphthalene; acenaphthene; acenaphthylene; anthracene; benzo(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; benzo(g,h,i)perylene; benzo(k)fluoranthene; carbazole; chrysene; dibenz(a,h)anthracene; dibenzofuran; fluoranthene; fluorene; indeno(1,2,3-cd)pyrene; naphthalene; phenanthrene; pyrene; and bis(2-ethylhexyl)phthalate.

SAP Worksheet #28-3—Laboratory QC Samples Table

Matrix: SS, SB, SD

Analytical Group: PEST/PCB

Analytical Method / SOP Reference: SW-846 8081A, 8082 / CA-302,CA-329

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Pesticides (SW-846 8081A)						
Method Blank	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected >1/2 QL	Investigate source of contamination. Evaluate the samples and associated QC: i.e. If the blank results are above the QL, report sample results which are <QL or > 10X the blank concentration. Otherwise, reprep a blank and samples >QL and <10XQL.	Analyst, Supervisor, QA Manager	Accuracy/bias- Contamination	No target > 1/2 QL
LCS	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria[1]. Please refer to Worksheet 15.	If an MS/MSD was performed and acceptable, narrate. If an LCS/LCSD was performed and only one of the set was unacceptable, narrate. If the LCS recovery is high but the sample results are <QL, narrate. Otherwise, re-extract blank and affected sample batch.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria[1].
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria. Please refer to Worksheet 15.	Evaluate the samples and associated QC. If the LCS results are acceptable, narrate. If both the LCS and MS/MSD are unacceptable, reprep the samples and QC.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike Duplicate	Same as MS	Same as MS and RPD ≤ 30%	Same as MS.	Analyst, Supervisor, QA Manager	Accuracy/bias & Precision	Same as MS and RPD ≤ 30%
Confirmation of positive results (second column or second detector)	All positive results must be confirmed.	Calibration and QC criteria same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.	Apply J-flag if RPD > 40%. Discuss in the case narrative.	Analyst, Supervisor, QA Manager	Precision	Calibration and QC criteria same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.
Surrogates	2 per Sample	DoD QSM: Decachlorobiphenyl - 55-130% TCMX - 70-125%	No CA will be taken when one surrogate is within criteria. If surrogates are outside high and sample is <QL no CA taken. If surrogates are outside low the affected samples are re-extracted and reanalyzed.	Analyst, Supervisor, QA Manager	Accuracy/bias	Decachlorobiphenyl - 55-130% TCMX - 70-125%
Breakdown Evaluation Check (EVAL)	Before samples are analyzed and at the beginning of each 12 hour shift	Breakdown of DDT or Endrin ≤ 15 %.	Perform instrument maintenance. Reanalyze all samples analyzed after the failing Eval.	Analyst, Supervisor, QA Manager	Accuracy/bias- Contamination	Breakdown of DDT or Endrin ≤ 15 %.

SAP Worksheet #28-3—Laboratory QC Samples Table (continued)

Matrix: SS, SB, SD

Analytical Group: PEST/PCB

Analytical Method / SOP Reference: SW-846 8081A, 8082 / CA-302,CA-329

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
PCBs (SW-846 8082)						
Method Blank	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected >1/2 QL	Investigate source of contamination. Evaluate the samples and associated QC: i.e. If the blank results are above the QL, report sample results which are <QL or > 10X the blank concentration. Otherwise, reprep a blank and samples >QL and <10XQL.	Analyst, Supervisor, QA Manager	Accuracy/bias- Contamination	No target > 1/2 QL
LCS	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria[1]. Please refer to Worksheet 15.	If an MS/MSD was performed and acceptable, narrate. If an LCS/LCSD was performed and only one of the set was unacceptable, narrate. If the LCS recovery is high but the sample results are <QL, narrate. Otherwise, re-extract blank and affected sample batch.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria[1].
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria. Please refer to Worksheet 15.	Evaluate the samples and associated QC. If the LCS results are acceptable, narrate. If both the LCS and MS/MSD are unacceptable, reprep the samples and QC.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike Duplicate	Same as MS	Same as MS and RPD ≤ 30%	Same as MS.	Analyst, Supervisor, QA Manager	Accuracy/bias & Precision	Same as MS and RPD ≤ 30%
Confirmation of positive results (second column or second detector)	All positive results must be confirmed.	Calibration and QC criteria same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.	Apply J-flag if RPD > 40%. Discuss in the case narrative.	Analyst, Supervisor, QA Manager	Precision	Calibration and QC criteria same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.
Surrogates	2 per Sample	DoD QSM: DCB - 60-125% KAS Statisically-derived: TCX - 56-115%	No CA will be taken when one surrogate is within criteria. If surrogates are outside high and sample is <QL no CA taken. If surrogates are outside low the affected samples are re-extracted and reanalyzed.	Analyst, Supervisor, QA Manager	Accuracy/bias	DCB - 60-125% TCX - 56-115%

DoD QSM: Department of Defense Quality Systems Manual for Environmental Laboratories April 2009, Version 4.1 . Statistically-derived limits are used when DoD QSM limits do not exist.

1. The following analytes may not exceed their LCS control limits, even marginally: 4,4'-DDD; 4,4'-DDE; 4,4'-DDT; alpha-chlordane; dieldrin; endrin aldehyde; endrin ketone; heptachlor epoxide; methoxychlor; and Aroclor-1260.

SAP Worksheet #28-4—Laboratory QC Samples Table

Matrix: SS, SB,SD, ASH

Analytical Group: METAL

Analytical Method / SOP Reference: SW-846 6010B, 6020, 7471A, 9012B / CA-608, CA-611, CA-627, CA-773

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Metals (SW-846 6010B)						
Preparation Blank (PBS)	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected > 1/2 QL	Investigate source of contamination. If blank value > PQL report sample results if < PQL or > 10 x the blank value. Otherwise redigest.	Analyst, Supervisor, QA Manager	Accuracy/Bias	No analyte detected > 1/2 QL
Laboratory Control Sample (LCSS)	One per prep batch of twenty or fewer samples of similar matrix	80-120%R (75-125%R for silver)	if the LCS recoveries are > the vendor upper limit but the sample results are <QL, narrate. Redigest and reanalyze all associated samples for affected analyte.	Analyst, Supervisor, QA Manager	Accuracy/Bias	80-120%R (75-125%R for silver)
Matrix Spike Sample	One per prep batch of twenty or fewer samples of similar matrix	Same as LCS if sample < 4x spike value	Flag results for affected analytes for all associated samples with "N".	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	Same as LCS if sample < 4x spike value
Matrix Spike Duplicate	Same as MS	Same as MS and RPD ≤ 20%	Same as MS. Flag results for affected analytes for all associated samples with"*". Perform postdigestion spike for all failing elements, except Ag, at 2x the indigenous level or 2x the PQL, whichever is greater.	Analyst, Supervisor, QA Manager	Accuracy/bias	Same as MS and RPD ≤ 20%
Serial Dilution (L)	One per prep batch of twenty or fewer samples of similar matrix	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.	Perform post-digestion spike (PDS) addiiton.	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.
Post Digestion Spike (for elements that have a failing MS)	One per prep batch of twenty or fewer samples of similar matrix	75-125% recovery	Failures will be noted in the case narrative	Analyst, Supervisor	accuracy/bias	75-125% recovery
Metals (SW-846 6020)						
Preparation Blank (PBS)	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected > 1/2 QL	Investigate source of contamination. If blank value > PQL report sample results if < PQL or > 10 x the blank value. Otherwise redigest.	Analyst, Supervisor, QA Manager	Accuracy/Bias	No analyte detected > 1/2 QL
Laboratory Control Sample (LCSS)	One per prep batch of twenty or fewer samples of similar matrix	80-120%R (75-125%R for silver)	if the LCS recoveries are > the vendor upper limit but the sample results are <QL, narrate. Otherwise, redigest and reanalyze all associated samples for affected analyte.	Analyst, Supervisor, QA Manager	Accuracy/Bias	80-120%R (75-125%R for silver)
Matrix Spike Sample	One per prep batch of twenty or fewer samples of similar matrix	Same as LCS if sample < 4x spike value	Flag results for affected analytes for all associated samples with "N".	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	Same as LCS if sample < 4x spike value
Matrix Spike Duplicate	Same as MS	Same as MS and RPD ≤ 20%	Same as MS. Flag results for affected analytes for all associated samples with"*". Perform postdigestion spike for all failing elements, except Ag, at 2x the indigenous level or 2x the PQL, whichever is greater.	Analyst, Supervisor, QA Manager	Accuracy/bias	Same as MS and RPD ≤ 20%

SAP Worksheet #28-4—Laboratory QC Samples Table (continued)

Matrix: SS, SB,SD, ASH
Analytical Group: METAL
Analytical Method / SOP Reference: SW-846 6010B, 6020, 7471A, 9012B / CA-608, CA-611, CA-627, CA-773

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Serial Dilution (L)	One per prep batch of twenty or fewer samples of similar matrix	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.	Perform post-digestion spike (PDS) addiiton.	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.
Internal Standards	Internal Standard (IS), Appropriate IS required for all analytes in all samples. Mass of IS must be <50 amu different from that of analyte	For each sample, IS intensity within 30%-120% of that of initial calib. standard. For ICV, ICB, CCV, and CCB, IS intensity within 80%-120% of that in initial calib. standard.	Reanalyze affected samples	Analyst, Supervisor, QA Manager	Accuracy	For each sample, IS intensity within 30%-120% of that of initial calib. standard. For ICV, ICB, CCV, and CCB, IS intensity within 80%-120% of that in initial calib. standard.
Post Digestion Spike (for elements that have a failing MS)	One per prep batch of twenty or fewer samples of similar matrix	75-125% recovery	Failures will be noted in the case narrative	Analyst, Supervisor	accuracy/bias	75-125% recovery
Mercury (SW-846 7471A)						
Preparation Blank (PBS)	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected > 1/2 QL	Investigate source of contamination. If blank value > PQL report sample results if < PQL or > 10 x the blank value. Otherwise redigest.	Analyst, Supervisor, QA Manager	Accuracy/Bias	No analyte detected > 1/2 QL
Laboratory Control Sample (LCSS)	One per prep batch of twenty or fewer samples of similar matrix	80-120%R	If the LCS recoveries are > the vendor upper limit but the sample results are <QL, narrate. Redigest and reanalyze all associated samples.	Analyst, Supervisor, QA Manager	Accuracy/Bias	80-120%R
Matrix Spike Sample	One per prep batch of twenty or fewer samples of similar matrix	Same as LCS if sample < 4x spike value	Flag results for affected analytes for all associated samples with "N".	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	Same as LCS if sample < 4x spike value
Matrix Spike Duplicate	Same as MS	Same as MS and RPD ≤ 20%	Same as MS. Flag results for affected analytes for all associated samples with"*". Perform postdigestion spike.	Analyst, Supervisor, QA Manager	Accuracy/bias	Same as MS and RPD ≤ 20%
Serial Dilution (L)	One per prep batch of twenty or fewer samples of similar matrix	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.	Flag results for affected analytes for all associated samples with "E".	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.
Cyanide (SW-846 9012B)						
Method Blank	One per batch of 20 samples or fewer	Abs. value < 1/2 PQL	Investigate source of contamination. If blank value > PQL report sample results if < PQL or > 10 x the blank value. Otherwise reprep	Analyst, Supervisor, QA Manager	Accuracy / Bias / Contamination	Abs. value < 1/2 PQL
Laboratory Control Sample (LCS)	One per digestion batch of 20 samples or fewer	80-120 %R	If the LCS fails high, report samples that are <PQL. Recalibrate and/or reanalyze other samples.	Analyst, Supervisor, QA Manager	Accuracy / Bias	80-120 %R

SAP Worksheet #28-4—Laboratory QC Samples Table (continued)

Matrix: SS, SB,SD, ASH
Analytical Group: METAL
Analytical Method / SOP Reference: SW-846 6010B, 6020, 7471A, 9012B / CA-608, CA-611, CA-627, CA-773

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Laboratory Replicate	One sample duplicate per 20 samples	RPD ≤ 20 % for samples > 3X the PQL and <100% for samples < 3X the PQL.	Investigate problem and reanalyze sample in duplicate. If RPD still >20, report original result with notation or narration.	Analyst, Supervisor, QA Manager	Accuracy / Bias / Precision	RPD ≤ 20 % for samples <3X the PQL and <100% for samples >3X the PQL.
Matrix Spike (MS)	One for every set of 10 samples	75-125% Recovery if sample conc. < 4 X spike	Evaluate samples and associated QC: i.e. If the LCS results are acceptable, narrate. If both the LCS and MS are unacceptable reprep and reanalyze the samples and QC. May analyze unspiked sample digestate to confirm matrix interference. Notate sample result in raw data if matrix is confirmed	Analyst, Supervisor, QA Manager	Accuracy / Bias	75-125 % Recovery

DoD QSM: Department of Defense Quality Systems Manual for Environmental Laboratories April 2009, Version 4.1 .

SAP Worksheet #28-5—Laboratory QC Samples Table

Matrix: SS, SB, SD
Analytical Group: EXPLO
Analytical Method / SOP Reference: SW-846 8330M, IAPP, 6850 / CA-402, WS-LC-0010, WS-LC-0012

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Nitroaromatics/Nitroamines and Nitroglycerin (SW-846 8330M)						
Method Blank	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected > 1/2 PQL	Investigate source of contamination. Evaluate the samples and associated QC: ie. the blank results are above the PQL, report sample results which are <PQL or > 10X the blank concentration. Otherwise, reprep a blank and the remaining samples.	Analyst, Supervisor, QA Manager	Accuracy/bias- Contamination	No analyte detected > 1/2 PQL
LCS	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or nominal limits. Please refer to Worksheet 15.	Evaluate the samples and associated QC: i.e. If an MS/MSD was performed and acceptable, narrate. If an LCS/LCSD was performed and only one of the set was unacceptable, narrate. If the surrogate recoveries in the LCS are also low but are acceptable in the blank and samples, narrate. If the LCS recovery is high but the sample results are < PQL, narrate. Otherwise, reprep a blank and the remaining samples.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or nominal limits. Please refer to Worksheet 15.	Evaluate the samples and associated QC: ie. If the LCS results are acceptable, narrate. If both the LCS and MS/MSD are unacceptable, reprep the samples and QC.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike Duplicate	Same as MS	Same as MS and RPD ≤ 30 %	Same as MS.	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	Same as MS and RPD ≤ 30 %
Confirmation of positive results (second column or second detector)	All positive results must be confirmed.	Calibration and QC criteria same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.	Apply J-flag if RPD > 40%. Discuss in the case narrative.	Analyst, Supervisor, QA Manager	Precision	Calibration and QC criteria same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.
Surrogates	One per sample	Nominal: 1,2-Dinitrobenzene - 30-150%	If surrogate is outside high and sample is <QL no CA taken. If surrogate is outside low the affected samples are re-extracted and reanalyzed	Analyst, Supervisor, QA Manager	Accuracy/bias	1,2-Dinitrobenzene - 30-150%
Nitroguanidine (IAPP)						
Method Blank	One per preparation batch	No target analytes ≥ ½ RL in accordance with DoD QSM requirements	Correct problem, then re-extract and reanalyze method blank and all samples processed with the contaminated blank in accordance with DoD QSM requirements	Lab Manager / Analyst	Accuracy/Bias Contamination	No target analytes ≥ ½ RL in accordance with DoD QSM requirements
LCS	One LCS per analytical/preparation batch	DoD QSM Limits including the DOD QSM marginal exceedance criteria or laboratory statistically derived limits. Please refer to Worksheet 15.	Correct problem, then re-extract and reanalyze the LCS and all associated batch samples in accordance with DoD QSM requirements.	Lab Manager / Analyst	Accuracy/Bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria or laboratory statistically derived limits.

SAP Worksheet #28-5—Laboratory QC Samples Table (continued)

Matrix: SS, SB, SD
Analytical Group: EXPLO
Analytical Method / SOP Reference: SW-846 8330M, IAPP, 6850 / CA-402, WS-LC-0010, WS-LC-0012

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or laboratory statistically derived limits. Please refer to Worksheet 15.	Examine the project specific DQOs. Evaluate the data, and re-prepare/reanalyze the native sample and MS/MSD pair as indicated.	Lab Manager / Analyst	Accuracy/Bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria or laboratory statistically derived limits. Please refer to Worksheet 15.
Matrix Spike Duplicate	Same as MS.	Same as MS and RPD ≤ 30%	Same as MS	Lab Manager / Analyst	Accuracy/Bias, Precision	Same as MS and RPD ≤ 30%
Perchlorate (SW-846 6850)						
Method Blank	One per preparation batch	No target analytes ≥ ½ RL in accordance with DoD QSM requirements	Correct problem, then re-extract and reanalyze method blank and all samples processed with the contaminated blank in accordance with DoD QSM requirements	Lab Manager / Analyst	Accuracy/Bias Contamination	No target analytes ≥ ½ RL in accordance with DoD QSM requirements
Internal Standards	During acquisition of calibration standard, samples, and QC check samples	Areas within -50% to +100% of the midpoint of the last ICAL for each sample and QC in accordance with DoD QSM requirements. RRT of the perchlorate ion must be 1.0 ± 2% (0.98 - 1.02).	Inspect LCMS for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning in accordance with DoD QSM requirements	Lab Manager / Analyst	Accuracy/Bias	Areas within -50% to +100% of the midpoint of the last ICAL for each sample and QC in accordance with DoD QSM requirements. RRT of the perchlorate ion must be 1.0 ± 2% (0.98 - 1.02).
Interference Check Standard (ICS)	One ICS is prepared with every batch of 20 samples and must undergo the same preparation and pretreatment steps as the samples in the batch. It verifies the method performance at the matrix conductivity threshold (MCT). At least one ICS must be analyzed daily.	Within ±30% of true value.	Correct problem and then reanalyze all samples in that batch. If poor recovery from the cleanup filters is suspected, a different lot of filters must be used to reextract all samples in the batch. If column degradation is suspected, a new column must be calibrated before the samples can be reanalyzed. Flagging criteria are not appropriate.	Lab Manager / Analyst	Accuracy/Bias	Within ±30% of true value.
Isotope Ratio	Every Sample and QC	83/85 ratio within ± 30% of the mid-range ICAL standard ratio, or within ± 30% of the ratio of the average of the areas from all CCVs in the run, if the ICAL is not run the same day. Must fall within 2.3 to 3.8.	N/A	Lab Manager / Analyst	Qualitative Identification	83/85 ratio within ± 30% of the mid-range ICAL standard ratio, or within ± 30% of the ratio of the average of the areas from all CCVs in the run, if the ICAL is not run the same day. Must fall between 2.3 to 3.8.
LCS	One LCS per analytical/preparation batch	QC acceptance criteria: 80% to 120% accuracy,15% precision; or laboratory statistically derived control limits.	Correct problem, then re-extract and reanalyze the LCS and all associated batch samples in accordance with DoD QSM requirements.	Lab Manager / Analyst	Accuracy/Bias	QC acceptance criteria: 80% to 120% accuracy,15% precision; or laboratory statistically derived control limits.
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	Same as LCS	Examine the project specific DQOs. Evaluate the data, and re-prepare/reanalyze the native sample and MS/MSD pair as indicated.	Lab Manager / Analyst	Accuracy/Bias	Same as LCS
Matrix Spike Duplicate	Same as MS.	Same as MS and RPD ≤ 15%	Same as MS	Lab Manager / Analyst	Accuracy/Bias, Precision	Same as MS and RPD ≤ 15%

DoD QSM: Department of Defense Quality Systems Manual for Environmental Laboratories April 2009, Version 4.1 . Statistically-derived limits are used when DoD QSM limits do not exist.

SAP Worksheet #28-6—Laboratory QC Samples Table

Matrix: SS, SB, SD

Analytical Group: WCHEM

Analytical Method / SOP Reference: SW-846 9045C, Lloyd Kahn, / CA-709, CA-741

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
pH (SW-846 9045C)						
Laboratory Control Sample (LCS)	One per 20 samples	90-110% recovery	Correct problem, recalibrate	Analyst, Supervisor, QA Manager	Accuracy/Bias	90-110% recovery
Laboratory Replicate	One sample duplicate per every 10 field samples.	RPD < 20%	1) Investigate problem and reanalyze sample in duplicate (2) If RPD is still unacceptable, report original result with notation or narration.	Analyst, Supervisor, QA Manager	Precision	RPD < 20%
Total Organic Carbon (Lloyd Kahn)						
Method Blank	One per 20 samples	No analyte > PQL	Investigate source of contamination. Report all sample results > 10 x the blank result and flag results with “B”. Reprep and anlyze method blank and all other samples processed with the contaminated blank.	Analyst, Supervisor, QA Manager	Accuracy/Bias, Contamination	No analyte > PQL
Laboratory Quadruplicate	One sample quadruplicate per 20 samples.	RSD < 30%	If lab QC in criteria and matrix interference suspected, flag data. Else, reanalyze.	Analyst, Supervisor, QA Manager	Precision	RSD < 30%
Matrix Spike (MS)	One per 10 samples	80-120 % recovery	If LCS in criteria and matrix interference suspected, flag data. Else, reanalyze.	Analyst, Supervisor, QA Manager	Accuracy/Bias	80-120 % recovery
Laboratory Control Sample (LCS)	One per 20 samples	80-120%	IInvestifgate source of problem. f the LCS fails high, report samples that are < PQL. Reprep a blank the remaining samples.	Analyst, Supervisor, QA Manager	Accuracy/Bias	80-120%

Measurement performance criteria are based on the analytical laboratory SOPs.

SAP Worksheet #28-7—Laboratory QC Samples Table

Matrix: SD

Analytical Group: GRAINSIZE

Analytical Method / SOP Reference: ASTM D422 / BR-GT-006

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Laboratory Replicate	Client designated	N/A	N/A	Analyst, Supervisor, QA Manager	Precision	N/A

Measurement performance criteria are based on the analytical laboratory SOPs. There are no acceptance limits for grain size precision.

SAP Worksheet #28-8—Laboratory QC Samples Table

Matrix: GW, AQ
Analytical Group: VOC
Analytical Method / SOP Reference: SW-846 8260B / CA-202

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected > 1/2 QL. For common laboratory contaminants > QL	Investigate source of contamination. Rerun method blank prior to analysis of samples if possible. Evaluate the samples and associated QC: if blank results are above QL, report sample results which are < QL or > 10X the blank concentration. Reanalyze blank and samples >QL and < 10X the blank.	Analyst, Supervisor, QA Manager	Accuracy/bias- Contamination	No analyte detected > 1/2 QL. For common laboratory contaminants > QL
LCS	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria[1] or laboratory statistically derived limits. Please refer to Worksheet 15.	Evaluate and reanalyze if possible. If an MS/MSD was performed in the same 12 hour clock and acceptable narrate. If the LCS recoveries are high but the sample results are <QL narrate. Otherwise reprep and reanalyze.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria[1].
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or laboratory statistically derived limits. Please refer to Worksheet 15.	CA will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met. If both the LCS and MS/MSD are unacceptable reprep the samples and QC.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike Duplicate	Same as MS.	Same as MS and RPD ≤ 20%	Same as MS.	Analyst, Supervisor, QA Manager	Accuracy/bias & Precision	Same as MS and RPD ≤ 20%
Internal Standards (IS)	Each field and QC sample	RT ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard	Reanalyze affected samples	Analyst	Accuracy	RT ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard
Surrogates	4 Per Sample	DoD QSM: 1,2-Dichloroethane-d4 - 70-120% 4-Bromofluorobenzene - 75-120% Dibromofluoromethane - 85-115% Toluene-d8 - 85-120%	Reanalyze if sample volume is available and within hold time. Otherwise, contact client.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM: 1,2-Dichloroethane-d4 - 70-120% 4-Bromofluorobenzene - 75-120% Dibromofluoromethane - 85-115% Toluene-d8 - 85-120%

DoD QSM: Department of Defense Quality Systems Manual for Environmental Laboratories April 2009, Version 4.1 . Statistically-derived limits are used when DoD QSM limits do not exist.

1. The following analytes may not exceed their LCS control limits, even marginally: bromodichloromethane.

SAP Worksheet #28-9—Laboratory QC Samples Table

Matrix: GW, AQ

Analytical Group: SVOC

Analytical Method / SOP Reference: SW-846 8270C, 8270C-SIM / CA-204, CA-213

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Low (SW-846 8270C)						
Method Blank	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected > 1/2 QL. For common laboratory contaminants > QL	Investigate source of contamination. Evaluate the samples and associated QC: if blank results are above QL, report sample results which are < QL or > 10X the blank concentration. Reprep and analyze method blank and all samples processed with the contaminated blank.	Analyst, Supervisor, QA Manager	Accuracy/bias-Contamination	No analyte detected > 1/2 QL. For common laboratory contaminants > QL
LCS	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or laboratory statistically derived limits. Please refer to Worksheet 15.	Reanalyze if sample volume is available and within hold time. Otherwise, contact client.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or laboratory statistically derived limits. Please refer to Worksheet 15.	Evaluate and reanalyze if possible. If an MS/MSD was extracted in the same extraction batch and acceptable narrate. If the LCS recoveries are high but the sample results are <QL narrate. Otherwise reprep and reanalyze	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike Duplicate	Same as MS.	Same as MS and RPD ≤ 30%	Same as MS.	Analyst, Supervisor, QA Manager	Accuracy/bias	Same as MS and RPD ≤ 30%
Surrogates	6 per sample	DoD QSM: 2-Fluorobiphenyl - 50-110% Terphenyl-d14 - 50-135% 2,4,6-Tribromophenol - 40-125 2-Fluorophenol - 20-110% Nitrobenzene-d5 - 40-110% Phenol - 10-115%	Reanalyze if sample volume is available and within hold time. Otherwise, contact client.	Analyst, Supervisor, QA Manager	Accuracy/bias & Precision	DoD QSM: 2-Fluorobiphenyl - 50-110% Terphenyl-d14 - 50-135% 2,4,6-Tribromophenol - 40-125 2-Fluorophenol - 20-110% Nitrobenzene-d5 - 40-110% Phenol - 10-115%
Internal Standards (IS)	Each field and QC sample	RT ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard	Reanalyze affected samples	Analyst	Accuracy	RT ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard

SAP Worksheet #28-9—Laboratory QC Samples Table (continued)

Matrix: GW, AQ
Analytical Group: SVOC
Analytical Method / SOP Reference: SW-846 8270C, 8270C-SIM / CA-204, CA-213

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
SIM (SW-846 8270C-SIM)						
Method Blank	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected > 1/2 QL. For common laboratory contaminants > QL	Investigate source of contamination. Evaluate the samples and associated QC: if blank results are above QL, report sample results which are < QL or > 10X the blank concentration. Reprep and analyze method blank and all samples processed with the contaminated blank.	Analyst, Supervisor, QA Manager	Accuracy/bias-Contamination	No analyte detected > 1/2 QL. For common laboratory contaminants > QL
LCS	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or nominal limits. Please refer to Worksheet 15.	Evaluate and reanalyze if possible. If an MS/MSD was extracted in the same extraction batch and acceptable narrate. If the LCS recoveries are high but the sample results are <QL narrate. Otherwise reprep and reanalyze	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or nominal limits. Please refer to Worksheet 15.	CA will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met. If both the LCS and MS/MSD are unacceptable reprep the samples and QC.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike Duplicate	Same as MS.	Same as MS and RPD ≤ 30%	Same as MS.	Analyst, Supervisor, QA Manager	Accuracy/bias & Precision	Same as MS and RPD ≤ 30%
Surrogates	Up to 4 Per Sample	KAS Statisically-derived: 2-Methylnaphthalene-d10 - 34-110% Fluorene-d10 - 46-122% Pyrene-d10 - 36-134% Nominal: 2,4-Dibromophenol - 30-150%	Reanalyze if sample volume is available and within hold time. Otherwise, contact client.	Analyst, Supervisor, QA Manager	Accuracy/bias	KAS Statisically-derived: 2-Methylnaphthalene-d10 - 34-110% Fluorene-d10 - 46-122% Pyrene-d10 - 36-134% Nominal: 2,4-Dibromophenol - 30-150%
Internal Standards (IS)	Each field and QC sample	RT ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard	Reanalyze affected samples	Analyst	Accuracy	RT ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard

DoD QSM: Department of Defense Quality Systems Manual for Environmental Laboratories April 2009, Version 4.1 . Statistically-derived limits are used when DoD QSM limits do not exist.

SAP Worksheet #28-10—Laboratory QC Samples Table

Matrix: GW, AQ

Analytical Group: PEST/PCB

Analytical Method / SOP Reference: SW-846 8081A, 8082 / CA-302, CA-327

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Pesticides (SW-846 8081A)						
Method Blank	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected >1/2 QL	Investigate source of contamination. Evaluate the samples and associated QC: i.e. If the blank results are above the QL, report sample results which are <QL or > 10X the blank concentration. Otherwise, reprep a blank and samples >QL and <10XQL.	Analyst, Supervisor, QA Manager	Accuracy/bias-Contamination	No target > 1/2 QL
LCS	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the marginal exceedance criteria. Please refer to Worksheet 15.	If an MS/MSD was performed and acceptable, narrate. If an LCS/LCSD was performed and only one of the set was unacceptable, narrate. If the LCS recovery is high but the sample results are <QL, narrate. Otherwise, re-extract blank and affected sample batch.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the marginal exceedance criteria.
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the marginal exceedance criteria. Please refer to Worksheet 15.	Evaluate the samples and associated QC. If the LCS results are acceptable, narrate. If both the LCS and MS/MSD are unacceptable, reprep the samples and QC.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the marginal exceedance criteria.
Matrix Spike Duplicate	Same as MS.	Same as MS and RPD ≤ 30%	Same as MS.	Analyst, Supervisor, QA Manager	Accuracy/bias & Precision	Same as MS and RPD ≤ 30%
Confirmation of positive results (second column or second detector)	All positive results must be confirmed.	Calibration and QC criteria same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.	Apply J-flag if RPD > 40%. Discuss in the case narrative.	Analyst, Supervisor, QA Manager	Precision	Calibration and QC criteria same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.
Surrogates	2 per Sample	DoD QSM:Decachlorobiphenyl - 30-135%TCMX - 25-14%	No CA will be taken when one surrogate is within criteria. If surrogates are outside high and sample is <QL no CA taken. If surrogates are outside low the affected samples are re-extracted and reanalyzed.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM:Decachlorobiphenyl - 30-135%TCMX - 25-14%
Breakdown Evaluation Check (EVAL) Pesticides Only	Before samples are analyzed and at the beginning of each 12 hour shift	Breakdown of DDT or Endrin ≤ 15 %.	Perform instrument maintenance. Reanalyze all samples analyzed after the failing Eval.	Analyst, Supervisor, QA Manager	Accuracy/bias-Contamination	Breakdown of DDT or Endrin ≤ 15 %.

SAP Worksheet #28-10—Laboratory QC Samples Table (continued)

Matrix: GW, AQ
Analytical Group: PEST/PCB
Analytical Method / SOP Reference: SW-846 8081A, 8082 / CA-302, CA-327

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
PCBs (SW-846 8082)						
Method Blank	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected >1/2 QL	Investigate source of contamination. Evaluate the samples and associated QC: i.e. If the blank results are above the QL, report sample results which are <QL or > 10X the blank concentration. Otherwise, reprep a blank and samples >QL and <10XQL.	Analyst, Supervisor, QA Manager	Accuracy/bias-Contamination	No target > 1/2 QL
LCS	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the marginal exceedance criteria. Please refer to Worksheet 15.	If an MS/MSD was performed and acceptable, narrate. If an LCS/LCSD was performed and only one of the set was unacceptable, narrate. If the LCS recovery is high but the sample results are <QL, narrate. Otherwise, re-extract blank and affected sample batch.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the marginal exceedance criteria. Please refer to Worksheet 15.	Evaluate the samples and associated QC. If the LCS results are acceptable, narrate. If both the LCS and MS/MSD are unacceptable, reprep the samples and QC.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria.
Matrix Spike Duplicate	Same as MS.	Same as MS and RPD ≤ 30%	Same as MS.	Analyst, Supervisor, QA Manager	Accuracy/bias & Precision	Same as MS and RPD ≤ 30%
Confirmation of positive results (second column or second detector)	All positive results must be confirmed.	Calibration and QC criteria same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.	Apply J-flag if RPD > 40%. Discuss in the case narrative.	Analyst, Supervisor, QA Manager	Precision	Calibration and QC criteria same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.
Surrogates	2 per Sample	DoD QSM: DCB - 40-135% KAS Statisically-derived: TCX - 62-111%	No CA will be taken when one surrogate is within criteria. If surrogates are outside high and sample is <QL no CA taken. If surrogates are outside low the affected samples are re-extracted and reanalyzed.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM: DCB - 40-135% KAS Statisically-derived: TCX - 62-111%

DoD QSM: Department of Defense Quality Systems Manual for Environmental Laboratories April 2009, Version 4.1 . Statistically-derived limits are used when DoD QSM limits do not exist.

1. The following analytes may not exceed their LCS control limits, even marginally: 4,4'-DDD; 4,4'-DDT; and heptachlor epoxide.

SAP Worksheet #28-11—Laboratory QC Samples Table

Matrix: GW, AQ
Analytical Group: METAL
Analytical Method / SOP Reference: SW-846 6010B, 6020, 7470A, 9012B / CA-608, CA-627, CA-615, CA-773

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Metals (SW-846 6010B)						
Preparation Blank (PBW)	One per prep batch of twenty or fewer samples of similar matrix	Absolute value < 1/2 PQL.	Investigate source of contamination. If blank value > PQL report sample results if < PQL or > 10 x the blank value. Otherwise redigest.	Analyst, Supervisor, QA Manager	Accuracy/bias-Contamination	Absolute value < 1/2 PQL.
Laboratory Control Sample (LCSW)	One per prep batch of twenty or fewer samples of similar matrix	Recovery within ± 20% of true value.	If the LCS recoveries are > 120 % but the sample results are <QL narrate. Redigest and reanalyze all associated samples for affected analyte.	Analyst, Supervisor, QA Manager	Accuracy/Bias	Recovery within ± 20% of true value.
Matrix Spike Sample	One per prep batch of twenty or fewer samples of similar matrix	Recovery ± 25 % of true value if sample < 4x spike value	Flag results for affected analytes for all associated samples with “N”.	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	Recovery ± 20 % of true value if sample < 4x spike value
Matrix Spike Duplicate	Same as MS.	Same as MS and RPD ≤ 20%	Same as MS. Flag results for affected analytes for all associated samples with”*”. Perform postdigestion spike for all failing elements, except Ag, at 2x the indigenous level or 2x the PQL, whichever is greater.	Analyst, Supervisor, QA Manager	Accuracy/bias	Same as MS and RPD ≤ 20%
Serial Dilution (L)	One per prep batch of twenty or fewer samples of similar matrix	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.	Perform post-digestion spike (PDS) addiiton.	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.
Post Digestion Spike (for elements that have a failing MS)	One per prep batch of twenty or fewer samples of similar matrix	75-125% recovery	Failures will be noted in the case narrative	Analyst, Supervisor	accuracy/bias	75-125% recovery
Metals (SW-846 6020)						
Preparation Blank (PBW)	One per prep batch of twenty or fewer samples of similar matrix	Absolute value < 1/2 PQL.	Investigate source of contamination. If blank value > PQL report sample results if < PQL or > 10 x the blank value. Otherwise redigest..	Analyst, Supervisor, QA Manager	Accuracy/bias-Contamination	Absolute value < 1/2 PQL.
Laboratory Control Sample (LCSW)	One per prep batch of twenty or fewer samples of similar matrix	Recovery within ± 20% of true value.	If the LCS recoveries are > 120 % but the sample results are <QL narrate. Redigest and reanalyze all associated samples for affected analyte.	Analyst, Supervisor, QA Manager	Accuracy/Bias	Recovery within ± 20% of true value.
Matrix Spike Sample	One per prep batch of twenty or fewer samples of similar matrix	Recovery ± 25 % of true value if sample < 4x spike value	Flag results for affected analytes for all associated samples with “N”.	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	Recovery ± 20 % of true value if sample < 4x spike value
Matrix Spike Duplicate	One per prep batch of twenty or fewer samples of similar matrix	Same as MS and RPD ≤ 20%	Same as MS. Flag results for affected analytes for all associated samples with”*”. Perform postdigestion spike for all failing elements, except Ag, at 2x the indigenous level or 2x the PQL, whichever is greater.	Analyst, Supervisor, QA Manager	Accuracy/bias	Same as MS and RPD ≤ 20%
Serial Dilution (L)	One per prep batch of twenty or fewer samples of similar matrix	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.	Perform post-digestion spike (PDS) addiiton.	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.

SAP Worksheet #28-11—Laboratory QC Samples Table (continued)

Matrix: GW, AQ
Analytical Group: METAL
Analytical Method / SOP Reference: SW-846 6010B, 6020, 7470A, 9012B / CA-608, CA-627, CA-615, CA-773

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Post Digestion Spike (for elements that have a failing MS)	One per prep batch of twenty or fewer samples of similar matrix	75-125% recovery	Failures will be noted in the case narrative	Analyst, Supervisor	accuracy/bias	75-125% recovery
Internal Standards	Internal Standard (IS); Appropriate IS required for all analytes in all samples. Mass of IS must be <50 amu different from that of analyte	For each sample, IS intensity within 30%-120% of that of initial calib. standard. For ICV, ICB, CCV, and CCB, IS intensity within 80%-120% of that in initial calib. standard.	Reanalyze affected samples	Analyst, Supervisor, QA Manager	Accuracy	For each sample, IS intensity within 30%-120% of that of initial calib. standard. For ICV, ICB, CCV, and CCB, IS intensity within 80%-120% of that in initial calib. standard.
Mercury (SW-846 7470A)						
Preparation Blank (PBW)	One per prep batch of twenty or fewer samples of similar matrix	Absolute value < 1/2 PQL.	Investigate source of contamination. If blank value > PQL report sample results if < PQL or > 10 x the blank value. Otherwise redigest.	Analyst, Supervisor, QA Manager	Accuracy/bias-Contamination	Absolute value < 1/2 PQL.
Laboratory Control Sample (LCSW)	One per prep batch of twenty or fewer samples of similar matrix	Recovery within ± 20% of true value.	If the LCS recoveries are > 120 % but the sample results are <QL narrate. Redigest and reanalyze all associated samples.	Analyst, Supervisor, QA Manager	Accuracy/Bias	Recovery within ± 20% of true value.
Matrix Spike Sample	One per prep batch of twenty or fewer samples of similar matrix	Recovery ± 25 % of true value if sample < 4x spike value	Flag results for affected analytes for all associated samples with “N”.	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	Recovery ± 20 % of true value if sample < 4x spike value
Matrix Spike Duplicate	One per prep batch of twenty or fewer samples of similar matrix	Same as MS and RPD ≤ 20%	Same as MS. Flag results for affected analytes for all associated samples with”*”. Perform postdigestion spike.	Analyst, Supervisor, QA Manager	Accuracy/bias	Same as MS and RPD ≤ 20%
Serial Dilution (L)	One per prep batch of twenty or fewer samples of similar matrix	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.	Flag results for affected analytes for all associated samples with “E”.	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.
Cyanide (SW-846 9012B)						
Method Blank	One per batch of 20 samples or fewer	Abs. value < 1/2 PQL	Investigate source of contamination. If blank value > PQL report sample results if < PQL or > 10 x the blank value. Otherwise reprep	Analyst, Supervisor, QA Manager	Accuracy/bias-Contamination	Abs. value < 1/2 PQL
Laboratory Control Sample (LCS)	One per digestion batch of 20 samples or fewer	80-120 %R	If the LCS fails high, report samples that are <PQL. Recalibrate and/or reanalyze other samples.	Analyst, Supervisor, QA Manager	Accuracy / Bias	80-120 %R
Laboratory Replicate	One sample duplicate per 20 samples	RPD ≤ 20 % for samples > 3X the PQL and <100% for samples < 3X the PQL.	Investigate problem and reanalyze sample in duplicate. If RPD still >20, report original result with notation or narration.	Analyst, Supervisor, QA Manager	Accuracy / Bias / Precision	RPD ≤ 20 % for samples <3X the PQL and <100% for samples >3X the PQL.
Matrix Spike (MS)	One for every set of 10 samples	75-125% Recovery if sample conc. < 4 X spike	Evaluate samples and associated QC: i.e. If the LCS results are acceptable, narrate. If both the LCS and MS are unacceptable reprep and reanalyze the samples and QC. May analyze unspiked sample digestate to confirm matrix interference. Notate sample result in raw data if matrix is confirmed	Analyst, Supervisor, QA Manager	Accuracy / Bias	75-125 % Recovery

DoD QSM: Department of Defense Quality Systems Manual for Environmental Laboratories April 2009, Version 4.1 .

SAP Worksheet #28-12—Laboratory QC Samples Table

Matrix: GW, AQ
Analytical Group: FMETAL
Analytical Method / SOP Reference: SW-846 6010B, 6020, 7470A / CA-608, CA-327, CA-615

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Metals (SW-846 6010B)						
Preparation Blank (PBW)	One per prep batch of twenty or fewer samples of similar matrix	Absolute value < 1/2 PQL.	Investigate source of contamination. If blank value > PQL report sample results if < PQL or > 10 x the blank value. Otherwise redigest.	Analyst, Supervisor, QA Manager	Accuracy/bias-Contamination	Absolute value < 1/2 PQL.
Laboratory Control Sample (LCSW)	One per prep batch of twenty or fewer samples of similar matrix	Recovery within ± 20% of true value.	If the LCS recoveries are > 120 % but the sample results are <QL narrate. Redigest and reanalyze all associated samples for affected analyte.	Analyst, Supervisor, QA Manager	Accuracy/Bias	Recovery within ± 20% of true value.
Matrix Spike Sample	One per prep batch of twenty or fewer samples of similar matrix	Recovery ± 25 % of true value if sample < 4x spike value	Flag results for affected analytes for all associated samples with “N”.	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	Recovery ± 20 % of true value if sample < 4x spike value
Matrix Spike Duplicate	Same as MS.	Same as MS and RPD ≤ 20%	Same as MS. Flag results for affected analytes for all associated samples with”*”. Perform postdigestion spike for all failing elements, except Ag, at 2x the indigenous level or 2x the PQL, whichever is greater.	Analyst, Supervisor, QA Manager	Accuracy/bias	Same as MS and RPD ≤ 20%
Serial Dilution (L)	One per prep batch of twenty or fewer samples of similar matrix	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.	Perform post-digestion spike (PDS) addiiton.	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.
Post Digestion Spike (for elements that have a failing MS)	One per prep batch of twenty or fewer samples of similar matrix	75-125% recovery	Failures will be noted in the case narrative	Analyst, Supervisor	accuracy/bias	75-125% recovery
Metals (SW-846 6020)						
Preparation Blank (PBW)	One per prep batch of twenty or fewer samples of similar matrix	Absolute value < 1/2 PQL.	Investigate source of contamination. If blank value > PQL report sample results if < PQL or > 10 x the blank value. Otherwise redigest..	Analyst, Supervisor, QA Manager	Accuracy/bias-Contamination	Absolute value < 1/2 PQL.
Laboratory Control Sample (LCSW)	One per prep batch of twenty or fewer samples of similar matrix	Recovery within ± 20% of true value.	If the LCS recoveries are > 120 % but the sample results are <QL narrate. Redigest and reanalyze all associated samples for affected analyte.	Analyst, Supervisor, QA Manager	Accuracy/Bias	Recovery within ± 20% of true value.
Matrix Spike Sample	One per prep batch of twenty or fewer samples of similar matrix	Recovery ± 25 % of true value if sample < 4x spike value	Flag results for affected analytes for all associated samples with “N”.	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	Recovery ± 20 % of true value if sample < 4x spike value
Matrix Spike Duplicate	One per prep batch of twenty or fewer samples of similar matrix	Same as MS and RPD ≤ 20%	Same as MS. Flag results for affected analytes for all associated samples with”*”. Perform postdigestion spike for all failing elements, except Ag, at 2x the indigenous level or 2x the PQL, whichever is greater.	Analyst, Supervisor, QA Manager	Accuracy/bias	Same as MS and RPD ≤ 20%
Serial Dilution (L)	One per prep batch of twenty or fewer samples of similar matrix	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.	Perform post-digestion spike (PDS) addiiton.	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.

SAP Worksheet #28-12—Laboratory QC Samples Table (continued)

Matrix: GW, AQ
Analytical Group: FMETAL
Analytical Method / SOP Reference: SW-846 6010B, 6020, 7470A / CA-608, CA-327, CA-615

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Post Digestion Spike (for elements that have a failing MS)	One per prep batch of twenty or fewer samples of similar matrix	75-125% recovery	Failures will be noted in the case narrative	Analyst, Supervisor	accuracy/bias	75-125% recovery
Internal Standards	Internal Standard (IS); Appropriate IS required for all analytes in all samples. Mass of IS must be <50 amu different from that of analyte	For each sample, IS intensity within 30%-120% of that of initial calib. standard. For ICV, ICB, CCV, and CCB, IS intensity within 80%-120% of that in initial calib. standard.	Reanalyze affected samples	Analyst, Supervisor, QA Manager	Accuracy	For each sample, IS intensity within 30%-120% of that of initial calib. standard. For ICV, ICB, CCV, and CCB, IS intensity within 80%-120% of that in initial calib. standard.
Mercury (SW-846 7470A)						
Preparation Blank (PBW)	One per prep batch of twenty or fewer samples of similar matrix	Absolute value < 1/2 PQL.	Investigate source of contamination. If blank value > PQL report sample results if < PQL or > 10 x the blank value. Otherwise redigest.	Analyst, Supervisor, QA Manager	Accuracy/bias-Contamination	Absolute value < 1/2 PQL.
Laboratory Control Sample (LCSW)	One per prep batch of twenty or fewer samples of similar matrix	Recovery within ± 20% of true value.	If the LCS recoveries are > 120 % but the sample results are <QL narrate. Redigest and reanalyze all associated samples.	Analyst, Supervisor, QA Manager	Accuracy/Bias	Recovery within ± 20% of true value.
Matrix Spike Sample	One per prep batch of twenty or fewer samples of similar matrix	Recovery ± 25 % of true value if sample < 4x spike value	Flag results for affected analytes for all associated samples with "N".	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	Recovery ± 20 % of true value if sample < 4x spike value
Matrix Spike Duplicate	One per prep batch of twenty or fewer samples of similar matrix	Same as MS and RPD ≤ 20%	Same as MS. Flag results for affected analytes for all associated samples with"*". Perform postdigestion spike.	Analyst, Supervisor, QA Manager	Accuracy/bias	Same as MS and RPD ≤ 20%
Serial Dilution (L)	One per prep batch of twenty or fewer samples of similar matrix	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.	Flag results for affected analytes for all associated samples with "E".	Analyst, Supervisor, QA Manager	Accuracy/Bias, Precision	If original sample result is at least 50x IDL, 5-fold dilution must agree within ± 10% of the original result.

DoD QSM: Department of Defense Quality Systems Manual for Environmental Laboratories April 2009, Version 4.1 .

SAP Worksheet #28-13—Laboratory QC Samples Table

Matrix: GW, AQ
Analytical Group: EXPLO
Analytical Method / SOP Reference: SW-846 8330M, IAPP, 6850 / CA-402, WS-LC-0010, WS-LC-0012

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Nitroaromatics/Nitroamines and Nitroglycerin (SW-846 8330M)						
Method Blank	One per prep batch of twenty or fewer samples of similar matrix	No analyte detected > 1/2 PQL	Investigate source of contamination. Evaluate the samples and associated QC: ie. the blank results are above the PQL, report sample results which are <PQL or > 10X the blank concentration. Otherwise, reprep a blank and the remaining samples.	Analyst, Supervisor, QA Manager	Accuracy/bias-Contamination	No analyte detected > 1/2 PQL
LCS	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or nominal limits. Please refer to Worksheet 15.	Evaluate the samples and associated QC: i.e. If an MS/MSD was performed and acceptable, narrate. If an LCS/LCSD was performed and only one of the set was unacceptable, narrate. If the surrogate recoveries in the LCS are also low but are acceptable in the blank and samples, narrate. If the LCS recovery is high but the sample results are < PQL, narrate. Otherwise, reprep a blank and the remaining samples.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or nominal limits. Please refer to Worksheet 15.	Evaluate the samples and associated QC: ie. If the LCS results are acceptable, narrate. If both the LCS and MS/MSD are unacceptable, reprep the samples and QC.	Analyst, Supervisor, QA Manager	Accuracy/bias	DoD QSM Limits
Matrix Spike Duplicate	Same as MS	Same as MS and RPD ≤30%.	Same as MS	Analyst, Supervisor, QA Manager	Accuracy/bias &	DoD QSM Limits, RPD ≤30%.
Confirmation of positive results (second column or second detector)	All positive results must be confirmed.	Calibration and QC criteria same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.	Apply J-flag if RPD > 40%. Discuss in the case narrative.	Analyst, Supervisor, QA Manager	Precision	Calibration and QC criteria same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.
Surrogates	One per sample	Nominal: 1,2-Dinitrobenzene - 30-150%	If surrogate is outside high and sample is <QL no CA taken. If surrogate is outside low the affected samples are re-extracted and reanalyzed	Analyst, Supervisor, QA Manager	Accuracy/bias	Nominal: 1,2-Dinitrobenzene - 30-150%
Nitroguanidine (IAPP)						
Method Blank	One per preparation batch	No target analytes ≥ ½ RL in accordance with DoD QSM requirements	Correct problem, then re-extract and reanalyze method blank and all samples processed with the contaminated blank in accordance with DoD QSM requirements	Lab Manager / Analyst	Accuracy/Bias Contamination	No target analytes ≥ ½ RL in accordance with DoD QSM requirements
LCS	One LCS per analytical/preparation batch	DoD QSM Limits including the DOD QSM marginal exceedance criteria or laboratory statistically derived limits. Please refer to Worksheet 15.	Correct problem, then re-extract and reanalyze the LCS and all associated batch samples in accordance with DoD QSM requirements.	Lab Manager / Analyst	Accuracy/Bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria or laboratory statistically derived limits.

SAP Worksheet #28-13—Laboratory QC Samples Table (continued)

Matrix: GW, AQ
Analytical Group: EXPLO
Analytical Method / SOP Reference: SW-846 8330M, IAPP, 6850 / CA-402, WS-LC-0010, WS-LC-0012

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	DoD QSM Limits including the DOD QSM marginal exceedance criteria or laboratory statistically derived limits. Please refer to Worksheet 15.	Examine the project specific DQOs. Evaluate the data, and re-prepare/reanalyze the native sample and MS/MSD pair as indicated.	Lab Manager / Analyst	Accuracy/Bias	DoD QSM Limits including the DOD QSM marginal exceedance criteria or laboratory statistically derived limits.
Matrix Spike Duplicate	Same as MS	Same as MS and RPD ≤ 30%	Same as MS	Lab Manager / Analyst	Accuracy/Bias, Precision	Same as MS and RPD ≤ 30%
Perchlorate (SW-846 6850)						
Method Blank	One per preparation batch	No target analytes ≥ ½ RL in accordance with DoD QSM requirements	Correct problem, then re-extract and reanalyze method blank and all samples processed with the contaminated blank in accordance with DoD QSM requirements	Lab Manager / Analyst	Accuracy/Bias Contamination	No target analytes ≥ ½ RL in accordance with DoD QSM requirements
IS	During acquisition of calibration standard, samples, and QC check samples	Areas within -50% to +100% of the midpoint of the last ICAL for each sample and QC in accordance with DoD QSM requirements. RRT of the perchlorate ion must be 1.0 ± 2% (0.98 - 1.02).	Inspect LCMS for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning in accordance with DoD QSM requirements	Lab Manager / Analyst	Accuracy/Bias	Areas within -50% to +100% of the midpoint of the last ICAL for each sample and QC in accordance with DoD QSM requirements. RRT of the perchlorate ion must be 1.0 ± 2% (0.98 - 1.02).
Interference Check Standard (ICS)	One ICS is prepared with every batch of 20 samples and must undergo the same preparation and pretreatment steps as the samples in the batch. It verifies the method performance at the matrix conductivity threshold (MCT). At least one ICS must be analyzed daily.	Within ±30% of true value.	Correct problem and then reanalyze all samples in that batch. If poor recovery from the cleanup filters is suspected, a different lot of filters must be used to reextract all samples in the batch. If column degradation is suspected, a new column must be calibrated before the samples can be reanalyzed. Flagging criteria are not appropriate.	Lab Manager / Analyst	Accuracy/Bias	Within ±30% of true value.
Isotope Ratio	Every Sample and QC	83/85 ratio within ± 30% of the mid-range ICAL standard ratio, or within ± 30% of the ratio of the average of the areas from all CCVs in the run, if the ICAL is not run the same day. Must fall within 2.3 to 3.8.	N/A	Lab Manager / Analyst	Qualitative Identification	83/85 ratio within ± 30% of the mid-range ICAL standard ratio, or within ± 30% of the ratio of the average of the areas from all CCVs in the run, if the ICAL is not run the same day. Must fall within 2.3 to 3.8.
LCS	One LCS per analytical/preparation batch	QC acceptance criteria: 80% to 120% accuracy,15% precision; or laboratory statistically derived control limits.	Correct problem, then re-extract and reanalyze the LCS and all associated batch samples in accordance with DoD QSM requirements.	Lab Manager / Analyst	Accuracy/Bias	QC acceptance criteria: 80% to 120% accuracy, 15% precision; or laboratory statistically derived control limits
Matrix Spike	One per prep batch of twenty or fewer samples of similar matrix	Same as LCS	Examine the project specific DQOs. Evaluate the data, and re-prepare/reanalyze the native sample and MS/MSD pair as indicated.	Lab Manager / Analyst	Accuracy/Bias	Same as LCS
Matrix Spike Duplicate	Same as MS	Same as MS and RPD ≤ 15%	Same as MS	Lab Manager / Analyst	Accuracy/Bias, Precision	Same as MS and RPD ≤ 15%

DoD QSM: Department of Defense Quality Systems Manual for Environmental Laboratories April 2009, Version 4.1 . Statistically-derived limits are used when DoD QSM limits do not exist.

SAP Worksheet #28-14—Laboratory QC Samples Table

Matrix: GW
Analytical Group: WCHEM
Analytical Method / SOP Reference: EPA 130.2 / CA-707

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method blank	One per prep batch	No analyte detected > PQL	(1) Investigate source of contamination. (2) Report all sample results <PQL. (3) Report sample results >10X the blank result and flag results with a “B”. (4) Reanalyze all other samples associated with the failing blank.	Analyst, Laboratory Supervisor	Accuracy/Bias, Contamination	No analyte detected > PQL
LCS/ICV	One per prep batch	80-120 %R	(1) If the LCS fails high, report samples that are <PQL. (2) Recalibrate and/or reanalyze other samples.	Analyst, Laboratory Supervisor	Accuracy, Bias	80-120 %R
Matrix Spike	One for every set of 10 samples	80-120 %R	(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.	Analyst, Laboratory Supervisor	Accuracy, Bias	80-120 %R
Laboratory Replicate	One sample duplicate per ten samples	RPD ≤ 20 for samples >3X the PQL and <100 RPD for samples <3X the PQL.	(1) Investigate problem and reanalyze sample in duplicate. (2) If RPD still out, report original result with notation or narration.	Analyst, Laboratory Supervisor	Precision	RPD ≤ 20 for samples >3X the PQL and <100 RPD for samples <3X the PQL.

Measurement performance criteria are based on the analytical laboratory SOPs.

SAP Worksheet #28-15—Laboratory QC Samples Table

Matrix: SS, SB, SD, ASH
Analytical Group: DIOXIN
Analytical Method / SOP Reference: SW-846 8290A / HMS-8290

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparatory batch, run after calibration standards and before samples	No analytes detected ≥ LOD for the analyte or ≥ 5% of the sample result for the analyte, which is greater, per method.	Correct problem, then see criteria in Box D-1 of DoD QSM v. 4.1 . If required, reprep 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. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. Problem mustbe corrected. Results may not be reported without a valid method blank. Flagging is only appropriate when samples cannot be reanalyzed.	Analyst, Laboratory Supervisor	Accuracy/Bias - Contamination	No analytes detected ≥ LOD for the analyte or ≥ 5% of the sample result for the analyte, which is greater, per method.
Laboratory Control Sample	One per preparatory batch.	CAS-Houston In-House Statistically-Derived Limits. Please refer to Worksheet 15.	Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	Analyst, Laboratory Supervisor	Accuracy/Bias	CAS-Houston In-House Statistically-Derived Limits. Please refer to Worksheet 15.
Laboratory Replicate	One per preparatory batch	RPD ≤ 25% between sample and laboratory replicate, per method.	For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met.	Analyst, Laboratory Supervisor	Precision	RPD ≤ 25% between sample and laboratory replicate, per method.
Internal Standards	Every field sample, standard, and QC sample	40-135% recovery, per method	Correct problem, then reprep and reanalyze the samples with failed IS. Apply Q-flag to results of all affected samples.	Analyst, Laboratory Supervisor	Accuracy	40-135% recovery, per method
Matrix Spike Sample	One per preparatory batch per matrix	Same as LCS.	For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. The data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error.	Analyst, Laboratory Supervisor	Accuracy/Bias	Same as LCS.
Matrix Spike Duplicate	Same as MS.	Same as MS and RPD ≤ 20%	Same as MS.	Analyst, Laboratory Supervisor	Accuracy/Bias, Precision	Same as MS and RPD ≤ 20%

DoD QSM: Department of Defense Quality Systems Manual for Environmental Laboratories April, 2009, Version 4.1

SAP Worksheet #28-16—Laboratory QC Samples Table

Matrix: GW, AQ
Analytical Group: DIOXIN
Analytical Method / SOP Reference: SW-846 8290A / HMS-8290

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparatory batch, run after calibration standards and before samples	No analytes detected ≥ LOD for the analyte or ≥ 5% of the sample result for the analyte, which is greater, per method.	Correct problem, then see criteria in Box D-1 of DoD QSM v. 4.1 . If required, reprep 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. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. Problem mustbe corrected. Results may not be reported without a valid method blank. Flagging is only appropriate when samples cannot be reanalyzed.	Analyst, Laboratory Supervisor	Accuracy/Bias - Contamination	No analytes detected ≥ LOD for the analyte or ≥ 5% of the sample result for the analyte, which is greater, per method.
Laboratory Control Sample	One per preparatory batch.	CAS-Houston In-House Statistically-Derived Limits. Please refer to Worksheet 15.	Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	Analyst, Laboratory Supervisor	Accuracy/Bias	CAS-Houston In-House Statistically-Derived Limits. Please refer to Worksheet 15.
Laboratory Replicate	One per preparatory batch	RPD ≤ 25% between sample and laboratory replicate, per method.	For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met.	Analyst, Laboratory Supervisor	Precision	RPD ≤ 25% between sample and laboratory replicate, per method.
Internal Standards	Every field sample, standard, and QC sample	40-135% recovery, per method	Correct problem, then reprep and reanalyze the samples with failed IS. Apply Q-flag to results of all affected samples.	Analyst, Laboratory Supervisor	Accuracy	40-135% recovery, per method
Matrix Spike Sample	One per preparatory batch per matrix	Same as LCS.	For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. The data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error.	Analyst, Laboratory Supervisor	Accuracy/Bias	Same as LCS.
Matrix Spike Duplicate	Same as MS.	Same as MS and RPD ≤ 20%	Same as MS.	Analyst, Laboratory Supervisor	Accuracy/Bias, Precision	Same as MS and RPD ≤ 20%

DoD QSM: Department of Defense Quality Systems Manual for Environmental Laboratories April, 2009, Version 4.1

SAP Worksheet #29—Project Documents and Records Table

Document	Where Maintained
Field Notebooks	Electronic .pdf copies in the project file. Hardcopy (bound notebook) in the project file. Archived at project closeout.
CoC Records	Electronic .pdf copies in the project file. Hardcopy in the project file. Archived at project closeout.
Airbills	Hardcopy in the project file. Archived at project closeout.
Telephone Logs	Hardcopy in the project file. Archived at project closeout.
CA Forms	Electronic .pdf copies in the project file. Hardcopy in the project file. Archived at project closeout.
PID/FID readings	Recorded in Field Notebook. Stored in Data Warehouse.
Water quality parameters collected during groundwater sampling	Recorded in Field Notebook. Stored in Data Warehouse.
PID readings	Recorded in Field Notebook. Stored in Data Warehouse.
Various field measurements	Recorded in Field Notebook.
All field equipment calibration information	Recorded in Field Notebook.
Pertinent telephone conversations	Recorded in Field Notebook.
Field equipment maintenance records	Inspected by Field Team Leader. Not maintained.
Sample Receipt, Custody, and Tracking Records	Electronic .pdf copies in the project file. Hardcopy in the full data package.
Standard Traceability Logs	Hardcopy in the full data package. Archived at project closeout.
Equipment Calibration Logs	Hardcopy in the full data package. Archived at project closeout.
Sample Prep Logs	Hardcopy in the full data package. Archived at project closeout.
Run Logs	Hardcopy in the full data package. Archived at project closeout.
Equipment Maintenance, Testing, and Inspection Logs	Hardcopy in the full data package. Archived at project closeout.
Reported Field Sample Results	Electronic .pdf copies in the project file. Hardcopy in the data package. Archived at project closeout.

SAP Worksheet #29—Project Documents and Records Table (continued)

Document	Where Maintained
Reported Results for Standards, QC Checks, and QC Samples	Hardcopy in the full data package. Archived at project closeout.
Instrument Printouts (raw data) for Field Samples, Standards, QC Checks, and QC Samples	Hardcopy in the full data package. Archived at project closeout.
Data Package Completeness Checklists	Hardcopy in the data validation report. Archived at project closeout.
Sample Disposal Records	Maintained by the laboratory.
Extraction/Clean-up Records	Maintained by the laboratory.
Raw Data	Hardcopy in the full data package. Archived at project closeout.
Field Sampling Audit Checklists	Hardcopy in the project file. Archived at project closeout.
Fixed Laboratory Audit Checklists	If completed, hardcopy in the project file. Archived at project closeout.
Data Validation Reports	Electronic .pdf copies in the project file. Hardcopy stored with the data package. Archived at project closeout.

SAP Worksheet #29a—Level IV Data Package Components

TITLE: **ASSEMBLY OF LEVEL III AND IV REPORTS**

FIGURE 1

DATA PACKAGE LEVELS

Deliverable	Data Reporting Level				
	I	II(+)	III	IV	CLP
Report of Analysis (Form 1 or equiv – TICs optional)	√	√	√	√	1
External chains of custody	√	√	√	√	1
Blank Results (Org Form 1/Ino Form 3 or equiv)	√*	√	√	√	1
Surrogate Recoveries (Org Form 2 or equiv)		√	√	√	1
Laboratory Control Sample Recovery (Org Form 3/Ino Form 7 or equiv)		√	√	√	1
Dup/MS/MSD if performed on client sample (Org Form 3/Ino Form 5A&6 or equiv)		√(+)	√	√	1
Blank Summary (Org Form 4 or equiv)	√*	√	√	√	1
Tune Summary (Org Form 5 or equiv)			√	√	1
Initial Calibration (Org Form 6/Ino Form 2A&3 or equiv)			√	√	1
Continuing Calibration (Org Form 7/Ino Form 2A&3 or equiv)			√	√	1
Internal Standard Area Summary (Org Form 8 or equiv)			√	√	1
Run Logs			√	√	1
Sample Preparation logs			√	√	1
Raw data				√	1
Florisil cartridge check (Org Form 9A or equiv) - (CLP only)					1
GPC calibration if performed (Org Form 9B or equiv) - (CLP only)					1
Dual column ID summary (Pesticide Form 10 or equiv) - (if requested)			√	√	1
Instrument Sensitivity Check (Ino Form 2B or equiv)			√	√	1
Interference Check Sample (Ino Form 4 or equiv)			√	√	1
Post Digest Spike Sample – if performed (Ino Form 5B)			√	√	1
Standard Addition Results Summary – if performed (Ino Form 8 or equiv)			√	√	1
ICP Serial Dilutions – if performed (Ino Form 9 or equiv)			√	√	1
IDLs (Ino Form 10 or equiv)			√	√	1
Interelement Correction Factors (Ino Form 11A&B or equiv)			√	√	1
ICP Linear Ranges (Ino Form 12 or equiv)			√	√	1
Standard Preparation logs - (if requested)				√	1
Internal chains of custody - (if requested)				√	1

√ Data included in reporting level. + Dup/MS/MSD provided if requested on client sample.

* Blank results provided for organics data.

1 CLP is performed and reported according to the appropriate protocol.

☐ Data not included in reporting level.

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SAP Worksheet #30—Analytical Services Table

Matrix	Analytical Group	Sample Locations/ID Number	Analytical Method	Data Package Turnaround Time (TAT)	Laboratory / Organization[1] (name and address, contact person, and telephone number)	Backup Laboratory / Organization (name and address, contact person, and telephone number)
SS	VOC	24	Volatiles by SW-846 8260B w/ EnCores	Standard 28 Calendar-day TAT	Katahdin Analytical Services, Inc. 600 Technology Way Scarborough, ME 04074 POC: Andrea Colby (207) 874-2400	TestAmerica-Burlington 30 Community Drive Burlington, VT 05403 POC: Chris Anderson (802) 660-1990
	SVOC		Semivolatiles by SW-846 8270C SIM Semivolatiles by SW-846 8270C-SIM			
	PEST/PCB		Pesticides by SW-846 8081A PCBs by SW-846 8082			
	METAL		Metals by SW-846 6010B Metals by SW-846 6020 Mercury by SW-846 7471A Cyanide by SW-846 9012B			
	EXPLO		Nitroaromatics/Nitroamines and Nitroglycerin by SW-846 8330			
			Nitroguanidine by IAPP		TestAmerica-West Sacramento 880 Riverside Parkway West Sacramento, CA 95605 POC: Karen Sellers (916) 374-4442	TBD
			Perchlorate by SW-846 6850			TBD
	DIOXIN		Dioxins and Furans by SW-846 8290A		Columbia Analytical Services-Houston 19408 Park Row; Suite 320 Houston, TX 77084 POC: Karen Verschoor (281) 994-2960	TBD
SB	VOC	20	Volatiles by SW-846 8260B w/ EnCores	Standard 28 Calendar-day TAT	Katahdin Analytical Services, Inc.	TestAmerica-Burlington
	SVOC		Semivolatiles by SW-846 8270C SIM Semivolatiles by SW-846 8270C-SIM			
	PEST/PCB		Pesticides by SW-846 8081A PCBs by SW-846 8082			
	METAL		Metals by SW-846 6010B Metals by SW-846 6020 Mercury by SW-846 7471A Cyanide by SW-846 9012B			
	EXPLO		Nitroaromatics/Nitroamines and Nitroglycerin by SW-846 8330			
			Nitroguanidine by IAPP		TestAmerica-West Sacramento	TBD
			Perchlorate by SW-846 6850			TBD
	DIOXIN		Dioxins and Furans by SW-846 8290A		Columbia Analytical Services -Houston	TBD

SAP Worksheet #30—Analytical Services Table (continued)

Matrix	Analytical Group	Sample Locations/ID Number	Analytical Method	Data Package Turnaround Time (TAT)	Laboratory / Organization[1] (name and address, contact person, and telephone number)	Backup Laboratory / Organization (name and address, contact person, and telephone number)
SD	VOC	10	Volatiles by SW-846 8260B no EnCores	Standard 28 Calendar-day TAT	Katahdin Analytical Services, Inc.	TestAmerica-Burlington
	SVOC		Semivolatiles by SW-846 8270C SIM Semivolatiles by SW-846 8270C-SIM			
	PEST/PCB		Pesticides by SW-846 8081A PCBs by SW-846 8082			
	METAL		Metals by SW-846 6010B Metals by SW-846 6020 Mercury by SW-846 7471A Cyanide by SW-846 9012B			
	EXPLO		Nitroaromatics/Nitroamines and Nitroglycerin by SW-846 8330			
			Nitroguanidine by IAPP		TestAmerica-West Sacramento	TBD
			Perchlorate by SW-846 6850			TBD
	DIOXIN		Dioxins and Furans by SW-846 8290A		Columbia Analytical Services -Houston	TBD
	WCHEM		pH by SW-846 9045C Total Organic Carbon (TOC) by Lloyd Kahn		Katahdin Analytical Services, Inc.	TestAmerica-Burlington
	GRAINSIZE		Grain Size (Sieve Only) by ASTM D422		TestAmerica-Burlington	TBD
GW	VOC	5	Volatiles by SW-846 8260B w/ EnCores	Standard 28 Calendar-day TAT	Katahdin Analytical Services, Inc.	TestAmerica-Burlington
	SVOC		Semivolatiles by SW-846 8270C SIM Semivolatiles by SW-846 8270C-SIM			
	PEST/PCB		Pesticides by SW-846 8081A PCBs by SW-846 8082			
	METAL		Metals by SW-846 6010B Metals by SW-846 6020 Mercury by SW-846 7471A Cyanide by SW-846 9012B			
	FMETAL		Filtered Metals by SW-846 6010B Filtered Metals by SW-846 6020 Filtered Mercury by SW-846 7471A			
	EXPLO		Nitroaromatics/Nitroamines and Nitroglycerin by SW-846 8330			
			Nitroguanidine by IAPP		TestAmerica-West Sacramento	TBD
			Perchlorate by SW-846 6850			TBD
	DIOXIN		Dioxins and Furans by SW-846 8290A		Columbia Analytical Services -Houston	TBD
	WCHEM		Hardness by SM2340C		Katahdin Analytical Services, Inc.	TestAmerica-Burlington
ASH	METAL	6	Metals by SW-846 6010B Metals by SW-846 6020 Mercury by SW-846 7471A Cyanide by SW-846 9012B	Standard 28 Calendar-day TAT	Katahdin Analytical Services, Inc.	TestAmerica-Burlington
	DIOXIN	3	Dioxins and Furans by SW-846 8290A		Columbia Analytical Services -Houston	TBD

[1]If the laboratory is not known at time of SAP submission, put "TBD" in the column as a placeholder.

SAP Worksheet #31—Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing CA	Person(s) Responsible for Monitoring Effectiveness of CA
Field Performance Audit	Once during sampling activities	Internal	CH2M HILL	Lisa Carter Program Field Auditor CH2M HILL	Christine Metcalf PM CH2M HILL	Christine Metcalf PM CH2M HILL	John Tomik AQM - CH2M HILL
Offsite Laboratory Technical Systems Audit	Laboratory must have current DOD ELAP certification which will identify the period of performance. The laboratory must be re-evaluated prior to explanation of period of performance. If DOD ELAP is not yet applicable to the DOD program at the time of sampling, then the laboratory must hold a current NFESC evaluation letter.	External	DOD ELAP Accrediting Body (TBD)	DOD ELAP Accrediting Body (TBD)	Respective Laboratory QA Officer	Respective Laboratory QA Officer	Respective Laboratory QA Officer

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SAP Worksheet #32—Assessment Findings and CA Responses

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, Org.)	Timeframe for Response
Field Performance Audit	Checklist and Written Audit Report	Christine Metcalf PM, CH2M HILL	Within 1 week of audit	Memorandum	TBD FTL CH2M HILL Brett Doerr QAM CH2M HILL	Within 1 week of receipt of CA Form
Offsite Laboratory Technical Systems Audit	Written audit report	Respective Laboratory QA Officer	Within 2 months of audit	Memorandum	DOD ELAP Accrediting Body (TBD)	Within 2 months of receipt of initial notification

Worksheet #32-1—Corrective Action Form

Person initiating corrective action ______________________________ **Date** ______________

Description of problem and when identified: ____

____

____

____

Cause of problem, if known or suspected: ____

____

____

____

<u>Sequence of Corrective Action (CA):</u> (including date implemented, action planned and personnel/data affected) ____

____

____

____

____

____

____

____

CA implemented by: ___________________________________ **Date:** _____________________

CA initially approved by: _______________________________ **Date:** _____________________

Follow-up date: ____

Final CA approved by: __________________________________ **Date:** ________________

Information copies to:

____

____

____

____

Worksheet #32-2—Field Performance Audit Checklist

Project Responsibilities

Project No.: ____________ Date: ________________________________

Project Location: __________ Signature: _____________________________

Team Members:

Yes _ No _ 1) Is the approved work plan being followed?
Comments ____

____

Yes _ No _ 2) Was a briefing held for project participants?
Comments ____

____

Yes _ No _ 3) Were additional instructions given to project participants?
Comments ____

____

Sample Collection

Yes _ No _ 1) Is there a written list of sampling locations and descriptions?
Comments ____

____

Yes _ No _ 2) Are samples collected as stated in the Master SOPs?
Comments ____

____

Yes _ No _ 3) Are samples collected in the type of containers specified in the work plan?
Comments ____

____

Yes _ No _ 4) Are samples preserved as specified in the work plan?
Comments ____

____

Worksheet #32-2—Field Performance Audit Checklist (continued)

Yes _ No _ 5) Are the number, frequency, and type of samples collected as specified in the work plan?
Comments ____________________

____

Yes _ No _ 6) Are quality assurance checks performed as specified in the work plan?
Comments ____________________

____

Yes _ No _ 7) Are photographs taken and documented?
Comments ____________________

____

Document Control

Yes _ No _ 1) Have any accountable documents been lost?
Comments ____________________

____

Yes _ No _ 2) Have any accountable documents been voided?
Comments ____________________

____

Yes _ No _ 3) Have any accountable documents been disposed of?
Comments ____________________

Yes _ No _ 4) Are the samples identified with sample tags?
Comments ____________________

____

Yes _ No _ 5) Are blank and duplicate samples properly identified?
Comments ____________________

____

Yes _ No _ 6) Are samples listed on a chain-of-custody record?
Comments ____________________

____

Worksheet #32-2—Field Performance Audit Checklist (continued)

Yes _ No _ 7) Is chain-of-custody documented and maintained?
Comments ____

____

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SAP Worksheet #33—QA Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)
Field Audit Report	Once during sampling activities	Submitted with final reports	Lisa Carter Program Field Auditor CH2M HILL	Included in RI Report. See Worksheet 3 for distribution list.
Data Usability Assessment Report	Once after all data are generated and validated	Submitted with final reports	Mike Zamboni Project Chemist, CH2M HILL	Included in RI Report. See Worksheet 3 for distribution list.

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SAP Worksheet #34—Verification (Step I) Process Table

Verification Input	Description	Internal / External	Responsible for Verification (name, organization)
Field Notebooks	Field notebooks will be reviewed internally and placed into the project file for archival at project closeout.	Internal	PM: Christine Metcalf/CH2M HILL
Field SOPs	Ensure that all field SOPs were followed.	Internal	FTL (TBD)/CH2M HILL
CoCs and Shipping Forms	CoC 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 CoC will be initialed by the reviewer, a copy of the CoC retained in the site file, and the original and remaining copies taped inside the cooler for shipment.	Internal	FTL (TBD)/CH2M HILL Project EIS: Hillary Ott/CH2M HILL
Sample Condition upon Receipt	Any discrepancies, missing, or broken containers will be communicated to the project EIS in the form of laboratory logins.	Internal	Project EIS: Hillary Ott/CH2M HILL
Sample Chronology	Holding times from collection to extraction or analysis and from extraction to analysis will be considered by the data validator during the data validation process.	External	Data Validation Subcontractor: Kevin Harmon/Validata Chemical Services, Inc.
Documentation of Laboratory Method Deviations	Laboratory method deviations will be discussed and approved by the Project Chemist. Documentation will be incorporated into the case narrative which becomes part of the final hardcopy data package.	Internal	Project Chemist: Michael Zamboni/CH2M HILL
Electronic Data Deliverables	Electronic Data Deliverables will be compared against hardcopy laboratory results (100% check).	Internal	Project EIS: Hillary Ott/CH2M HILL
Case Narrative	Case narratives will be reviewed by the data validator during the data validation process.	External	Data Validation Subcontractor: Kevin Harmon/Validata Chemical Services, Inc.
Laboratory SOPs	Ensure that approved analytical laboratory SOPs were followed.	External	Respective Laboratory QA Officer
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal. All received data packages will be verified externally by the third-party validator. Also, the data will be verified for completeness by an EIS. A chemist will perform a data quality evaluation.	Internal and External	Respective Laboratory QA Officer Data Validation Subcontractor: Kevin Harmon/Validata Chemical Services, Inc. Project EIS: Hillary Ott/CH2M HILL Project Chemist: Michael Zamboni/CH2M HILL
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.	Internal	PM: Chris Metcalf/CH2M HILL Project Chemist: Michael Zamboni/CH2M HILL
CA Reports	CA reports will be reviewed by the Project Chemist or PM and placed into the project file for archival at project closeout.	Internal	Project Chemist: Michael Zamboni/CH2M HILL PM: Chris Metcalf/CH2M HILL

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SAP Worksheet #35—Validation (Steps IIa and IIb) Process Table

Step IIa / IIb	Validation Input	Description	Responsible for Validation (name, organization)
IIa	Laboratory Methods	Ensure the laboratory analyzed samples using the correct methods.	Project Chemist: Michael Zamboni/CH2M HILL
IIa	TCL and TAL	Ensure the laboratory reported all analytes from each analysis group unless a site-specific requirement dictates a different list.	Project Chemist: Michael Zamboni/CH2M HILL
IIa / IIb	RLs	Ensure the laboratory met the CRQLs, CRDLs, and otherwise project-designated quantitation limits. If quantitation limits were not met, the reason will be determined and documented.	Project Chemist: Michael Zamboni/CH2M HILL
IIa	Laboratory SOPs	Ensure that approved analytical laboratory SOPs were followed.	Data Validation Subcontractor: Kevin Harmon/Validata Chemical Services, Inc.
IIa	Raw Data	Perform 10 percent review of raw data to confirm laboratory calculations.	Data Validation Subcontractor: Kevin Harmon/Validata Chemical Services, Inc.
IIb	Onsite Screening	Review all non-analytical field data against QAPP requirements for completeness and accuracy based on the field calibration records.	Field Team Leader (TBD)/CH2M HILL
IIa	Documentation of Method QC Results	Establish that all required QC samples were run and met required limits.	Data Validation Subcontractor: Kevin Harmon/Validata Chemical Services, Inc.
IIb	Documentation of field QC Sample Results	Establish that all required QAPP QC samples were run and met required limits	Project Chemist: Michael Zamboni/CH2M HILL Data Validation Subcontractor: Kevin Harmon/Validata Chemical Services, Inc.
IIb	NFESC Evaluation	Ensure that each laboratory is NFESC-evaluated for the analyses they are to perform. Ensure evaluation timeframe does not expire.	Project Chemist: Michael Zamboni/CH2M HILL

[1]IIa=compliance with methods, procedures, and contracts [see Table 10, page 117, UFP-QAPP manual, V.1, March 2005.]

IIb=comparison with measurement performance criteria in the SAP [see Table 11, page 118, UFP-QAPP manual, V.1, March 2005]

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SAP Worksheet #36—Analytical Data Validation (Steps IIa and IIb) Summary Table

Step IIa / IIb	Matrix	Analytical Group	Validation Criteria	Data Validator (title and organizational affiliation)
IIa and IIb	SS or SB or SD or GW or ASH	VOC or SVOC or PEST/PCB or EXPLO	Analytical methods and laboratory SOPs, as presented in this UFP-SAP, will be used to evaluate compliance against QA/QC criteria. Limits for calibration are presented in Worksheet 24 and limits for laboratory QC samples are presented in Worksheet 28. Data may be qualified if QA/QC exceedances have occurred. Data qualifiers will be those presented in *Region III Modifications to National Functional Guidelines for Organic Data Review* (EPA, 1994). Guidance and qualifiers from *EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, 999) may also be applicable.	Data Validation Subcontractor: Kevin Harmon/Validata Chemical Services, Inc.
		DIOXIN	Analytical methods and laboratory SOPs, as presented in this UFP-SAP, will be used to evaluate compliance against QA/QC criteria. Limits for calibration are presented in Worksheet 24 and limits for laboratory QC samples are presented in Worksheet 28. Data may be qualified if QA/QC exceedances have occurred. Data qualifiers will be those presented in *Region III Standard Operating Procedure for Dioxin/Furan Data Validation* (EPA, March, 1999). Guidance and qualifiers from *National Functional Guidelines for Chlorinated Dibenzo-p-Dioxins (CDDs) and Chlorinated Dibenzofurans (CDFs) Data Review* (EPA, 2005b) may also be applicable.	
		METAL or FMETAL or WCHEM	Analytical methods and laboratory SOPs, as presented in this UFP-SAP, will be used to evaluate compliance against QA/QC criteria. Limits for calibration are presented in Worksheet 24 and limits for laboratory QC samples are presented in Worksheet 28. Data may be qualified if QA/QC exceedances have occurred. Data qualifiers will be those presented in *Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses* (EPA, 1993). Guidance and qualifiers from *Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, Rev. Final, 2004) may also be applicable.	

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SAP Worksheet #37—Usability Assessment

The following is a summary of the usability assessment process and procedures, including interim steps and any statistics, equations, and computer algorithms that will be used:

- The data will be evaluated by the project chemist to see if the project required QLs listed in Worksheet 15 were achieved for non-detected constituents.
- If verification and validation are not acceptable, the data will be qualified by the validator. The data may be qualified for minor QC deviations that do not affect the data usability (i.e., "attributable to blank contamination" (B), estimated (J), estimated, biased high (K), estimated, biased low (L), nondetect, estimated QL (UJ), nondetect, QL biased low (UL)), or the data may be rejected (R-Flag) for major QC deviations affecting data usability. The use and implications of estimated data will be discussed in the project report. Rejected data will not be used. The impact of data qualified as rejected because of analytical deficiencies will be discussed with the project team and will be evaluated to determine the need for any corrective actions. Depending on the analytical deficiency and the intended use of the data, the project team may or may not agree that the data are of sufficient quality to support project decisions.
- For statistical comparisons and risk assessment calculations, non-detect values will be represented by a concentration equal to one-half the sample-specific QL. Where duplicates are collected, the greater of the two concentrations will be used for risk evaluation and nature and extent determinations.
- The site data will not be evaluated for outliers. It is anticipated that the site data will have significant variations based on localized sources.
- Analytical data will be checked by the project chemist and the project EIS to ensure that they are accurately transferred to the electronic project database and GIS.
- Laboratory and field precision, as computed from duplicate samples, will be compared by the data validator. These computations will be based on calculation of RPD = (Difference of two results) / (average of two results) *100%. Laboratory and field duplicate precision are addressed in Worksheets 28 and 12, respectively.
- Deviations from the procedures outlined in this SAP will be reviewed by the project chemist and the project manager to assess whether the deviations were significant enough to compromise the attainment of project objectives.

The following evaluative procedures will be used to assess overall measurement error associated with the project:

- The project manager and the data users will reconcile the validated data with the method performance criteria to determine whether sufficient data of acceptable quality are available for decision making. A series of evaluations and statistical analyses will be performed to estimate the data characteristics. The statistical evaluations will include, for each target constituent or group: maximum concentration, minimum concentration, number of samples

SAP Worksheet #37—Usability Assessment (continued)

with non-detected results, number of samples with positive results, and the proportion of samples with detected and non-detected results.

- If a significant deviation occurs between lab and field precision (using the method described above), the data validator will notify the project chemist. The cause will be investigated, described, and interpreted for its impact on decision making. The expectation is that laboratory precision values (RPDs) will be no greater than RPDs for field duplicates of the same matrix.
- If significant biases are detected (represented by low or high matrix spike, LCS, or surrogate recoveries), the data validator will qualify the data. The project chemist will describe the impact of the data qualification on the quality and usability of the data for making decisions. The tendency will be to emphasize low biases more than high biases unless biased results are near action levels. Low biases will be emphasized more because they are likely to represent an inability to detect compounds that are present at the site and, on a percentage basis, generally represent a greater proportion of the reported values.

The following personnel are responsible for performing the usability assessment:

- CH2M HILL PM, Project Chemist, and other CH2M HILL team members will compile project data and make recommendations pertaining to the usability of the data. The data will be provided to the project team for discussion and review, and the project team as a whole will weigh in on the usability of the data.

The following documentation will be generated during the usability assessment and will be presented to identify trends, relationships (correlations), and anomalies:

- The data will be presented in tabular format in the RI report. Data qualifications such as “attributable to blank contamination” (B), estimation (J, K, L, UJ, UL) or rejection (R) will be applied. Written documentation will be provided to support any non-compliance, or rejected data results. The project report will identify and describe the data usability limitations and suggest CAs.
- A description of the precision and bias evaluations described above will be included in the RI report. This will include a summary with supporting documentation. Significant deviations or deficiencies will be conveyed to the Navy RPM for consideration.

References

CH2M HILL. 2008. *Final Site 66 – Turkey Run Disposal Area Site Inspection Report, Naval Support Facility, Indian Head, Indian Head, Maryland*. November.

CH2M HILL, 2004. *Final Remedial Investigation Report, Sites 11, 13, 17, 21, and 25, Indian Head Division–NSWC, Indian Head, Maryland*. April.

DOD. 2006. *Quality Systems Manual for Environmental Laboratories, Version 3.*

Ensafe/Allen and Hoshall. 1994. *Final Site Inspection Report, Phase II, Indian Head Division, Naval Surface Warfare Center*. March 4.

EPA. 2005a. 505-B-04-900A. *Intergovernmental Data Quality Task Force, Uniform Federal Policy for Quality Assurance Project Plans, Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs Part 1: UFP-QAPP Manual*. March.

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EPA. 2002. *Guidance for Quality Assurance Project Plans,* 240-R-02-009. December.

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Hiortdahl, Steven N. 1993. Personal Communication – Comments: Draft Site Inspection Report, Indian Head, Maryland.

Naval Energy and Environment Support Activity. 1992. Preliminary Assessment Report, Naval Ordnance Station, Indian Head, Maryland. *NEESA 13-021A*.

Tetra Tech NUS. 2004. *Master Plans for Installation Restoration Program Environmental Investigations at Naval District Washington, Indian Head, Indian Head, Maryland*. June.

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Figures

\\APHRODITE\PROJ\USNAVFACENGCOM\INDIANHEAD\MAPFILES\SITE_66\RI\FIGURE 1 - FACILITY LOCATION MAP.MXD MRISSING 7/14/2009 09:35:47

Legend

- Streams
- Topographic Contours
- Buildings
- Roads and Paved Areas
- Wooded Area
- Densely Wooded Area
- Approximate Site 66 Boundary
- Water Bodies
- Installation Boundary

N

0 1,875 3,750 Feet

Figure 1
Facility Location Map
Site 66 Remedial Investigation
NSF-IH, Indian Head, Maryland

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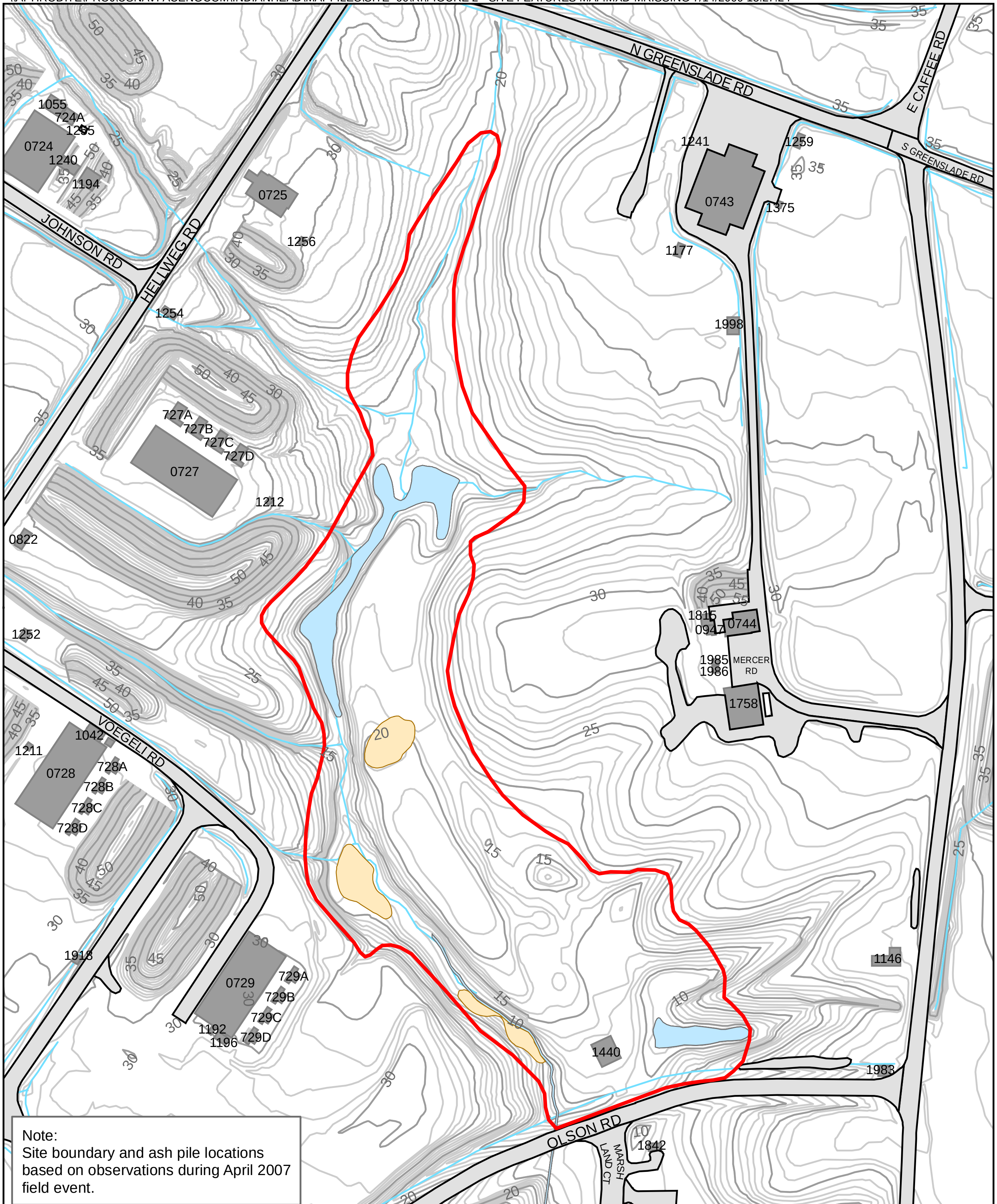
\\APHRODITE\PROJ\USNAVFACENGCOM\INDIANHEAD\MAPFILES\SITE_66\RI\FIGURE 2 - SITE FEATURES MAP.MXD MRISSING 7/14/2009 13:27:24



Legend

- Surface Water
- 1 Foot Elevation Contour
- 5 Foot Elevation Contour
- Site Boundary (Approximate Limit of Visible Waste Material)
- Ash Pile
- Roads
- Buildings
- Surface Waterbodies

N

0 100 200 Feet

Figure 2
Site Features Map
Site 66 Remedial Investigation
NSF-IH, Indian Head, Maryland

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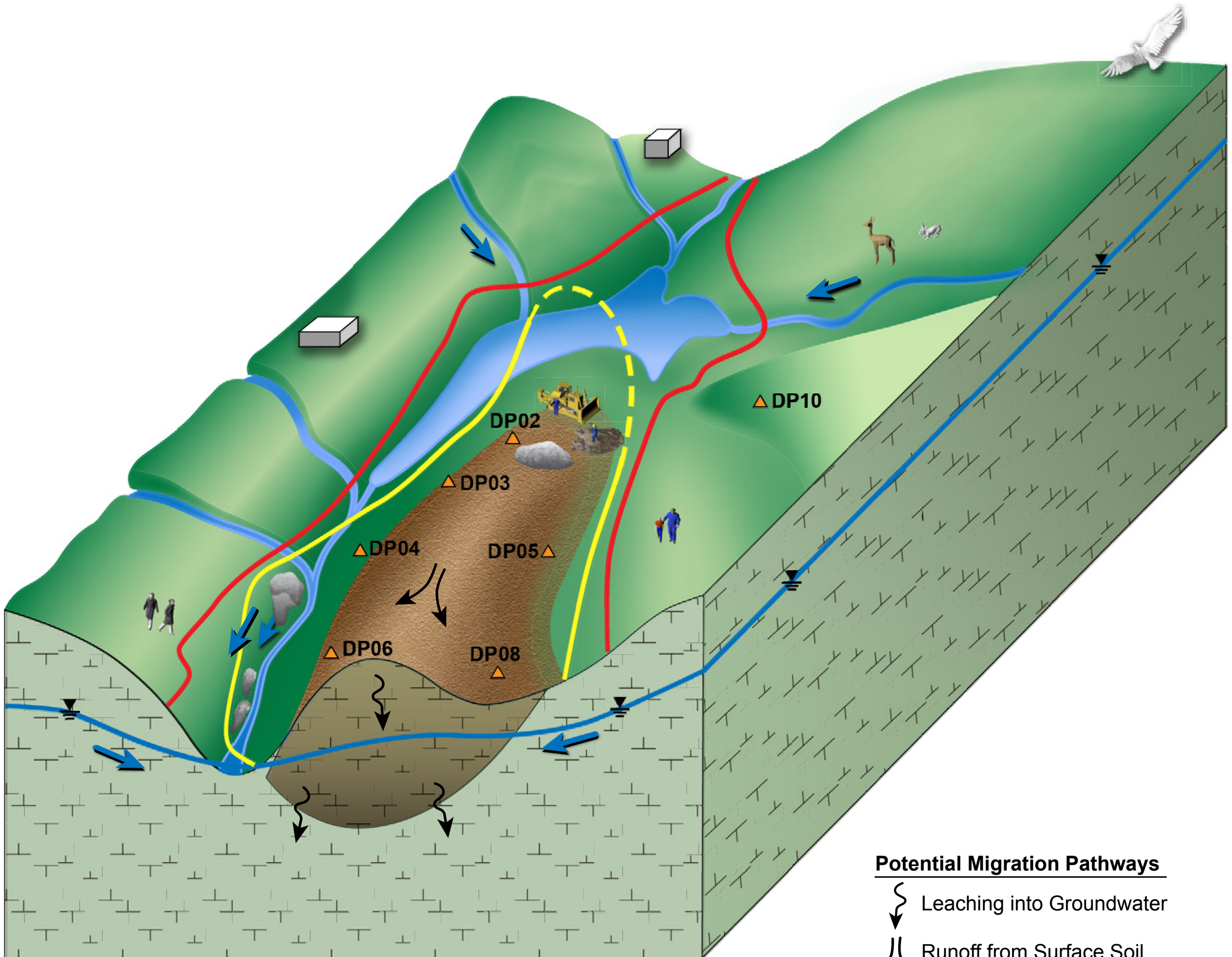

Potential Migration Pathways

- Leaching into Groundwater
- Runoff from Surface Soil

N

Not to Scale

- Previous Soil/ In Situ Groundwater Sample
- Site Boundary
- Approximate Limit of Waste
- Surface Water & Waterbodies
- Potentiometric Surface
- General Groundwater & Surface Water Flow Direction
- Waste Consisting of Silt, Sand, Debris, & Ash-Like Material
- Silt, Clay, and Sand
- Ash Pile

HUMAN RECEPTORS	
Current Human Health Exposure Scenarios	• Adult and adolescent trespassers/visitors exposed to constituents of potential concern (COPCs) in surface soil and ash through incidental ingestion, dermal contact, and inhalation of particulate and volatile emissions. • Adult and adolescent trespassers/visitors exposed to COPCs in sediment through incidental ingestion, dermal contact, and inhalation of particulate and volatile emissions. (The SI risk screening concluded that it is unlikely exposure to sediment would result in any unacceptable human health risks; however, this pathway will be re-evaluated if the RI data shows higher or different chemical detections in this medium than the SI data.)
Future Human Health Exposure Scenarios	• Industrial workers, construction workers, adult and child residents, and adult and adolescent trespassers/visitors exposed to COPCs in surface and subsurface soil and ash through incidental ingestion, dermal contact, and inhalation of particulate and volatile emissions. • Adult and child residents exposed to COPCs in groundwater used as a potable supply through ingestion, dermal contact, and inhalation of volatiles while showering. • Construction workers exposed to COPCs in groundwater through dermal contact and inhalation of volatiles. • Industrial workers and adult and child residents exposed to COPCs in indoor air from vapor intrusion from groundwater through a future building foundation through inhalation. • Industrial workers, construction workers, adult and child residents, and adult and adolescent trespassers/visitors exposed to COPCs in sediment through incidental ingestion and dermal contact. (The SI risk screening concluded that it is unlikely exposure to sediment would result in any unacceptable human health risks; however, this pathway will be re-evaluated if the RI data shows higher or different chemical detections in this medium than the SI data.)
ECOLOGICAL RECEPTORS	
Current and Future Exposure Scenarios	• Soil invertebrates exposed to COPCs in the surface soil through dermal contact and ingestion. • Benthic invertebrates exposed to COPCs in the sediment through dermal contact and ingestion. • Upper trophic level receptors (i.e., carnivorous birds and mammals) exposed to COPCs accumulated in the tissues of soil invertebrates, benthic invertebrates, small mammals, amphibians, fish, or reptiles exposed to COPCs in site media.

FIGURE 3
Conceptual Site Model
Site 66 Remedial Investigation
NSF-IH, Indian Head, Maryland

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\\APHRODITE\PROJ\USNAVFACENGCOM\INDIANHEAD\MAPFILES\SITE_66\RI\FIGURE 4 - PREVIOUS SITE INVESTIGATION SAMPLE LOCATIONS.MXD MRISSING 7/14/2009 13:35:06

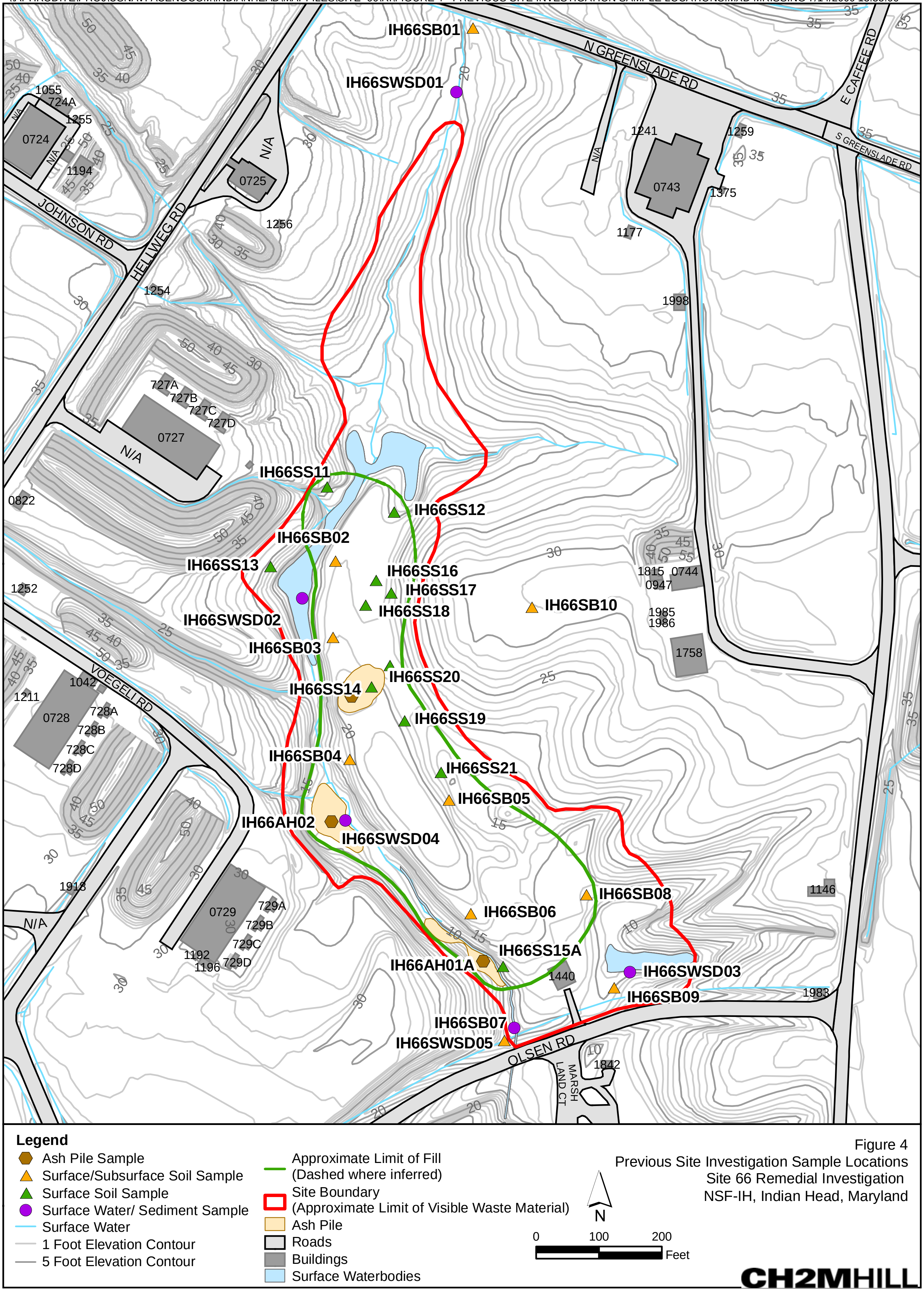

Figure 4
Previous Site Investigation Sample Locations
Site 66 Remedial Investigation
NSF-IH, Indian Head, Maryland

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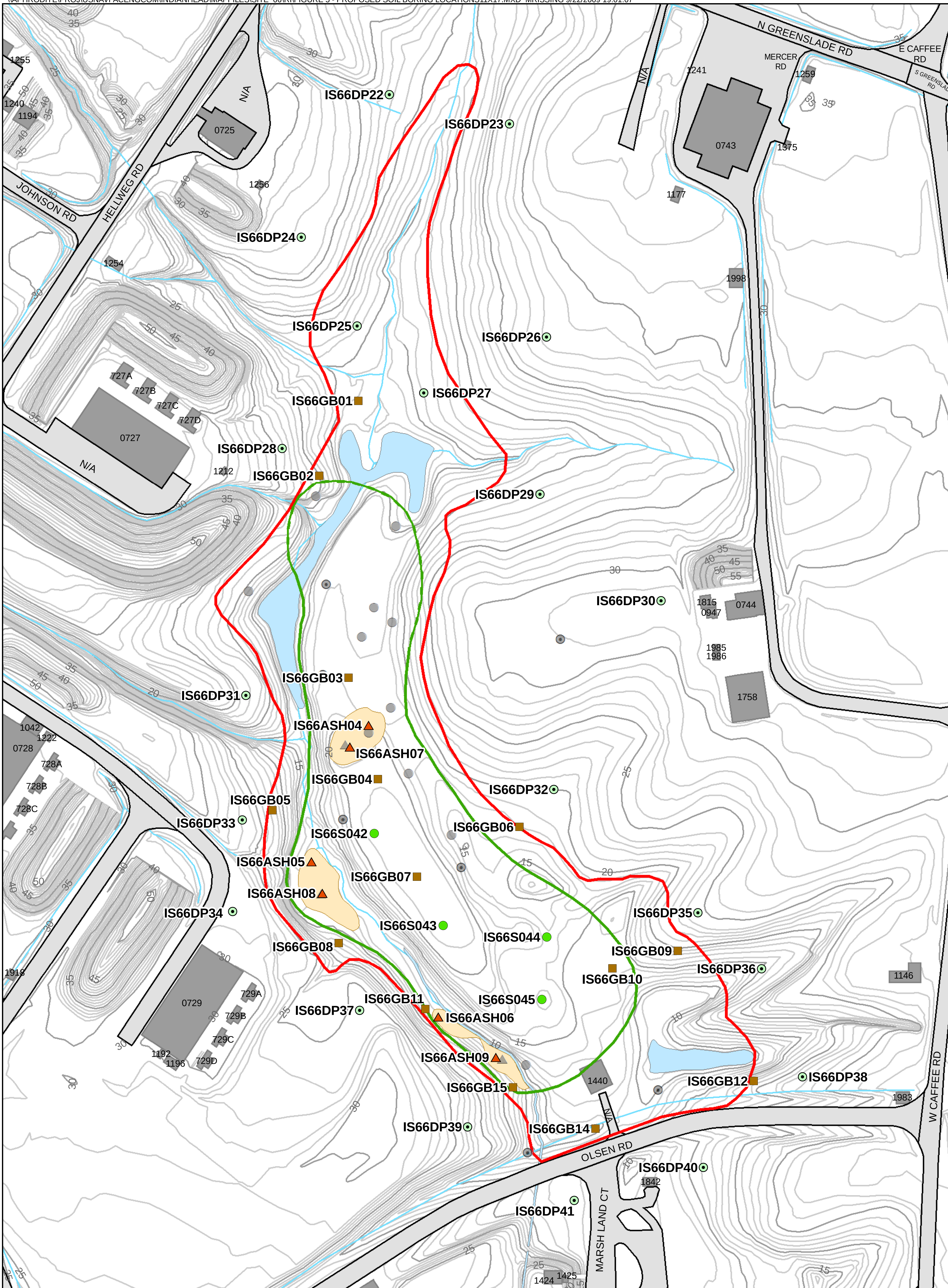
\\APHRODITE\PROJ\USNAVFACENGCOM\INDIANHEAD\MAPFILES\SITE_66\RI\FIGURE 5 - PROPOSED SOIL BORING LOCATIONS11X17.MXD MRISSING 9/22/2009 19:01:07



Legend

Proposed Sample Locations

- Proposed Ash Sample Location
- Proposed Surface and Subsurface Soil Sample Location
- Proposed Soil Boring Location for Stratigraphy only
- Proposed Surface Soil Sample Location

Previous Site Investigation Sample Locations

- Ash Pile Sample
- Surface/Subsurface Soil Sample
- Surface Soil Sample
- Approximate Limit of Fill (Dashed where inferred)

- 5 Foot Elevation Contour
- 1 Foot Elevation Contour
- Surface Water
- Site Boundary (Approximate Limit of Visible Waste Material)
- Ash Pile
- Roads
- Buildings
- Surface Waterbodies

N W E S

0 62.5 125 250 Feet

Figure 5
Proposed Soil Boring and Ash Sample Locations
Site 66 Remedial Investigation
NSF-IH, Indian Head, Maryland

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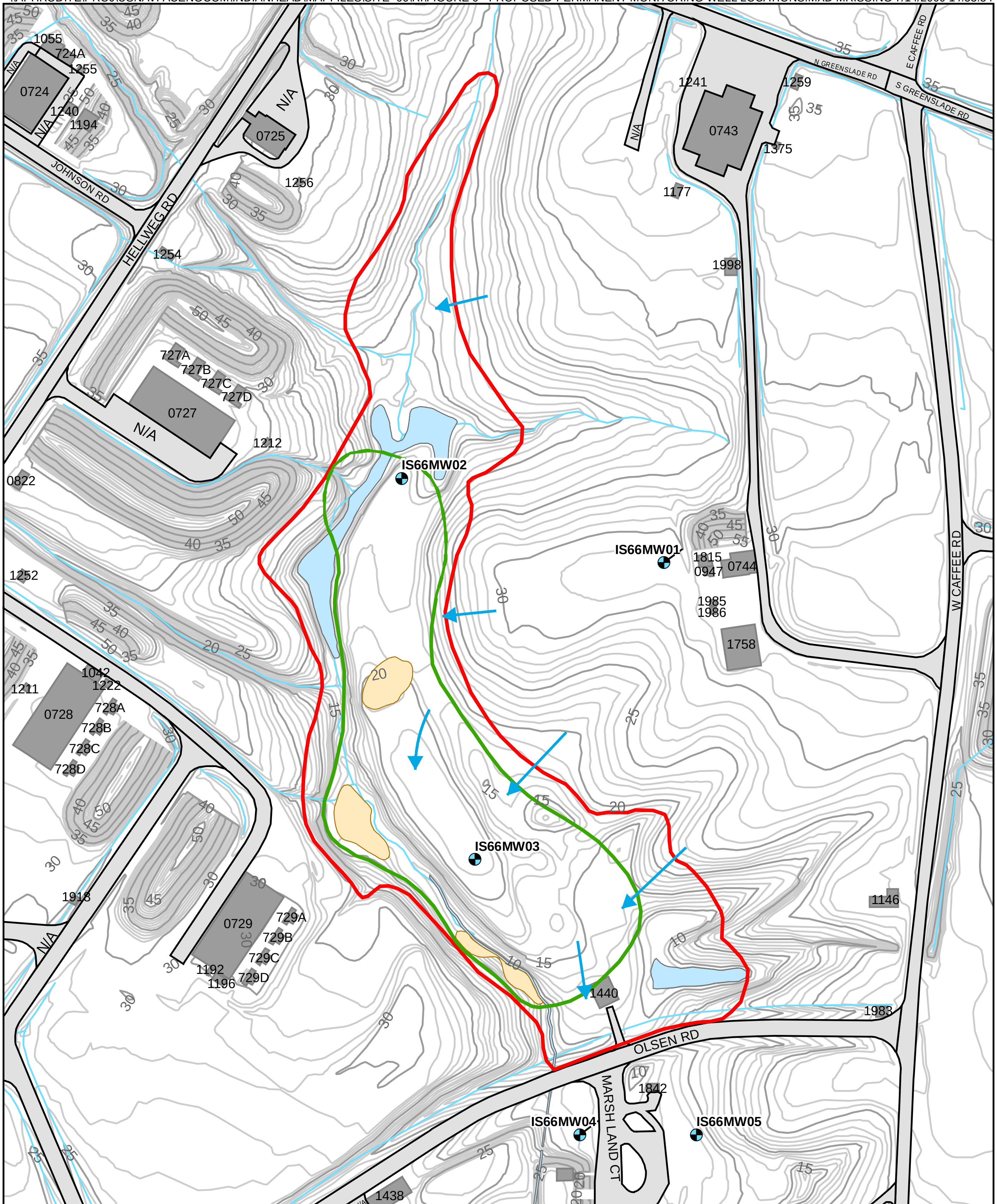
\\APHRODITE\PROJ\USNAVFACENGCOM\INDIANHEAD\MAPFILES\SITE_66\RI\FIGURE 6 - PROPOSED PERMANENT MONITORING WELL LOCATIONS.MXD MRISSING 7/14/2009 14:33:54



Legend

- Proposed Permanent Monitoring Well Location
- Surface Water
- 1 Foot Elevation Contour
- 5 Foot Elevation Contour
- Approximate Limit of Fill (Dashed where inferred)
- Groundwater Flow Direction (based on static water levels measured April 2007)
- Site Boundary (Approximate Limit of Visible Waste Material)
- Ash Pile
- Roads
- Buildings
- Surface Waterbodies

N

0 100 200 Feet

Figure 6
Proposed Permanent Monitoring Well Locations
Site 66 Remedial Investigation
NSF-IH, Indian Head, Maryland

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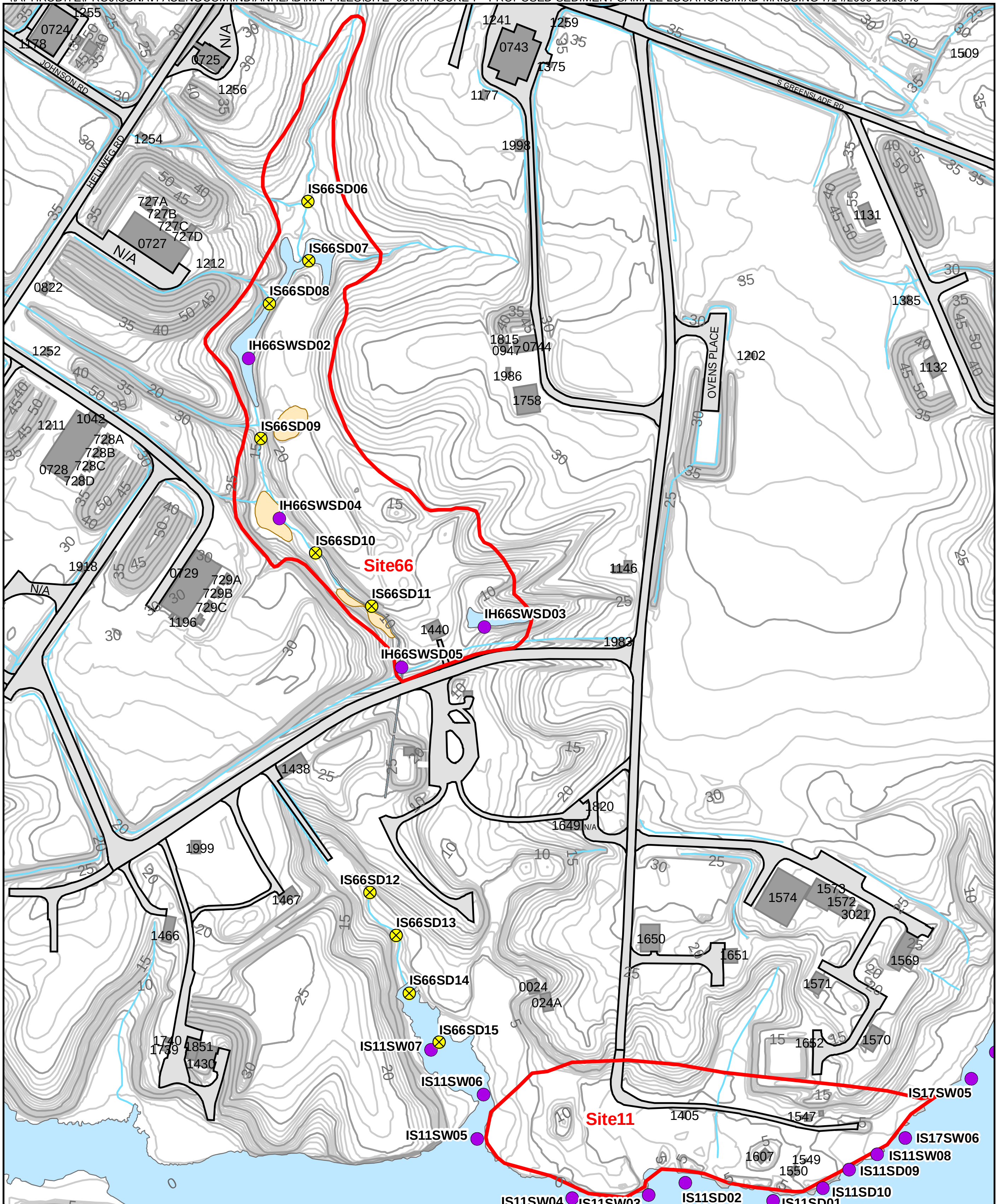
\\APHRODITE\PROJ\USNAVFACENGCOM\INDIANHEAD\MAPFILES\SITE_66\RI\FIGURE 7 - PROPOSED SEDIMENT SAMPLE LOCATIONS.MXD MRISSING 7/14/2009 15:13:49



Legend

- Proposed Sediment Sample Location
- Historical Surface Water/ Sediment Sample
- Surface Water
- 1 Foot Elevation Contour
- 5 Foot Elevation Contour
- Site Boundary
- Ash Pile
- Roads
- Buildings
- Surface Waterbodies

N

0 150 300
Feet

Figure 7
Proposed Sediment Sample Locations
Site 66 Remedial Investigation
NSF-IH, Indian Head Maryland

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Appendix A
Ecological Risk Assessment Work Plan

APPENDIX A

Screening Ecological Risk Assessment Work Plan

A Screening Ecological Risk Assessment (SERA) [Steps 1 and 2] and if warranted, the first step of the Baseline Ecological Risk Assessment (BERA) [Step 3A] will be prepared for Site 66 in general accordance with Navy (CNO 1999; NAVFAC 2001; EFACHES, 2001) and USEPA (USEPA 1997) ERA guidance.

The objectives of the SERA are to:

- Determine if potential risks to ecological receptors warrant either: (1) additional assessment beyond the conservative screening steps of the ERA process (unacceptable ecological risks possible), or (2) the removal of Site 66 from further ecological consideration (no unacceptable ecological risks)
- To identify any data gaps or areas of unacceptable uncertainty that may require the collection of additional data to support ERA evaluations beyond the screening level

Screening Level Problem Formulation

The products of screening level problem formulation are the preliminary conceptual site model (CSM) and the preliminary assessment and measurement endpoints. The purpose of the CSM is to describe how ecological receptors may be exposed to chemical constituents that are present at the site. Development of the CSM requires the identification and description of major habitats and other ecological receptors, media of concern, and potential contaminant sources. These elements (sources and receptors) and an understanding of how chemicals move through the local environment (transport mechanisms and exposure routes) are used to build the CSM.

Preliminary Conceptual Site Model

Figure 1 and the following text outline the most likely sources of contaminants, transport pathways, exposure media and potential exposure routes, and receptor groups. Exposure, and thus potential for risk, can only occur if each of the following conditions is present (USEPA 1998):

- A source of contamination must be present;
- Release and transport mechanisms must be available to move the contaminants from the source to an exposure point;
- An exposure point must exist where ecological receptors could contact the affected media; and/or
- An exposure route must exist whereby the contaminant can be taken up by ecological receptors.

Contaminant Sources - waste materials such as lead flooring, transite roofing, ash/slag, metal debris (sheeting, pipes, copper pieces, rebar), laboratory bottles and empty 5-gallon containers, concrete pads and debris, creosote telephone poles, land clearing debris, and other miscellaneous materials (tires, trash cans, appliances) are present at the site. Results of the Site Investigation indicated that chemicals in the surface soil and sediment at the site warrant further consideration for ecological risk.

The Site Investigation results suggested that the inorganic chemicals detected in the surface water at the site were likely related to background conditions and did not warrant further consideration for ecological risk. Three pesticide compounds and one explosive compound were detected in one groundwater sample, but not in the surface water. Thus, the compounds are either not migrating to surface water or are not persisting in the surface water, and therefore do not warrant further consideration for ecological risk. No volatile organic compounds (VOCs) were detected in the subsurface soil during the Site Investigation.

Transport Pathways – a transport pathway describes the mechanisms whereby contaminants may be transported from a source of contamination to ecologically relevant media. The primary mechanisms for contaminant transport from potential source areas to the down gradient stream are believed to include the following:

- Overland transport of contaminants within surface soil via surface runoff;
- Leaching of contaminants from surface soil and/or subsurface soil by infiltrating precipitation and transport; and/or
- Uptake by biota and trophic transfer to upper trophic levels.

Exposure Pathways and Routes - An exposure pathway links a source of contamination with one or more receptors via exposure to one or more media. An exposure route describes the specific mechanism(s) by which a receptor is exposed to a chemical present in an environmental medium. The primary exposure routes expected at Site 66 are as follows:

- Direct contact with surface soil and sediment (lower trophic level receptors groups)
- Ingestion of surface soil and sediment (lower and upper trophic level receptor groups)
- Root uptake from soil and sediment (plants)
- Ingestion of contaminated plant and/or animal tissue (upper trophic level receptors)
- Direct contact and incidental ingestion of subsurface soil associated with burrowing and grooming (burrowing mammals)

Potential Receptors - the habitat at Site 66 includes mixed deciduous woods with a small stream running north to south through the middle of the site, with wetlands along portions of the floodplain. There is a small pond at the northern end of the site, from which the stream originates. The site provides habitat for limited aquatic biota, such as small fish, aquatic insects, amphibians, and reptiles. The forested area provides refuge and foraging habitat for some mammal and avian species.

Potential ecological receptors include plants, invertebrates, amphibians, fish, reptiles, birds, and mammals. Soil invertebrates may be exposed to contaminants in the soil through dermal contact and ingestion. Benthic invertebrates may be exposed to contaminants in the sediment through dermal contact and ingestion. Because these organisms are the prey base for other animals, they also represent an exposure source. Similarly, small mammals, amphibians, fish, and reptiles may accumulate contaminants in their tissue, and are thus a possible exposure source for upper trophic level receptors (i.e., carnivorous birds and mammals).

Assessment and Measurement Endpoints

Endpoints in the SERA define ecological attributes that are to be protected (assessment endpoints) and measurable characteristics of those attributes (measurement endpoints) that can be used to gauge the degree of impact that has or could occur. Assessment endpoints most often relate to attributes of biological populations or communities, and are intended to focus the risk assessment on particular components of the ecosystem that could be adversely affected by exposure to contaminants from the site (EPA, 1997). Assessment endpoints contain an entity (e.g., carnivorous birds) and an attribute of that entity, such as survival rate.

Because of the complexity of natural systems, it is generally not possible to directly assess the potential impacts to all ecological receptors present within an area. Therefore, receptor species (e.g., green heron) or species groups are often selected as surrogates to evaluate potential risks to larger components of the ecological community (feeding guilds; e.g., carnivorous birds) represented in the assessment endpoints (e.g., survival and reproduction of carnivorous birds). Selection criteria typically include species that:

- Are known to occur, or are likely to occur, at the site
- Have a particular ecological, economic, or aesthetic value
- Are representative of taxonomic groups, life history traits, and/or trophic levels in the habitats present at the site for which complete exposure pathways are likely to exist
- Can be expected to represent potentially sensitive populations at the site because of their toxicological sensitivity or potential exposure magnitude
- Can be evaluated because of the availability of sufficient ecotoxicological information

Based on the habitats and types of contaminants present, the assessment endpoints chosen to evaluate the risk to ecological receptor populations are impacts to growth, survival, and/or reproduction. The assessment endpoints and measurement endpoints for terrestrial receptors and for aquatic receptors are presented in Table 1.

Although potentially complete exposure pathways exist for reptiles and amphibians, they were not specifically selected as receptors because use of ambient water quality criteria is protective of the larval stages of amphibians and no COPCs were identified for surface water in the Site Investigation. Furthermore, information about the toxicological effects of chemicals on adult amphibians and reptiles via ingestion is limited. Reptiles and amphibians are also unlikely to be more sensitive to chemical exposures than other receptor groups that are evaluated in a risk assessment (A.T. Kearney, 1997).

TABLE 1
Measurement Endpoints for Site 66
NSF-IH, Indian Head, Maryland

Assessment Endpoints		Measurement Endpoints
Terrestrial Receptors		
Impact on growth and survival of the soil invertebrate community.	⇨	Comparison of hazard quotients (HQs) for soil invertebrates to a target HQ of 1. Medium-specific HQs are calculated by dividing the soil concentration by a soil benchmark that is intended to be protective of soil invertebrates.
Impact on growth and survival of the plant community.	⇨	Comparison of HQs for terrestrial plants to a target HQ of 1. Medium-specific HQs are calculated by dividing the soil concentration by a soil benchmark that is intended to be protective of terrestrial plants.
Impact on growth, survival, and reproduction of terrestrial insectivorous birds.	⇨	Comparison of HQs for American woodcock to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated level of exposure (dose) by a screening toxicity value that is associated with no adverse effects.
Impact on growth, survival, and reproduction of terrestrial carnivorous birds.	⇨	Comparison of HQs for Eastern screech owl to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated level of exposure (dose) by a screening toxicity value that is associated with no adverse effects.
Impact on growth, survival, and reproduction of terrestrial insectivorous mammals.	⇨	Comparison of HQs for short-tailed shrew to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated level of exposure (dose) by a screening toxicity value that is associated with no adverse effects.
Impact on growth, survival, and reproduction of terrestrial carnivorous mammals.	⇨	Comparison of HQs for red fox to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated level of exposure (dose) by a screening toxicity value that is associated with no adverse effects.
Aquatic and Semi-aquatic Receptors		
Impact on the growth and survival of the benthic invertebrate community.	⇨	Comparison of HQs for benthic invertebrates to a target HQ of 1. Media-specific HQs are calculated by dividing the sediment concentration by a sediment screening value that is intended to be protective of benthic invertebrates.
Impact on the growth and survival of the aquatic plant community.	⇨	Comparison of HQs for aquatic plants to a target HQ of 1. Media-specific HQs are calculated by dividing the sediment concentration by a sediment screening value that is intended to be protective of aquatic plants.
Impact on growth, survival, and reproduction of insectivorous aquatic birds.	⇨	Comparison of HQs for spotted sandpiper to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated maximum level of exposure by a screening toxicity value that is associated with no adverse effects.
Impact on growth, survival, and reproduction of carnivorous aquatic birds.	⇨	Comparison of HQs for great blue heron to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated maximum level of exposure by a screening toxicity value that is associated with no adverse effects.
Impact on growth, survival, and reproduction of semi-aquatic omnivorous mammals.	⇨	Comparison of HQs for raccoon to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated maximum level of exposure by a screening toxicity value that is associated with no adverse effects.
Impact on growth, survival, or reproduction of burrowing semi-aquatic mammals.	⇨	Comparison of HQs for muskrat to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated maximum level of exposure by a screening toxicity value that is associated with no adverse effects.

Screening-Level Effects Evaluation

Medium-specific Screening Values

The purpose of the screening-level effects evaluation is to establish chemical exposure levels (screening values) that represent conservative thresholds for adverse ecological effects. Typically, one set of screening values is developed for each selected assessment endpoint.

The soil screening values that will be used in this assessment are derived from the following sources: EPA Ecological Soil Screening Levels (Eco-SSLs) (USEPA, 2008); Efoymson et al., 1997a; Efroymson et al., 1997b; EPA Region IV soil-screening values (USEPA, 2001), NOAA Screening Quick Reference Tables (Buchman, 2008), and Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities (USEPA, 1999).

The screening values use to evaluate potential ecological risks form chemicals in sediment were derived from the following sources: EPA Region III Freshwater Sediment Screening Benchmarks (USEPA, 2005); NOAA Screening Quick Reference Tables (Buchmann, 2008); and Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-associated Biota: 1997 Revision (Jones et al., 1997).

Ingestion Screening Values

Toxicity reference values (TRVs) based on ingestion were derived for dietary exposures to the bioaccumulative chemicals at the site. Bioaccumulative chemicals were identified based on USEPA, 2000. Toxicological information from the literature for wildlife species most closely related to the receptor species was used, where available, but was supplemented by laboratory studies of non-wildlife species (e.g., laboratory mice) where necessary. The ingestion screening values are expressed as milligrams of the chemical per kilogram body weight of the receptor per day (mg/kg-BW/day) (Table 2 for mammals and Table 3 for birds).

Allometric scaling as discussed in Sample et al. (1996) were not used to adjust TRVs obtained from the literature for the following reasons. Allometric scaling factors discussed in Sample et al. (1996) are all based on acute toxicity (i.e., LD50s). These factors are derived by regressing the body weight of the test animal against the amount of chemical given in a single dose that resulted in mortality. In application however, these acute relationships are used to estimate variation in chronic effects. However, the mode of action for an acute exposure is likely to be dramatically different from what would be expected for a chronic exposure. The acute effects are due to comparatively large doses causing severe toxic responses that result in fairly rapid mortality. Chronic exposures/effects are comparatively more subtle and multiple types of effects could result (e.g., reproductive, growth, organ systems, etc.). Each type of chronic effect could have different scaling factors depending on the detoxification and sensitivity characteristics of the animal. Because sufficient information does not exist pertaining to the relationship between acute and chronic effects for different chemicals across different taxa, the use of acute data-based allometric scaling factors may actually increase the level of uncertainty in the TRVs, rather than decreasing it. Therefore, for these reasons, the TRVs used in this risk assessment were not adjusted for body weight differences between test species and surrogate receptor species.

Growth and reproduction were emphasized within the assessment endpoints since they are the most relevant, ecologically, to maintaining viable populations and because they are generally the most studied chronic toxicological endpoints for ecological receptors. If several chronic toxicity studies were available from the literature, the most appropriate study was selected for each receptor species based on study design, study methodology, study duration, study endpoint, and test species (i.e., longer duration studies were selected over shorter duration ones, preference was given to studies using reproduction endpoints, and studies with tests species most similar to receptor species were selected where possible). No Observed Adverse Effect Levels (NOAELs) based on growth and reproductions were utilized, where available, as the screening values. When chronic NOAEL values were unavailable, estimates were derived or extrapolated from chronic Lowest Observed Adverse Effect Levels (LOAELs) or acute values as follows:

- An uncertainty factor of five was used to convert a reported LOAEL to a NOAEL because Dourson and Stara (1983) conducted a data review of toxicity values and found that 96 percent of the chemicals reviewed had a LOAEL/NOAEL ratio of five or less.
- When values for chronic toxicity were not available, the median lethal dose (LD_{50}) was used. An uncertainty factor of 100 was used to convert the acute LD_{50} to a chronic NOAEL (i.e., the LD_{50} was multiplied by 0.01 to obtain the chronic NOAEL).

Screening-Level Exposure Estimate

For the initial screening-level risk estimates, maximum concentrations in environmental media will be used to conservatively estimate potential chemical exposures to ecological receptors. For conservatism, the maximum detection limit for chemicals that are analyzed for but not detected will also be compared to medium-specific screening values. This will be done to ensure that detection limits are similar to or less than chemical concentrations at which potential adverse effects to ecological receptors might occur. For samples with duplicate analyses, the higher of the two concentrations will be used in the screening (i.e., when both values are detects or both values are nondetects). In cases where one result is detected and the other is a nondetect, the detected value will be used in the assessment.

Validated analytical data will be used in the SERA based on the following criteria. Data with rejected (R) values will not be used in the risk assessment. Unqualified data and data qualified as J, L, or K will be treated as detected. Data qualified as U or B will be treated as nondetected.

Upper trophic level receptor exposures to chemicals in site media will be determined by estimating the concentration of each chemical in each relevant dietary component. Incidental ingestion of soil or sediment was included when calculating the total exposure, where appropriate.

Body weights, ingestion rates, and dietary composition for each receptor are presented in Tables 4 and 5. Conservative body weights (i.e., minimums) and ingestion rates (i.e., maximums) will be used in calculating food web exposures for the initial assessment (Step 2 of the ERA).

Dietary items for which tissue concentrations will be modeled include terrestrial plants, soil invertebrates (earthworms), small mammals, aquatic plants, aquatic invertebrates, and fish/frogs. The methodologies used for these tissue calculations are outlined in the following subsection. For the screening-level exposure estimation, the uptake of chemicals from abiotic media into these food items will be conservatively estimated based on maximum or "high-end" (e.g., 90th percentile) bioconcentration factors (BCFs) or bioaccumulation factors (BAFs) from the literature (Tables 6 through 8). Default factors of 1.0 will be used only where data are unavailable for a chemical in the literature. More detailed information regarding development of exposure point concentrations and ingestion exposure calculations is provided below.

Foodweb Exposure Point Concentrations

Maximum measured media concentrations will be used as exposure point concentrations for the screening-level exposure estimation and food web modeling. Exposure point concentrations for terrestrial and aquatic prey items (plants, soil invertebrates, small mammals, fish/frogs, and aquatic invertebrates) will be estimated using bioaccumulation models and maximum measured media concentrations. The models used to derive these estimates are described below.

Terrestrial Plants. Tissue concentrations in the aboveground vegetative portion of terrestrial plants will be estimated by multiplying the maximum measured surface soil concentration for each chemical by chemical-specific soil-to-plant BCFs obtained from the literature (Table 6). The BCF values used are based on root uptake from soil and on the ratio between dry-weight soil and dry-weight plant tissue. Literature values based on the ratio between dry-weight soil and wet-weight plant tissue were converted to a dry-weight basis by dividing the wet-weight BCF by the estimated solids content for terrestrial plants (15 percent [0.15]; Sample et al., 1997).

For inorganic chemicals without literature based BCFs, a soil-to-plant BCF of 1.0 was assumed. For organic chemicals without literature based BCFs, soil-to-plant BCFs were estimated using the algorithm provided in Travis and Arms (1988):

$$\log B_v = 1.588 - (0.578)(\log K_{ow})$$

where: B_v = Soil-to-plant BCF (unitless; dry weight basis)
K_{ow} = Octanol-water partitioning coefficient (unitless)

The log K_{ow} values used in the calculations were obtained mostly from USEPA (1995b; 1996a).

Earthworms. Tissue concentrations in soil invertebrates (earthworms) will be estimated by multiplying the maximum measured surface soil concentration for each chemical by chemical-specific BCFs or BAFs obtained from the literature (Table 6). BCFs are calculated by dividing the concentration of a chemical in the tissues of an organism by the concentration of that same chemical in the surrounding environmental medium (in this case, soil) without accounting for uptake via the diet. BAFs consider both direct exposure to soil and exposure via the diet. Since earthworms consume soil, BAFs are more appropriate values and are used in the food web models when available. BAFs based on depurated analyses (soil was purged from the gut of the earthworm prior to analysis) are given preference over undepurated analyses when selecting BAF values since direct ingestion of soil is accounted for separately in the food web model.

The BCF/BAF values are based on the ratio between dry-weight soil and dry-weight earthworm tissue. Literature values based on the ratio between dry-weight soil and wet-weight earthworm tissue were converted to a dry-weight basis by dividing the wet-weight BCF/BAF by the estimated solids content for earthworms (16 percent [0.16]; USEPA 1993). For inorganic chemicals without available measured BAFs or BCFs, an earthworm BAF of 1.0 was assumed.

Small Mammals. Whole-body tissue concentrations in small mammals (shrews, voles, and/or mice) will be estimated using one of two methodologies. For chemicals with literature-based soil-to-small mammal BCFs, the small mammal tissue concentration were obtained by multiplying the maximum measured surface soil concentration for each chemical by a chemical-specific soil-to-small mammal BCF obtained from the literature. The BCF values used are based on the ratio between dry-weight soil and whole-body dry-weight tissue. Literature values based on the ratio between dry-weight soil and wet-weight tissue were converted to a dry-weight basis by dividing the wet-weight BCF by the estimated solids content for small mammals (32 percent [0.32]; USEPA 1993). BCFs for shrews are those reported in Sample et al. (1998b) for insectivores (or for general small mammals if insectivore values were unavailable), for voles are those reported for herbivores, and for mice are those reported for omnivores. The soil-to-small mammal BAFs used are shown in Table 6.

For chemicals without soil-to-small mammal BCF values, an alternate approach will be used to estimate whole-body tissue concentrations. Because most chemical exposure for these small mammal species is via the diet, it is assumed that the concentration of each chemical in the small mammal's tissues will be equal to the chemical concentration in its diet, that is, a <u>diet</u> to whole-body BAF (wet-weight basis) of one was assumed. The use of a diet to whole-body BAF of one is likely to result in a conservative estimate of chemical concentrations for chemicals that are not known to biomagnify in terrestrial food chains (e.g., aluminum). For chemicals that are known to biomagnify (e.g., PCBs), a diet to whole-body BAF value of one likely results in a realistic estimate of tissue concentrations based on reported literature values.

Aquatic Plants. Tissue concentrations in the aboveground vegetative portion of aquatic plants will be estimated using the same methodologies as described above for terrestrial plants except that maximum sediment (not soil) concentrations was used in the calculation. Sediment-to-plant BCFs are presented in Table 7.

Aquatic Invertebrates. Tissue concentrations in aquatic invertebrates will be estimated by multiplying the maximum measured sediment concentration for each chemical by chemical-specific sediment-to-invertebrate BCFs obtained from the literature (Table 7). The BCF values used are based on the ratio between dry-weight sediment and dry-weight invertebrate tissue. BCFs based on depurated analyses (sediment was purged from the gut of the organism prior to analysis) were given preference over undepurated analyses when selecting BCF values since direct ingestion of sediment is accounted for separately in the food web model.

Literature values based on the ratio between dry-weight sediment and wet-weight invertebrate tissue were converted to a dry-weight basis by dividing the wet-weight BCF by the estimated solids content for aquatic invertebrates (21 percent [0.21]; USEPA 1993). For chemicals without literature based sediment-to-invertebrate BCFs, a BCF of 1.0 was assumed.

Aquatic Vertebrates. Tissue concentrations in whole-body fish and frogs will be estimated by multiplying the maximum measured sediment concentration for each chemical by chemical-specific sediment-to-vertebrate BCFs obtained from the literature (Table 8). The BCF values used were based on the ratio between dry-weight sediment and dry-weight tissue. Literature values based on the ratio between dry-weight sediment and wet-weight tissue were converted to a dry-weight basis by dividing the wet-weight BCF by the estimated solids content for aquatic vertebrates (25 percent [0.25]; USEPA 1993). For chemicals without literature based sediment-to-aquatic vertebrate BCFs, a BCF of 1.0 was assumed.

Dietary Intakes

Dietary intakes for each receptor species will be calculated using the following formula (modified from USEPA [1993]):

$$DI_x = \frac{[[\sum_i (FIR)(FC_{xi})(PDF_i)] + [(FIR)(SC_x)(PDS)] + [(WIR)(WC_x)]]}{BW}$$

where:

DI_x	=	Dietary intake for chemical x (mg chemical/kg body weight/day)
FIR	=	Food ingestion rate (kg/day, dry-weight)
FC_{xi}	=	Concentration of chemical x in food item i (mg/kg, dry weight)
PDF_i	=	Proportion of diet composed of food item i (dry weight basis)
SC_x	=	Concentration of chemical x in soil/sediment (mg/kg, dry weight)
PDS	=	Proportion of diet composed of soil/sediment (dry weight basis)
WIR	=	Water ingestion rate (L/day)
WC_x	=	Concentration of chemical x in water (mg/L)
BW	=	Body weight (kg, wet weight)

Receptor-specific values that will be used as inputs to this equation are provided in Tables 4 and 5. For conservatism, the model assumes that chemicals are 100 percent bioavailable to the receptor and that each receptor spends 100 percent of its time within the boundaries of the site.

Dioxins and Furans

The dietary intake for each polychlorinated dibenzo-p-dioxin (PCDDs) and polychloricated dibenzofuran (PCDFs) congener thought to have dioxin-like toxicity will be estimated by multiplying the estimated dose of each congener by a toxicity equivalence factor (TEF). The TEFs from Van den Berg et al. (1998) will be used to calculate TEQs for birds, and Van den Berg et al. (2006) for mammals. This will result in toxicity equivalence concentrations (TEC) for each of the 17 congeners. The TECs will be summed to produce an estimated dosage for each receptor. The toxicity equivalence factors that will be used in this assessment are provided in Table 9.

Screening-Level Risk Estimates

The screening-level risk calculation is the final step in the SERA (Step 2). In this step, the maximum exposure concentrations for abiotic media or exposure doses for upper trophic-level receptor species are compared with the corresponding screening values to derive screening risk estimates. The outcome of this step is a list of preliminary chemicals of potential concern (COPCs) for each media-pathway-receptor combination.

COPCs will be selected using the hazard quotient (HQ) method. HQs will be calculated by dividing the chemical concentrations in the media by the appropriate screening values. Chemicals with HQs greater than or equal to 1.0 will be considered preliminary COPCs. HQs exceeding 1.0 indicate the potential for risk since the chemical concentration (exposure) exceeds the screening value (effect). However, screening values and exposure estimates are derived using intentionally conservative assumptions so that HQs greater than or equal to 1.0 do not necessarily indicate that risks are present or impacts are occurring. Rather, HQs greater than 1.0 identify chemical-pathway-receptor combinations requiring further evaluation. Following the same reasoning, HQs that are less than 1.0 indicate that risks are very unlikely, enabling a conclusion of no unacceptable risk to be reached with high confidence.

Step 3A - Refinement of Conservative Exposure Assumptions

Step 3 initiates the problem formulation phase of the baseline ecological risk assessment. In Step 3A, the screening-level problem formulation is refined using more realistic exposure assumptions. As part of this refinement, exposure estimates are recalculated for the preliminary COPCs. Risk is again characterized and uncertainties assumptions are refined using more realistic parameters and risk estimates. If re-evaluation of the conservative exposure assumptions, consideration of background concentrations, and consideration of the frequency and magnitude of detections supports an acceptable risk determination (i.e., no remaining COPCs), then no further evaluation of ecological risk may be warranted. If however, the re-evaluation supports a determination that chemicals pose an unacceptable risk, then the product of Step 3A is a list of COPCs that warrant further evaluation.

Assumptions and methods that will be modified for the calculation of Step 3 media-specific and food chain hazard quotients are listed below.

- Maximum chemical concentrations will be replaced by average chemical concentrations. For individual mammalian and avian receptors, average chemical concentrations provide a better estimate of the likely level of chemical exposure because each of the receptors would be expected to forage in several different areas of the site, and, in many cases, off-site. Average concentrations also provided a better estimates of the exposures experienced at the population level. The average concentrations are also appropriate for evaluating impacts to populations of soil invertebrates, sediment invertebrates, and aquatic receptors. Because some of these receptors are relatively immobile, *individuals* are more likely to be impacted by locations of maximum concentration. However, evaluation of the average exposure case is more instructive with regard to the level of impact that might be expected at the *population* level.

- Mid-point body weight and food and water ingestion rates for surrogate species will be used to develop exposure estimates, rather than the minimum body weights and maximum food and water ingestion rates used in Step 2. Step 3 exposure parameters are presented in Tables 10 and 11. The use of midpoint exposure parameters is more relevant because they represent the characteristics of a greater proportion of the individuals in the population.

- Bioaccumulation factors (BAFs) and bioconcentration factors (BCFs) based on, or modeled from, central tendency estimates (e.g., median or mean) from the literature will be used as opposed to the maximum or "high-end" (e.g., 90th percentile) estimates used in the the Step 2 exposure estimates (Tables 12 through 14).
- LOAEL-based HQs will be considered along with NOAEL-based HQs to provide a bounding for the risk estimates for upper trophic level receptors.

References

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TABLE 2
Ingestion Screening Values for Mammals
Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference
Inorganics								
Arsenic	mouse	0.03	3 generations	oral in water	reproduction	1.26	0.25	Sample et al. 1996
Arsenic	dog	10.0	2 years	oral in diet	systemic	6.00	1.20	ATSDR 1993a
Cadmium	rat	0.303	6 weeks	oral (gavage)	reproduction	10.0	1.00	Sample et al. 1996
Cadmium	dog	10.0	3 months	oral in diet	reproduction	3.75	0.75	ATSDR 1999a
Chromium	rat	0.35	3 months	oral in water	mortality	131	26.3	Sample et al. 1996
Chromium	rat	0.35	1 year	oral in water	body weight/intake	16.4	3.28	Sample et al. 1996
Copper	mouse	0.03	1 month + GD 0-19	oral in diet	developmental	104	78.0	ATSDR 1990a
Copper	mink	1.00	357 days	oral in diet	reproduction	15.1	11.7	Sample et al. 1996
Lead	rat	0.35	3 generations	oral in diet	reproduction	80.0	8.00	Sample et al. 1996
Mercury	rat	0.35	3 generations	oral in diet	reproduction	0.16	0.032	Sample et al. 1996
Mercury	mink	1.00	93 days	oral in diet	survival/weight loss	0.25	0.15	Sample et al. 1996
Nickel	rat	0.35	3 generations	oral in diet	reproduction	80.0	40.0	Sample et al. 1996
Nickel	dog	10.0	2 years	oral in diet	systemic	62.5	25.0	ATSDR 1997a
Selenium	rat	0.35	1 year	oral in water	reproduction	0.33	0.20	Sample et al. 1996
Silver	rat	0.35	2 weeks	oral in water	survival	45.3	9.06	ATSDR 1990b
Zinc	rat	0.35	GD 1-16	oral in diet	reproduction	320	160	Sample et al. 1996
Zinc	mink	1.00	25 weeks	oral	reproduction	104	20.8	ATSDR 1994a
Pesticides/PCBs								
4,4'-DDD	rat	0.35	2 years	oral in diet	reproduction	4.00	0.80	Sample et al. 1996
4,4'-DDD	dog	10.0	2 generations	oral in diet	reproduction	5.00	1.00	ATSDR 1994b
4,4'-DDE	rat	0.35	2 years	oral in diet	reproduction	4.00	0.80	Sample et al. 1996
4,4'-DDE	dog	10.0	2 generations	oral in diet	reproduction	5.00	1.00	ATSDR 1994b
4,4'-DDT	rat	0.35	2 years	oral in diet	reproduction	4.00	0.80	Sample et al. 1996
4,4'-DDT	dog	10.0	2 generations	oral in diet	reproduction	5.00	1.00	ATSDR 1994b
Aldrin	rat	0.35	3 generations	oral in diet	reproduction	1.00	0.20	Sample et al. 1996
alpha-BHC	rat	0.35	4 generations	oral in diet	reproduction	3.20	1.60	Sample et al. 1996
alpha-Chlordane	mouse	0.03	6 generations	oral in diet	reproduction	9.16	4.58	Sample et al. 1996
Aroclor-1016	oldfield mouse	0.014	12 months	oral in diet	reproduction	0.68	0.14	Sample et al. 1996
Aroclor-1016	mink	1.00	18 months	oral in diet	reproduction	3.43	1.37	Sample et al. 1996
Aroclor-1221	oldfield mouse	0.014	12 months	oral in diet	reproduction	0.68	0.14	Sample et al. 1996
Aroclor-1221	mink	1.00	7 months	oral in diet	reproduction	0.69	0.14	Sample et al. 1996
Aroclor-1232	oldfield mouse	0.014	12 months	oral in diet	reproduction	0.68	0.14	Sample et al. 1996
Aroclor-1232	mink	1.00	7 months	oral in diet	reproduction	0.69	0.14	Sample et al. 1996

TABLE 2
Ingestion Screening Values for Mammals
Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference
Aroclor-1242	oldfield mouse	0.014	12 months	oral in diet	reproduction	0.68	0.14	Sample et al. 1996
Aroclor-1242	mink	1.00	7 months	oral in diet	reproduction	0.69	0.14	Sample et al. 1996
Aroclor-1248	oldfield mouse	0.014	12 months	oral in diet	reproduction	0.68	0.14	Sample et al. 1996
Aroclor-1248	mink	1.00	4.5 months	oral in diet	reproduction	0.69	0.14	Sample et al. 1996
Aroclor-1254	oldfield mouse	0.014	12 months	oral in diet	reproduction	0.68	0.14	Sample et al. 1996
Aroclor-1254	mink	1.00	4.5 months	oral in diet	reproduction	0.69	0.14	Sample et al. 1996
Aroclor-1260	oldfield mouse	0.014	12 months	oral in diet	reproduction	0.68	0.14	Sample et al. 1996
Aroclor-1260	mink	1.00	4.5 months	oral in diet	reproduction	0.69	0.14	Sample et al. 1996
PCBs (total)	oldfield mouse	0.014	12 months	oral in diet	reproduction	0.68	0.14	Sample et al. 1996
PCBs (total)	mink	1.00	4.5 months	oral in diet	reproduction	0.69	0.14	Sample et al. 1996
beta-BHC	rat	0.35	4 generations	oral in diet	reproduction	3.20	1.60	Sample et al. 1996
delta-BHC	rat	0.35	4 generations	oral in diet	reproduction	3.20	1.60	Sample et al. 1996
Dieldrin	rat	0.35	3 generations	oral in diet	reproduction	0.20	0.04	Sample et al. 1996
Dieldrin	dog	10	15.7 months	oral in diet	systemic	0.14	0.03	ATSDR 1993b
Endosulfan I	rat	0.35	30 days	oral (gavage)	fertility	7.50	1.50	Sample et al. 1996
Endosulfan I	dog	10.0	2 years	oral in diet	systemic	5.00	1.00	ATSDR 1993c
Endosulfan II	rat	0.35	30 days	oral (gavage)	fertility	7.50	1.50	Sample et al. 1996
Endosulfan II	dog	10.0	2 years	oral in diet	systemic	5.00	1.00	ATSDR 1993c
Endrin	mouse	0.03	120 days	oral in diet	reproduction	0.92	0.18	Sample et al. 1996
gamma-BHC (Lindane)	rat	0.35	3 generations	oral in diet	reproduction	40.0	8.00	Sample et al. 1996
gamma-Chlordane	mouse	0.03	6 generations	oral in diet	reproduction	9.16	4.58	Sample et al. 1996
Heptachlor	mouse	0.03	70 days	oral in diet	reproduction	1.63	0.33	ATSDR 1993d
Heptachlor	mink	1.00	181 days	oral in diet	reproduction	1.00	0.20	Sample et al. 1996
Heptachlor epoxide	mouse	0.03	70 days	oral in diet	reproduction	1.63	0.33	ATSDR 1993d
Heptachlor epoxide	mink	1.00	181 days	oral in diet	reproduction	1.00	0.20	Sample et al. 1996
Methoxychlor	rat	0.35	11 months	oral in diet	reproduction	8.00	4.00	Sample et al. 1996
Toxaphene	rat	0.35	3 generations	oral in diet	reproduction	40.0	8.00	Sample et al. 1996
Semivolatile Organics								
4-Bromophenyl-phenylether	--	--	--	--	--	NA	NA	--
4-Chlorophenyl-phenylether	--	--	--	--	--	NA	NA	--
Acenaphthene	mouse	0.03	13 weeks	oral (gavage)	reproduction	700	350	ATSDR 1995a
Acenaphthylene	mouse	0.03	13 weeks	oral (gavage)	reproduction	700	350	ATSDR 1995a
Anthracene	mouse	0.03	13 weeks	oral (gavage)	reproduction	5,000	1,000	ATSDR 1995a
Benzo(a)anthracene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996

TABLE 2
Ingestion Screening Values for Mammals
Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference
Benzo(a)pyrene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Benzo(b)fluoranthene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Benzo(g,h,i)perylene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Benzo(k)fluoranthene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Chrysene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Dibenz(a,h)anthracene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Fluoranthene	mouse	0.03	13 weeks	oral (gavage)	reproduction	2,500	500	ATSDR 1995a
Fluorene	mouse	0.03	13 weeks	oral (gavage)	reproduction	2,500	500	ATSDR 1995a
Hexachlorobenzene	rat	0.35	4 generations	oral in diet	reproduction	2.00	1.00	ATSDR 1996b
Hexachlorobenzene	dog	10.0	1 year	oral	systemic	12.0	1.20	ATSDR 1996b
Hexachlorobutadiene	rat	0.35	GD 1-22; LD 1-21	oral in diet	developmental	20.0	2.00	ATSDR 1994c
Hexachlorocyclopentadiene	mouse	0.03	GD 6-15	oral (gavage)	developmental	375	75.0	ATSDR 1999b
Hexachloroethane	rat	0.35	GD 6-16	oral (gavage)	reproduction	500	100	ATSDR 1997b
Indeno(1,2,3-cd)pyrene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Pentachlorophenol	rat	0.35	2 generations	oral in diet	developmental	25.0	5.00	ATSDR 1994d
Phenanthrene	mouse	0.03	13 weeks	oral (gavage)	reproduction	2,500	500	ATSDR 1995a
Pyrene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Volatile Organics								
1,1,2,2-Tetrachloroethane	rat	0.35	78 weeks	oral (gavage)	reproduction	380	76.0	ATSDR 1996a
1,2,4-Trichlorobenzene	rat	0.35	3 generations	oral in water	reproduction	106	53.0	Coulston and Kolbye 1994
1,2-Dichlorobenzene	rat	0.35	chronic	oral (gavage)	liver/kidney	429	85.7	Coulston and Kolbye 1994
1,3-Dichlorobenzene	rat	0.35	chronic	oral (gavage)	liver/kidney	429	85.7	Coulston and Kolbye 1994
1,4-Dichlorobenzene	rat	0.35	GD 6-15	oral (gavage)	developmental	500	250	ATSDR 1998a
Dioxins/Furans								
Dioxin/furan (TEQ) - Mammal (ind)	rat	0.35	3 generations	oral in diet	reproduction	0.00001	0.000001	Sample et al. 1996

Notes:

Where two values are presented for the same chemical, the more appropriate test organism was used for a given receptor (e.g., arsenic: mouse for deer mouse and shrew, dog for red fox)

TABLE 3

Ingestion Screening Values for Birds

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference
Inorganics								
Arsenic	brown-headed cowbird	0.049	7 months	oral in diet	survival	7.38	2.46	Sample et al. 1996
Arsenic	mallard	1.00	128 days	oral in diet	survival	12.8	5.14	Sample et al. 1996
Cadmium	mallard	1.15	90 days	oral in diet	reproduction	20.0	1.45	Sample et al. 1996
Chromium	American black duck	1.25	10 months	oral in diet	reproduction	5.00	1.00	Sample et al. 1996
Copper	chicken (chicks)	0.534	10 weeks	oral in diet	growth/survival	61.7	47.0	Sample et al. 1996
Lead	Japanese quail	0.15	12 weeks	oral in diet	reproduction	11.3	1.13	Sample et al. 1996
Lead	American kestrel	0.13	7 months	oral in diet	reproduction	19.3	3.85	Sample et al. 1996
Mercury	red-tailed hawk	1.10	12 weeks	oral in diet	survival/neurological	1.20	0.49	USEPA 1995b
Mercury	Japanese quail	0.15	1 year	oral in diet	reproduction	0.90	0.45	Sample et al. 1996
Mercury	mallard	1.00	3 generations	oral in diet	reproduction	0.078	0.026	USEPA 1997b
Nickel	mallard	0.782	90 days	oral in diet	growth/survival	107	77.4	Sample et al. 1996
Selenium	black-crowned night-heron	0.88	94 days	oral in diet	reproduction	9.00	1.80	Sample et al. 1996
Selenium	mallard	1.00	100 days	oral in diet	reproduction	0.80	0.40	Sample et al. 1996
Selenium	screech owl	0.20	13.7 weeks	oral in diet	reproduction	1.50	0.44	Sample et al. 1996
Silver	mallard	1.10	14 days	oral in diet	survival	178	35.6	USEPA 1999
Silver	chicken (chicks)	0.80	not specified	oral in diet	growth	35.0	7.00	Eisler 1996
Zinc	chicken	1.94	44 weeks	oral in diet	reproduction	131	14.5	Sample et al. 1996
Pesticides/PCBs								
4,4'-DDD	Japanese quail	0.11	3 generations	oral in diet	reproduction	5.00	0.50	USEPA 1995b
4,4'-DDD	barn owl	0.47	2 years	oral in diet	reproduction	0.40	0.08	Blus 1996
4,4'-DDD	mallard	1.00	2 years	oral in diet	reproduction	0.60	0.12	USEPA 1995b
4,4'-DDD	bald eagle	4.74	112 days	oral in diet	survival	3.00	0.30	USEPA 1995b
4,4'-DDE	Japanese quail	0.11	3 generations	oral in diet	reproduction	5.00	0.50	USEPA 1995b
4,4'-DDE	barn owl	0.47	2 years	oral in diet	reproduction	0.40	0.08	Blus 1996
4,4'-DDE	mallard	1.00	2 years	oral in diet	reproduction	0.60	0.12	USEPA 1995b
4,4'-DDE	bald eagle	4.74	112 days	oral in diet	survival	3.00	0.30	USEPA 1995b
4,4'-DDT	Japanese quail	0.11	3 generations	oral in diet	reproduction	5.00	0.50	USEPA 1995b
4,4'-DDT	barn owl	0.47	2 years	oral in diet	reproduction	0.40	0.08	Blus 1996
4,4'-DDT	mallard	1.00	2 years	oral in diet	reproduction	1.50	0.60	USEPA 1995b
4,4'-DDT	bald eagle	4.74	112 days	oral in diet	survival	3.00	0.30	USEPA 1995b
Aldrin	ring-necked pheasant	1.14	5 days	oral in diet	survival	0.35	0.07	Hill et al. 1975

TABLE 3

Ingestion Screening Values for Birds

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference
Aldrin	mallard	1.00	5 days	oral in diet	survival	0.78	0.16	Hill et al. 1975
alpha-BHC	Japanese quail	0.15	90 days	oral in diet	reproduction	2.25	0.56	Sample et al. 1996
alpha-Chlordane	red-winged blackbird	0.064	84 days	oral in diet	survival	10.7	2.14	Sample et al. 1996
alpha-Chlordane	northern bobwhite	0.19	not specified	oral in diet	reproduction	5.95	1.19	Wiemeyer 1996
alpha-Chlordane	mallard	1.00	not specified	oral in diet	reproduction	4.00	0.80	Wiemeyer 1996
Aroclor-1016	ring-necked pheasant	1.00	17 weeks	oral	reproduction	1.80	0.36	Sample et al. 1996
Aroclor-1016	screech owl	0.181	2 generations	oral in diet	reproduction	2.05	0.41	Sample et al. 1996
Aroclor-1016	mallard	1.00	1 month	oral in diet	reproduction	7.50	1.50	USEPA 1995b
Aroclor-1221	ring-necked pheasant	1.00	17 weeks	oral	reproduction	1.80	0.36	Sample et al. 1996
Aroclor-1221	screech owl	0.181	2 generations	oral in diet	reproduction	2.05	0.41	Sample et al. 1996
Aroclor-1221	mallard	1.00	1 month	oral in diet	reproduction	7.50	1.50	USEPA 1995b
Aroclor-1232	ring-necked pheasant	1.00	17 weeks	oral	reproduction	1.80	0.36	Sample et al. 1996
Aroclor-1232	screech owl	0.181	2 generations	oral in diet	reproduction	2.05	0.41	Sample et al. 1996
Aroclor-1232	mallard	1.00	1 month	oral in diet	reproduction	7.50	1.50	USEPA 1995b
Aroclor-1242	ring-necked pheasant	1.00	17 weeks	oral	reproduction	1.80	0.36	Sample et al. 1996
Aroclor-1242	screech owl	0.181	2 generations	oral in diet	reproduction	2.05	0.41	Sample et al. 1996
Aroclor-1242	mallard	1.00	1 month	oral in diet	reproduction	7.50	1.50	USEPA 1995b
Aroclor-1248	ring-necked pheasant	1.00	17 weeks	oral	reproduction	1.80	0.36	Sample et al. 1996
Aroclor-1248	screech owl	0.181	2 generations	oral in diet	reproduction	2.05	0.41	Sample et al. 1996
Aroclor-1248	mallard	1.00	1 month	oral in diet	reproduction	7.50	1.50	USEPA 1995b
Aroclor-1254	ring-necked pheasant	1.00	17 weeks	oral	reproduction	1.80	0.36	Sample et al. 1996
Aroclor-1254	screech owl	0.181	2 generations	oral in diet	reproduction	2.05	0.41	Sample et al. 1996
Aroclor-1254	mallard	1.00	1 month	oral in diet	reproduction	7.50	1.50	USEPA 1995b
Aroclor-1260	ring-necked pheasant	1.00	17 weeks	oral	reproduction	1.80	0.36	Sample et al. 1996
Aroclor-1260	screech owl	0.181	2 generations	oral in diet	reproduction	2.05	0.41	Sample et al. 1996
Aroclor-1260	mallard	1.00	1 month	oral in diet	reproduction	7.50	1.50	USEPA 1995b
beta-BHC	Japanese quail	0.15	90 days	oral in diet	reproduction	2.25	0.56	Sample et al. 1996
delta-BHC	Japanese quail	0.15	90 days	oral in diet	reproduction	2.25	0.56	Sample et al. 1996
Dieldrin	barn owl	0.466	2 years	oral in diet	reproduction	0.39	0.08	Sample et al. 1996
Endosulfan I	gray partridge	0.40	4 weeks	oral in diet	reproduction	50.0	10.0	Sample et al. 1996
Endosulfan II	gray partridge	0.40	4 weeks	oral in diet	reproduction	50.0	10.0	Sample et al. 1996
Endrin	mallard	1.15	>200 days	oral in diet	reproduction	1.50	0.30	Sample et al. 1996

TABLE 3

Ingestion Screening Values for Birds

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference
Endrin	screech owl	0.181	>83 days	oral in diet	reproduction	0.10	0.02	Sample et al. 1996
gamma-BHC (Lindane)	mallard	1.00	8 weeks	oral (gavage)	reproduction	20.0	4.00	Sample et al. 1996
gamma-Chlordane	red-winged blackbird	0.064	84 days	oral in diet	survival	10.7	2.14	Sample et al. 1996
gamma-Chlordane	northern bobwhite	0.19	not specified	oral in diet	reproduction	5.95	1.19	Wiemeyer 1996
gamma-Chlordane	mallard	1.00	not specified	oral in diet	reproduction	4.00	0.80	Wiemeyer 1996
Heptachlor	ring-necked pheasant	1.14	5 days	oral in diet	survival	1.38	0.28	Hill et al. 1975
Heptachlor	mallard	1.00	5 days	oral in diet	survival	2.40	0.48	Hill et al. 1975
Heptachlor epoxide	ring-necked pheasant	1.14	5 days	oral in diet	survival	1.38	0.28	Hill et al. 1975
Heptachlor epoxide	mallard	1.00	5 days	oral in diet	survival	2.40	0.48	Hill et al. 1975
Methoxychlor	chicken	1.50	16 weeks	oral in diet	reproduction	1,775	355	Wiemeyer 1996
Toxaphene	American black duck	1.00	2 seasons	oral in diet	reproduction	5.00	1.00	Wiemeyer 1996
Semivolatile Organics								
4-Bromophenyl-phenylether	--	--	--	--	--	NA	NA	--
4-Chlorophenyl-phenylether	--	--	--	--	--	NA	NA	--
Acenaphthene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Acenaphthylene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Anthracene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Benzo(a)anthracene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Benzo(a)pyrene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Benzo(b)fluoranthene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Benzo(g,h,i)perylene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Benzo(k)fluoranthene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Chrysene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Dibenz(a,h)anthracene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Fluoranthene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Fluorene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Hexachlorobenzene	Japanese quail	0.15	90 days	oral in diet	reproduction	0.565	0.113	Coulston and Kolbye 1994; TERRETOX 2002
Hexachlorobutadiene	Japanese quail	0.15	90 days	oral in diet	reproduction	17.0	3.39	Coulston and Kolbye 1994; TERRETOX 2002
Hexachlorocyclopentadiene	--	--	--	--	--	NA	NA	--
Hexachloroethane	--	--	--	--	--	NA	NA	--

TABLE 3

Ingestion Screening Values for Birds

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference
Indeno(1,2,3-cd)pyrene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Pentachlorophenol	chicken	1.50	8 weeks	oral in diet	systemic/growth	8.52	4.26	Eisler 1989
Phenanthrene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Pyrene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Volatile Organics								
1,1,2,2-Tetrachloroethane	--	--	--	--	--	NA	NA	--
1,2,4-Trichlorobenzene	northern bobwhite	0.19	14 days	oral	survival	161	32.2	TERRETOX 2002
1,2-Dichlorobenzene	northern bobwhite	0.19	14 days	oral	survival	161	32.2	TERRETOX 2002
1,3-Dichlorobenzene	northern bobwhite	0.19	14 days	oral	survival	161	32.2	TERRETOX 2002
1,4-Dichlorobenzene	northern bobwhite	0.19	14 days	oral	survival	161	32.2	TERRETOX 2002
Dioxins/Furans								
Dioxin/furan (TEQ) - Bird (ind)	ring-necked pheasant	1.00	10 weeks	injection	reproduction	0.00014	0.000014	Sample et al. 1996

Notes:

Where two values are presented for the same chemical, the more appropriate test organism was used for a given receptor (e.g., arsenic: cowbird for robin, mallard for spotted sandpiper)

TABLE 4

Exposure Parameters for Upper Trophic Level Ecological Receptors - Step 2

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Receptor	Body Weight (kg)		Water Ingestion Rate (L/day)		Food Ingestion Rate (kg/day - dry)	
	Value	Reference	Value	Reference	Value	Reference
Birds						
American woodcock	0.145	Dunning 1993	0.0233	allometric equation	0.0292	USEPA 1993
Great blue heron	2.10	Butler 1992	0.1090	allometric equation	0.4389	allometric equation
Eastern screech owl	0.145	Dunning 1993	0.0216	allometric equation	0.0219	allometric equation
Spotted sandpiper	0.029	Dunning 1993	0.0089	allometric equation	0.0093	allometric equation
Mammals						
Muskrat	0.750	USEPA 1993	0.1426	allometric equation	0.0765	USEPA 1993a
Raccoon	4.23	Silva and Downing 1995	0.6092	allometric equation	0.1166	Conover 1989
Red fox	3.17	Silva and Downing 1995	0.4115	allometric equation	0.1476	Sample and Suter 1994
Short-tailed shrew	0.013	USEPA 1993	0.0048	USEPA 1993a	0.0019	USEPA 1993

TABLE 5

Exposure Parameters for Upper Trophic Level Ecological Receptors - Step 2

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Receptor	Dietary Composition (percent)							Soil/ Sediment Ingestion (percent)	
	Terr. Plants	Soil Invert.	Small Mammals	Fish/ Frogs	Aquatic Plants	Benthic Invert.	Reference	Value	Reference
Birds									
American woodcock	0	89.6	0	0	0	0	USEPA 1993	10.4	Beyer et al. 1994
Great blue heron	0	0	0	100	0	0	USEPA 1993a; Quinney and Smith 1980	0	Sample and Suter 1994
Eastern screech owl	0	28	70	0	0	0	Johnsgard 1988	2	Assumed based on diet
Spotted sandpiper	0	0	0	0	0	82.0	USEPA 1993	18.0	Beyer et al. 1994
Mammals									
Muskrat	0	0	0	0	90.6	0.0	USEPA 1993a	9.4	Beyer et al. 1994 (raccoon)
Raccoon	0	0	0	25.0	40.6	25	Assumed 100% aquatic diet for conservatism	9.4	Beyer et al. 1994
Red fox	7.0	2.8	87.4	0	0	0	USEPA 1993	2.8	Beyer et al. 1994
Short-tailed shrew	4.7	82.3	0	0	0	0	USEPA 1993; Sample and Suter 1994	13.0	Sample and Suter 1994

TABLE 6
Soil Bioconcentration Factors For Plants, Soil Invertebrates, and Small Mammals - Step 2
Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)		Soil-Mouse BAF (dry weight)	
	Value	Reference	Value	Reference	Value	Reference
Inorganics						
Arsenic	0.038	USEPA 2007	Regression	USEPA 2007	Regression	USEPA 2007
Cadmium	Regression	USEPA 2007	Regression	USEPA 2007	Regression	USEPA 2007
Chromium	Regression	USEPA 2007	0.306	USEPA 2007	Regression	USEPA 2007
Copper	Regression	USEPA 2007	0.515	USEPA 2007	Regression	USEPA 2007
Lead	Regression	USEPA 2007	Regression	USEPA 2007	Regression	USEPA 2007
Mercury	5.0	Bechtel Jacobs 1998	20.63	Sample et al. 1998a	0.130	Sample et al. 1998b
Nickel	Regression	USEPA 2007	4.730	Sample et al. 1998a	Regression	USEPA 2007
Selenium	Regression	USEPA 2007	Regression	USEPA 2007	Regression	USEPA 2007
Silver	0.014	USEPA 2007	2.05	Sample et al. 1998a	0.004	USEPA 2007
Zinc	Regression	USEPA 2007	Regression	USEPA 2007	Regression	USEPA 2007
Pesticides/PCBs						
4,4'-DDD	0.2024	USEPA 2007	Regression	USEPA 2007	--	see text
4,4'-DDE	0.1093	USEPA 2007	Regression	USEPA 2007	--	see text
4,4'-DDT	0.1354	USEPA 2007	Regression	USEPA 2007	--	see text
Aldrin	0.4100	USEPA 2007	14.70	USEPA 2007 (diedrin value)	--	see text
alpha-BHC	1.7352	USEPA 2007	1.00	--	--	see text
alpha-Chlordane	0.1648	USEPA 2007	4.00	Edwards and Bohlen 1992	--	see text
Aroclor-1016	0.3229	USEPA 2007	15.9	Sample et al. 1998a	--	see text
Aroclor-1221	0.7485	USEPA 2007	15.9	Sample et al. 1998a	--	see text
Aroclor-1232	0.5151	USEPA 2007	15.9	Sample et al. 1998a	--	see text
Aroclor-1242	0.3229	USEPA 2007	15.9	Sample et al. 1998a	--	see text
Aroclor-1248	0.1844	USEPA 2007	15.9	Sample et al. 1998a	--	see text
Aroclor-1254	0.1393	USEPA 2007	15.9	Sample et al. 1998a	--	see text
Aroclor-1260	0.1053	USEPA 2007	15.9	Sample et al. 1998a	--	see text
beta-BHC	1.7190	USEPA 2007	1.00	--	--	see text
delta-BHC	1.3111	USEPA 2007	1.00	--	--	see text
Dieldrin	0.4100	USEPA 2007	14.70	USEPA 2007	--	see text
Endosulfan I	1.6872	USEPA 2007	1.00	--	--	see text
Endosulfan II	0.8856	USEPA 2007	1.00	--	--	see text
Endrin	0.4100	USEPA 2007 (dieldrin value)	14.70	USEPA 2007 (diedrin value)	--	see text
gamma-BHC (Lindane)	1.8524	USEPA 2007	1.00	--	--	see text

TABLE 6
Soil Bioconcentration Factors For Plants, Soil Invertebrates, and Small Mammals - Step 2
Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)		Soil-Mouse BAF (dry weight)	
	Value	Reference	Value	Reference	Value	Reference
gamma-Chlordane	0.1648	USEPA 2007	4.00	Edwards and Bohlen 1992	--	see text
Heptachlor	0.1743	USEPA 2007	3.00	Edwards and Bohlen 1992	--	see text
Heptachlor epoxide	0.5656	USEPA 2007	8.39	USEPA 1999	--	see text
Methoxychlor	0.5249	USEPA 2007	1.00	--	--	see text
Toxaphene	0.3545	USEPA 2007	1.00	--	--	see text
Semivolatile Organics						
4-Bromophenyl-phenylether	0.5656	USEPA 2007	1.00	--	--	see text
4-Chlorophenyl-phenylether	0.5926	USEPA 2007	1.00	--	--	see text
Acenaphthene	Regression	USEPA 2007	3.04	USEPA 2007	--	see text
Acenaphthylene	Regression	USEPA 2007	1.47	USEPA 2007	--	see text
Anthracene	Regression	USEPA 2007	2.42	USEPA 2007	--	see text
Benzo(a)anthracene	Regression	USEPA 2007	1.59	USEPA 2007	--	see text
Benzo(a)pyrene	Regression	USEPA 2007	1.33	USEPA 2007	--	see text
Benzo(b)fluoranthene	0.3100	USEPA 2007	2.60	USEPA 2007	--	see text
Benzo(g,h,i)perylene	Regression	USEPA 2007	2.94	USEPA 2007	--	see text
Benzo(k)fluoranthene	Regression	USEPA 2007	2.60	USEPA 2007	--	see text
Chrysene	Regression	USEPA 2007	2.29	USEPA 2007	--	see text
Dibenz(a,h)anthracene	0.1300	USEPA 2007	2.31	USEPA 2007	--	see text
Fluoranthene	0.5000	USEPA 2007	3.04	USEPA 2007	--	see text
Fluorene	Regression	USEPA 2007	9.57	USEPA 2007	--	see text
Hexachlorobenzene	0.2463	USEPA 2007	1.69	Beyer 1996	--	see text
Hexachlorobutadiene	0.6754	USEPA 2007	1.00	--	--	see text
Hexachlorocyclopentadiene	0.3929	USEPA 2007	1.00	--	--	see text
Hexachloroethane	1.4395	USEPA 2007	1.00	--	--	see text
Indeno(1,2,3-cd)pyrene	0.1100	USEPA 2007	2.86	USEPA 2007	--	see text
Pentachlorophenol	0.5200	USEPA 2007	14.63	USEPA 2007	--	see text
Phenanthrene	Regression	USEPA 2007	1.72	USEPA 2007	--	see text
Pyrene	0.7200	USEPA 2007	1.75	USEPA 2007	--	see text
Volatile Organics						
1,1,2,2-Tetrachloroethane	6.4770	USEPA 2007	1.00	--	--	see text
1,2,4-Trichlorobenzene	1.4261	USEPA 2007	0.56	Beyer 1996	--	see text
1,2-Dichlorobenzene	2.4516	USEPA 2007	1.00	--	--	see text

TABLE 6

Soil Bioconcentration Factors For Plants, Soil Invertebrates, and Small Mammals - Step 2

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)		Soil-Mouse BAF (dry weight)	
	Value	Reference	Value	Reference	Value	Reference
1,3-Dichlorobenzene	2.2964	USEPA 2007	1.00	--	--	see text
1,4-Dichlorobenzene	2.4746	USEPA 2007	1.00	--	--	see text
Dioxin/Furans						
2,3,7,8-TCDD	5.60E-03	USEPA 1999	1.59E+00	USEPA 1999	7.81E-05	USEPA 1999
1,2,3,7,8-PCDD	5.20E-03	USEPA 1999	1.46E+00	USEPA 1999	7.19E-05	USEPA 1999
1,2,3,4,7,8-HxCDD	1.70E-03	USEPA 1999	4.90E-01	USEPA 1999	2.42E-05	USEPA 1999
1,2,3,6,7,8-HxCDD	6.70E-04	USEPA 1999	1.90E-01	USEPA 1999	9.37E-06	USEPA 1999
1,2,3,7,8,9-HxCDD*	7.80E-04	USEPA 1999	2.20E-01	USEPA 1999	1.09E-05	USEPA 1999
1,2,3,4,6,7,8-HpCDD	2.90E-04	USEPA 1999	8.10E-02	USEPA 1999	3.98E-06	USEPA 1999
OCDD*	6.70E-05	USEPA 1999	1.90E-02	USEPA 1999	9.37E-07	USEPA 1999
2,3,7,8-TCDF	4.50E-03	USEPA 1999	1.27E+00	USEPA 1999	6.25E-05	USEPA 1999
1,2,3,7,8-PCDF	1.10E-03	USEPA 1999	3.20E-01	USEPA 1999	1.72E-05	USEPA 1999
2,3,4,7,8-PCDF	9.00E-03	USEPA 1999	2.54E+00	USEPA 1999	1.25E-04	USEPA 1999
1,2,3,4,7,8-HxCDF	4.30E-04	USEPA 1999	1.21E-01	USEPA 1999	5.94E-06	USEPA 1999
1,2,3,6,7,8-HxCDF*	1.10E-03	USEPA 1999	3.00E-01	USEPA 1999	1.48E-05	USEPA 1999
2,3,4,6,7,8-HxCDF*	3.80E-03	USEPA 1999	1.07E+00	USEPA 1999	5.23E-05	USEPA 1999
1,2,3,7,8,9-HxCDF*	3.50E-03	USEPA 1999	1.00E+00	USEPA 1999	4.92E-05	USEPA 1999
1,2,3,4,6,7,8-HpCDF*	6.20E-05	USEPA 1999	1.70E-02	USEPA 1999	8.59E-07	USEPA 1999
1,2,3,4,7,8,9-HpCDF*	2.20E-03	USEPA 1999	6.20E-01	USEPA 1999	3.05E-05	USEPA 1999
OCDF*	9.00E-05	USEPA 1999	2.50E-02	USEPA 1999	1.25E-06	USEPA 1999

TABLE 7

Sediment Bioaccumulation Factors For Benthic Invertebrates and Plants - Step 2

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Sediment-Plant BCF (dry weight)		Sediment-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Inorganics				
Arsenic	1.103	Bechtel Jacobs 1998a	0.690	Bechtel Jacobs 1998b
Cadmium	3.250	Bechtel Jacobs 1998a	3.073	Bechtel Jacobs 1998b
Chromium	0.084	Bechtel Jacobs 1998a	0.186	Bechtel Jacobs 1998b
Copper	0.625	Bechtel Jacobs 1998a	7.957	Bechtel Jacobs 1998b
Lead	0.468	Bechtel Jacobs 1998a	0.326	Bechtel Jacobs 1998b
Mercury	5.000	Bechtel Jacobs 1998a	2.868	Bechtel Jacobs 1998b
Nickel	1.411	Bechtel Jacobs 1998a	0.214	Bechtel Jacobs 1998b
Selenium	3.012	Bechtel Jacobs 1998a	1.000	--
Silver	0.037	Bechtel Jacobs 1998a	0.180	Hirsch 1998
Zinc	1.820	Bechtel Jacobs 1998a	4.759	Bechtel Jacobs 1998b
Pesticides/PCBs				
4,4'-DDD	0.0151	Travis and Arms 1988	0.350	Oliver and Niimi 1988
4,4'-DDE	0.0216	Travis and Arms 1988	3.360	Oliver and Niimi 1988
4,4'-DDT	0.0237	Travis and Arms 1988	2.280	Oliver and Niimi 1988
Aldrin	0.0431	Travis and Arms 1988	1.000	--
alpha-BHC	0.2633	Travis and Arms 1988	1.000	--
alpha-Chlordane	0.0172	Travis and Arms 1988	1.000	--
Aroclor-1016	0.0224	Travis and Arms 1988	21.89	Bechtel Jacobs 1998b
Aroclor-1221	0.0744	Travis and Arms 1988	21.89	Bechtel Jacobs 1998b
Aroclor-1232	0.0437	Travis and Arms 1988	21.89	Bechtel Jacobs 1998b
Aroclor-1242	0.0224	Travis and Arms 1988	21.89	Bechtel Jacobs 1998b
Aroclor-1248	0.0101	Travis and Arms 1988	21.89	Bechtel Jacobs 1998b
Aroclor-1254	0.0068	Travis and Arms 1988	21.89	Bechtel Jacobs 1998b
Aroclor-1260	0.0045	Travis and Arms 1988	21.89	Bechtel Jacobs 1998b
beta-BHC	0.2633	Travis and Arms 1988	1.000	--
delta-BHC	0.1653	Travis and Arms 1988	1.000	--
Dieldrin	0.3089	Travis and Arms 1988	4.520	Standley 1997
Endosulfan I	0.3436	Travis and Arms 1988	1.000	--
Endosulfan II	0.3131	Travis and Arms 1988	1.000	--
Endrin	0.7948	Travis and Arms 1988	1.000	--
gamma-BHC (Lindane)	0.3173	Travis and Arms 1988	1.000	--
gamma-Chlordane	0.0172	Travis and Arms 1988	1.000	--
Heptachlor	0.0548	Travis and Arms 1988	1.000	--

TABLE 7
Sediment Bioaccumulation Factors For Benthic Invertebrates and Plants - Step 2
Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Sediment-Plant BCF (dry weight)		Sediment-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Heptachlor epoxide	0.3673	Travis and Arms 1988	1.000	--
Methoxychlor	0.1447	Travis and Arms 1988	1.000	--
Toxaphene	0.1217	Travis and Arms 1988	1.000	--
Semivolatile Organics				
4-Bromophenyl-phenylether	0.0578	Travis and Arms 1988	1.000	--
4-Chlorophenyl-phenylether	0.1697	Travis and Arms 1988	1.000	--
Acenaphthene	0.2564	Travis and Arms 1988	2.040	Maruya et al. 1997
Acenaphthylene	0.1653	Travis and Arms 1988	2.040	Acenaphthene value
Anthracene	0.1051	Travis and Arms 1988	0.271	Maruya et al. 1997
Benzo(a)anthracene	0.0222	Travis and Arms 1988	1.400	Maruya et al. 1997
Benzo(a)pyrene	0.0135	Travis and Arms 1988	0.191	Maruya et al. 1997
Benzo(b)fluoranthene	0.0174	Travis and Arms 1988	0.160	Maruya et al. 1997
Benzo(g,h,i)perylene	0.0061	Travis and Arms 1988	0.295	Maruya et al. 1997
Benzo(k)fluoranthene	0.0112	Travis and Arms 1988	0.421	Maruya et al. 1997
Chrysene	0.0289	Travis and Arms 1988	0.335	Maruya et al. 1997
Dibenz(a,h)anthracene	0.0068	Travis and Arms 1988	0.271	Anthracene value
Fluoranthene	0.0617	Travis and Arms 1988	0.312	Maruya et al. 1997
Fluorene	0.1790	Travis and Arms 1988	1.130	Maruya et al. 1997
Hexachlorobenzene	0.0367	Travis and Arms 1988	0.860	Oliver and Niimi 1988
Hexachlorobutadiene	0.0705	Travis and Arms 1988	0.610	Oliver and Niimi 1988
Hexachlorocyclopentadiene	0.0467	Travis and Arms 1988	1.000	--
Hexachloroethane	0.2399	Travis and Arms 1988	1.000	--
Indeno(1,2,3-cd)pyrene	0.0061	Travis and Arms 1988	0.355	Maruya et al. 1997
Pentachlorophenol	0.0492	Travis and Arms 1988	1.000	--
Phenanthrene	0.1154	Travis and Arms 1988	0.652	Maruya et al. 1997
Pyrene	0.0687	Travis and Arms 1988	0.803	Maruya et al. 1997
Volatile Organics				
1,1,2,2-Tetrachloroethane	1.7899	Travis and Arms 1988	1.000	--
1,2,4-Trichlorobenzene	0.2186	Travis and Arms 1988	0.480	Oliver and Niimi 1988
1,2-Dichlorobenzene	0.5475	Travis and Arms 1988	1.000	--
1,3-Dichlorobenzene	0.3673	Travis and Arms 1988	1.000	--
1,4-Dichlorobenzene	0.5055	Travis and Arms 1988	1.000	--

TABLE 8

Sediment Bioaccumulation Factors For Frogs and Fish - Step 2

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Sediment-Frog BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference
Inorganics				
Arsenic	0.126	Pascoe et al. 1996	0.126	Pascoe et al. 1996
Cadmium	0.164	Pascoe et al. 1996	0.164	Pascoe et al. 1996
Chromium	0.038	Krantzberg and Boyd 1992	0.038	Krantzberg and Boyd 1992
Copper	0.100	Krantzberg and Boyd 1992	0.100	Krantzberg and Boyd 1992
Lead	0.070	Krantzberg and Boyd 1992	0.070	Krantzberg and Boyd 1992
Mercury	4.580	Cope et al. 1990	4.580	Cope et al. 1990
Nickel	1.000	--	1.000	--
Selenium	1.000	--	1.000	--
Silver	1.000	--	1.000	--
Zinc	0.147	Pascoe et al. 1996	0.147	Pascoe et al. 1996
Pesticides/PCBs				
4,4'-DDD	2.250	Oliver and Niimi 1988	2.250	Oliver and Niimi 1988
4,4'-DDE	26.20	Oliver and Niimi 1988	26.20	Oliver and Niimi 1988
4,4'-DDT	8.800	Oliver and Niimi 1988	8.800	Oliver and Niimi 1988
Aldrin	1.000	--	1.000	--
alpha-BHC	1.000	--	1.000	--
alpha-Chlordane	1.000	--	1.000	--
Aroclor-1016	12.94	Oliver and Niimi 1988	12.94	Oliver and Niimi 1988
Aroclor-1221	12.94	Oliver and Niimi 1988	12.94	Oliver and Niimi 1988
Aroclor-1232	12.94	Oliver and Niimi 1988	12.94	Oliver and Niimi 1988
Aroclor-1242	12.94	Oliver and Niimi 1988	12.94	Oliver and Niimi 1988
Aroclor-1248	12.94	Oliver and Niimi 1988	12.94	Oliver and Niimi 1988
Aroclor-1254	12.94	Oliver and Niimi 1988	12.94	Oliver and Niimi 1988
Aroclor-1260	12.94	Oliver and Niimi 1988	12.94	Oliver and Niimi 1988
beta-BHC	1.000	--	1.000	--
delta-BHC	1.000	--	1.000	--
Dieldrin	1.000	--	1.000	--
Endosulfan I	1.000	--	1.000	--
Endosulfan II	1.000	--	1.000	--
Endrin	1.000	--	1.000	--
gamma-BHC (Lindane)	6.200	Oliver and Niimi 1988	6.200	Oliver and Niimi 1988
gamma-Chlordane	1.000	--	1.000	--

TABLE 8
Sediment Bioaccumulation Factors For Frogs and Fish - Step 2
Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Sediment-Frog BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference
Heptachlor	1.000	--	1.000	--
Heptachlor epoxide	1.000	--	1.000	--
Methoxychlor	1.000	--	1.000	--
Toxaphene	1.000	--	1.000	--
Semivolatile Organics				
4-Bromophenyl-phenylether	1.000	--	1.000	--
4-Chlorophenyl-phenylether	1.000	--	1.000	--
Acenaphthene	1.000	--	1.000	--
Acenaphthylene	1.000	--	1.000	--
Anthracene	1.000	--	1.000	--
Benzo(a)anthracene	1.000	--	1.000	--
Benzo(a)pyrene	1.000	--	1.000	--
Benzo(b)fluoranthene	1.000	--	1.000	--
Benzo(g,h,i)perylene	1.000	--	1.000	--
Benzo(k)fluoranthene	1.000	--	1.000	--
Chrysene	1.000	--	1.000	--
Dibenz(a,h)anthracene	1.000	--	1.000	--
Fluoranthene	1.000	--	1.000	--
Fluorene	1.000	--	1.000	--
Hexachlorobenzene	0.940	Oliver and Niimi 1988	0.940	Oliver and Niimi 1988
Hexachlorobutadiene	0.384	Parkerton et al. 1993	0.384	Parkerton et al. 1993
Hexachlorocyclopentadiene	1.000	--	1.000	--
Hexachloroethane	1.000	--	1.000	--
Indeno(1,2,3-cd)pyrene	1.000	--	1.000	--
Pentachlorophenol	1.000	--	1.000	--
Phenanthrene	1.000	--	1.000	--
Pyrene	1.000	--	1.000	--
Volatile Organics				
1,1,2,2-Tetrachloroethane	1.000	--	1.000	--
1,2,4-Trichlorobenzene	0.074	Parkerton et al. 1993	0.074	Parkerton et al. 1993
1,2-Dichlorobenzene	0.085	Parkerton et al. 1993	0.085	Parkerton et al. 1993
1,3-Dichlorobenzene	0.085	Parkerton et al. 1993	0.085	Parkerton et al. 1993
1,4-Dichlorobenzene	0.085	Parkerton et al. 1993	0.085	Parkerton et al. 1993

TABLE 9

Toxicity Equivalence Factors Used for Dioxin and Furan Compounds

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

AnalyteName	Mammalian TEF[1]	Avian TEF[1]
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	0.01	<0.001
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.01	0.01
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.01	0.01
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	0.1	0.05
1,2,3,4,7,8-Hexachlorodibenzofuran	0.1	0.1
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	0.1	0.01
1,2,3,6,7,8-Hexachlorodibenzofuran	0.1	0.1
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	0.1	0.1
1,2,3,7,8,9-Hexachlorodibenzofuran	0.1	0.1
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1	1
1,2,3,7,8-Pentachlorodibenzofuran	0.03	0.1
2,3,4,6,7,8-Hexachlorodibenzofuran	0.1	0.1
2,3,4,7,8-Pentachlorodibenzofuran	0.5	1
2,3,7,8-TCDD (dioxin)	1	1
2,3,7,8-Tetrachlorodibenzofuran	0.1	1
Octachlorodibenzo-p-dioxin	0.0003	0.0001
Octachlorodibenzofuran	0.0003	0.0001

1 - TEFs from van den Berg et al (2006) and WHO (2007) for individual congeners

TABLE 10

Exposure Parameters for Upper Trophic Level Ecological Receptors - Step 3

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Receptor	Body Weight (kg)		Water Ingestion Rate (L/day)		Food Ingestion Rate (kg/day - dry)	
	Value	Reference	Value	Reference	Value	Reference
Birds						
American woodcock	0.198	Dunning 1993	0.0199	allometric equation	0.0231	USEPA 1993a
Great blue heron	2.23	Quinney 1982	0.1010	allometric equation	0.3931	allometric equation
Eastern screech owl	0.18	Dunning 1993	0.0188	allometric equation	0.0191	allometric equation
Spotted sandpiper	0.040	Dunning 1993	0.0069	allometric equation	0.0072	allometric equation
Mammals						
Muskrat	1.169	Silva and Downing 1995	0.1139	allometric equation	0.0596	USEPA 1993a
Raccoon	5.94	Silva and Downing 1995	0.4921	allometric equation	0.0920	Conover 1989
Red fox	4.06	Silva and Downing 1995	0.3494	allometric equation	0.1231	Sample and Suter 1994
Short-tailed shrew	0.017	USEPA 1993a	0.0038	USEPA 1993a	0.0015	USEPA 1993a

TABLE 11

Exposure Parameters for Upper Trophic Level Ecological Receptors - Step 3

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Receptor	Dietary Composition (percent)							Soil/ Sediment Ingestion (percent)	
	Terr. Plants	Soil Invert.	Small Mammals	Fish/ Frogs	Aquatic Plants	Benthic Invert.	Reference	Value	Reference
Birds									
American woodcock	0	89.6	0	0	0	0	USEPA 1993a	10.4	Beyer et al. 1994
Great blue heron	0	0	0	100	0	0	USEPA 1993a; Quinney and Smith 1980	0	Sample and Suter 1994
Eastern screech owl	0	28	70	0	0	0	Johnsgard 1988	2	Assumed based on diet
Spotted sandpiper	0	0	0	0	0	82.0	USEPA 1993a	18.0	Beyer et al. 1994
Mammals									
Muskrat	0	0	0	0	90.6	0.0	USEPA 1993a	9.4	Beyer et al. 1994 (raccoon)
Raccoon	0	0	0	25.0	40.6	25	Assumed 100% aquatic diet for conservatism	9.4	Beyer et al. 1994
Red fox	7.0	2.8	87.4	0	0	0	USEPA 1993a	2.8	Beyer et al. 1994
Short-tailed shrew	4.7	82.3	0	0	0	0	USEPA 1993a; Sample and Suter 1994	13.0	Sample and Suter 1994

TABLE 12

Soil Bioconcentration Factors For Plants, Soil Invertebrates, and Small Mammals - Step 3

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)		Soil-Mouse BAF (dry weight)	
	Value	Reference	Value	Reference	Value	Reference
Inorganics						
Arsenic	0.038	USEPA 2007	Regression	USEPA 2007	Regression	USEPA 2007
Cadmium	Regression	USEPA 2007	Regression	USEPA 2007	Regression	USEPA 2007
Chromium	Regression	USEPA 2007	0.306	USEPA 2007	Regression	USEPA 2007
Copper	Regression	USEPA 2007	0.515	USEPA 2007	Regression	USEPA 2007
Lead	Regression	USEPA 2007	Regression	USEPA 2007	Regression	USEPA 2007
Mercury	0.344	Bechtel Jacobs 1998a	1.186	Sample et al. 1998a	0.054	Sample et al. 1998b
Nickel	Regression	USEPA 2007	1.656	Sample et al. 1998a	Regression	USEPA 2007
Selenium	Regression	USEPA 2007	Regression	USEPA 2007	Regression	USEPA 2007
Silver	0.014	USEPA 2007	2.045	Sample et al. 1998a	0.004	USEPA 2007
Zinc	Regression	USEPA 2007	Regression	USEPA 2007	Regression	USEPA 2007
Pesticides/PCBs						
4,4'-DDD	0.2024	USEPA 2007	Regression	USEPA 2007	--	see text
4,4'-DDE	0.1093	USEPA 2007	Regression	USEPA 2007	--	see text
4,4'-DDT	0.1354	USEPA 2007	Regression	USEPA 2007	--	see text
Aldrin	0.4100	USEPA 2007	14.7000	USEPA 2007 (diedrin value)	--	see text
alpha-BHC	1.7352	USEPA 2007	1.0000	--	--	see text
alpha-Chlordane	0.1648	USEPA 2007	4.0000	Edwards and Bohlen 1992	--	see text
Aroclor-1016	0.3229	USEPA 2007	4.2974	Sample et al. 1998a	--	see text
Aroclor-1221	0.7485	USEPA 2007	4.2974	Sample et al. 1998a	--	see text
Aroclor-1232	0.5151	USEPA 2007	4.2974	Sample et al. 1998a	--	see text
Aroclor-1242	0.3229	USEPA 2007	4.2974	Sample et al. 1998a	--	see text
Aroclor-1248	0.1844	USEPA 2007	4.2974	Sample et al. 1998a	--	see text
Aroclor-1254	0.1393	USEPA 2007	4.2974	Sample et al. 1998a	--	see text
Aroclor-1260	0.1053	USEPA 2007	4.2974	Sample et al. 1998a	--	see text
beta-BHC	1.7190	USEPA 2007	1.0000	--	--	see text
delta-BHC	1.3111	USEPA 2007	1.0000	--	--	see text
Dieldrin	0.4100	USEPA 2007	14.7000	USEPA 2007	--	see text
Endosulfan I	1.6872	USEPA 2007	1.0000	--	--	see text
Endosulfan II	0.8856	USEPA 2007	1.0000	--	--	see text
Endrin	0.4100	USEPA 2007 (dieldrin value)	14.7000	USEPA 2007 (diedrin value)	--	see text
gamma-BHC (Lindane)	1.8524	USEPA 2007	1.0000	--	--	see text
gamma-Chlordane	0.1648	USEPA 2007	4.0000	Edwards and Bohlen 1992	--	see text
Heptachlor	0.1743	USEPA 2007	3.0000	Edwards and Bohlen 1992	--	see text

TABLE 12

Soil Bioconcentration Factors For Plants, Soil Invertebrates, and Small Mammals - Step 3

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)		Soil-Mouse BAF (dry weight)	
	Value	Reference	Value	Reference	Value	Reference
Heptachlor epoxide	0.5656	USEPA 2007	8.3900	USEPA 1999	--	see text
Methoxychlor	0.5249	USEPA 2007	1.0000	--	--	see text
Toxaphene	0.3545	USEPA 2007	1.0000	--	--	see text
Semivolatile Organics						
4-Bromophenyl-phenylether	0.5656	USEPA 2007	1.0000	--	--	see text
4-Chlorophenyl-phenylether	0.5926	USEPA 2007	1.0000	--	--	see text
Acenaphthene	Regression	USEPA 2007	3.040	USEPA 2007	--	see text
Acenaphthylene	Regression	USEPA 2007	1.470	USEPA 2007	--	see text
Anthracene	Regression	USEPA 2007	0.320	Beyer and Stafford 1993	--	see text
Benzo(a)anthracene	Regression	USEPA 2007	1.5900	USEPA 2007	--	see text
Benzo(a)pyrene	Regression	USEPA 2007	1.3300	USEPA 2007	--	see text
Benzo(b)fluoranthene	0.3100	USEPA 2007	2.6000	USEPA 2007	--	see text
Benzo(g,h,i)perylene	Regression	USEPA 2007	2.9400	USEPA 2007	--	see text
Benzo(k)fluoranthene	Regression	USEPA 2007	2.6000	USEPA 2007	--	see text
Chrysene	Regression	USEPA 2007	2.2900	USEPA 2007	--	see text
Dibenz(a,h)anthracene	0.1300	USEPA 2007	2.3100	USEPA 2007	--	see text
Fluoranthene	0.5000	USEPA 2007	3.0400	USEPA 2007	--	see text
Fluorene	Regression	USEPA 2007	9.5700	USEPA 2007	--	see text
Hexachlorobenzene	0.2463	USEPA 2007	1.6900	Beyer 1996	--	see text
Hexachlorobutadiene	0.6754	USEPA 2007	1.0000	--	--	see text
Hexachlorocyclopentadiene	0.3929	USEPA 2007	1.0000	--	--	see text
Hexachloroethane	1.4395	USEPA 2007	1.0000	--	--	see text
Indeno(1,2,3-cd)pyrene	0.1100	USEPA 2007	2.8600	USEPA 2007	--	see text
Pentachlorophenol	0.5200	USEPA 2007	14.6300	USEPA 2007	--	see text
Phenanthrene	Regression	USEPA 2007	1.7200	USEPA 2007	--	see text
Pyrene	0.7200	USEPA 2007	1.7500	USEPA 2007	--	see text
Volatile Organics						
1,1,2,2-Tetrachloroethane	6.4770	USEPA 2007	1.0000	--	--	see text
1,2,4-Trichlorobenzene	1.4261	USEPA 2007	0.5600	Beyer 1996	--	see text
1,2-Dichlorobenzene	2.4516	USEPA 2007	1.0000	--	--	see text
1,3-Dichlorobenzene	2.2964	USEPA 2007	1.0000	--	--	see text
1,4-Dichlorobenzene	2.4746	USEPA 2007	1.0000	--	--	see text

TABLE 12

Soil Bioconcentration Factors For Plants, Soil Invertebrates, and Small Mammals - Step 3

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)		Soil-Mouse BAF (dry weight)	
	Value	Reference	Value	Reference	Value	Reference
Dioxin/Furans						
2,3,7,8-TCDD	0.0056	USEPA 1999	1.5900	USEPA 1999	7.81E-05	USEPA 1999
1,2,3,7,8-PCDD	0.0052	USEPA 1999	1.46	USEPA 1999	7.19E-05	USEPA 1999
1,2,3,4,7,8-HxCDD	0.0017	USEPA 1999	0.49	USEPA 1999	2.42E-05	USEPA 1999
1,2,3,6,7,8-HxCDD	0.00067	USEPA 1999	0.19	USEPA 1999	9.37E-06	USEPA 1999
1,2,3,7,8,9-HxCDD*	0.00078	USEPA 1999	0.22	USEPA 1999	1.09E-05	USEPA 1999
1,2,3,4,6,7,8-HpCDD	0.00029	USEPA 1999	0.081	USEPA 1999	3.98E-06	USEPA 1999
OCDD*	0.000067	USEPA 1999	0.019	USEPA 1999	9.37E-07	USEPA 1999
2,3,7,8-TCDF	0.0045	USEPA 1999	1.27	USEPA 1999	6.25E-05	USEPA 1999
1,2,3,7,8-PCDF	0.0011	USEPA 1999	0.32	USEPA 1999	1.72E-05	USEPA 1999
2,3,4,7,8-PCDF	0.009	USEPA 1999	2.54	USEPA 1999	1.25E-04	USEPA 1999
1,2,3,4,7,8-HxCDF	0.00043	USEPA 1999	0.121	USEPA 1999	5.94E-06	USEPA 1999
1,2,3,6,7,8-HxCDF*	0.0011	USEPA 1999	0.3	USEPA 1999	1.48E-05	USEPA 1999
2,3,4,6,7,8-HxCDF*	0.0038	USEPA 1999	1.07	USEPA 1999	5.23E-05	USEPA 1999
1,2,3,7,8,9-HxCDF*	0.0035	USEPA 1999	1	USEPA 1999	4.92E-05	USEPA 1999
1,2,3,4,6,7,8-HpCDF*	0.000062	USEPA 1999	0.017	USEPA 1999	8.59E-07	USEPA 1999
1,2,3,4,7,8,9-HpCDF*	0.0022	USEPA 1999	0.62	USEPA 1999	3.05E-05	USEPA 1999
OCDF*	0.00009	USEPA 1999	0.025	USEPA 1999	1.25E-06	USEPA 1999

TABLE 13

Sediment Bioaccumulation Factors For Benthic Invertebrates and Fish - Step 3

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference
Inorganics				
Arsenic	0.466	Bechtel Jacobs 1998b	0.126	Pascoe et al. 1996
Cadmium	0.679	Bechtel Jacobs 1998b	0.164	Pascoe et al. 1996
Chromium	0.083	Bechtel Jacobs 1998b	0.038	Krantzberg and Boyd 1992
Copper	0.919	Bechtel Jacobs 1998b	0.100	Krantzberg and Boyd 1992
Lead	0.080	Bechtel Jacobs 1998b	0.070	Krantzberg and Boyd 1992
Mercury	1.077	Bechtel Jacobs 1998b	3.250	Cope et al. 1990
Nickel	0.134	Bechtel Jacobs 1998b	1.000	--
Selenium	1.000	--	1.000	--
Silver	0.180	Hirsch 1998	1.000	--
Zinc	0.954	Bechtel Jacobs 1998b	0.147	Pascoe et al. 1996
Pesticides/PCBs				
4,4'-DDD	0.230	Oliver and Niimi 1988	2.250	Oliver and Niimi 1988
4,4'-DDE	2.000	Oliver and Niimi 1988	26.200	Oliver and Niimi 1988
4,4'-DDT	1.300	Oliver and Niimi 1988	8.800	Oliver and Niimi 1988
Aldrin	1.000	--	1.000	--
alpha-BHC	1.000	--	1.000	--
alpha-Chlordane	1.000	--	1.000	--
Aroclor-1016	1.919	Bechtel Jacobs 1998b	12.940	Oliver and Niimi 1988
Aroclor-1221	1.919	Bechtel Jacobs 1998b	12.940	Oliver and Niimi 1988
Aroclor-1232	1.919	Bechtel Jacobs 1998b	12.940	Oliver and Niimi 1988
Aroclor-1242	1.919	Bechtel Jacobs 1998b	12.940	Oliver and Niimi 1988
Aroclor-1248	1.919	Bechtel Jacobs 1998b	12.940	Oliver and Niimi 1988
Aroclor-1254	1.919	Bechtel Jacobs 1998b	12.940	Oliver and Niimi 1988
Aroclor-1260	1.919	Bechtel Jacobs 1998b	12.940	Oliver and Niimi 1988
PCBs (total)	1.919	Bechtel Jacobs 1998b	12.940	Oliver and Niimi 1988
beta-BHC	1.000	--	1.000	--
delta-BHC	1.000	--	1.000	--
Dieldrin	4.520	Standley 1997	1.000	--
Endosulfan I	1.000	--	1.000	--
Endosulfan II	1.000	--	1.000	--
Endrin	1.000	--	1.000	--
gamma-BHC (Lindane)	1.000	--	6.200	Oliver and Niimi 1988
gamma-Chlordane	1.000	--	1.000	--

TABLE 13

Sediment Bioaccumulation Factors For Benthic Invertebrates and Fish - Step 3

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference
Heptachlor	1.000	--	1.000	--
Heptachlor epoxide	1.000	--	1.000	--
Methoxychlor	1.000	--	1.000	--
Toxaphene	1.000	--	1.000	--
Semivolatile Organics				
4-Bromophenyl-phenylether	1.000	--	1.000	--
4-Chlorophenyl-phenylether	1.000	--	1.000	--
Acenaphthene	2.040	Maruya et al. 1997	1.000	--
Acenaphthylene	2.040	Acenaphthene value	1.000	--
Anthracene	0.191	Maruya et al. 1997	1.000	--
Benzo(a)anthracene	0.358	Maruya et al. 1997	1.000	--
Benzo(a)pyrene	0.127	Maruya et al. 1997	1.000	--
Benzo(b)fluoranthene	0.150	Maruya et al. 1997	1.000	--
Benzo(g,h,i)perylene	0.215	Maruya et al. 1997	1.000	--
Benzo(k)fluoranthene	0.232	Maruya et al. 1997	1.000	--
Chrysene	0.198	Maruya et al. 1997	1.000	--
Dibenz(a,h)anthracene	0.191	Anthracene value	1.000	--
Fluoranthene	0.212	Maruya et al. 1997	1.000	--
Fluorene	0.481	Maruya et al. 1997	1.000	--
Hexachlorobenzene	0.520	Oliver and Niimi 1988	0.940	Oliver and Niimi 1988
Hexachlorobutadiene	0.390	Oliver and Niimi 1988	0.384	Parkerton et al. 1993
Hexachlorocyclopentadiene	1.000	--	1.000	--
Hexachloroethane	1.000	--	1.000	--
Indeno(1,2,3-cd)pyrene	0.173	Maruya et al. 1997	1.000	--
Pentachlorophenol	1.000	--	1.000	--
Phenanthrene	0.294	Maruya et al. 1997	1.000	--
Pyrene	0.435	Maruya et al. 1997	1.000	--
Volatile Organics				
1,1,2,2-Tetrachloroethane	1.000	--	1.000	--
1,2,4-Trichlorobenzene	0.260	Oliver and Niimi 1988	0.074	Parkerton et al. 1993
1,2-Dichlorobenzene	1.000	--	0.085	Parkerton et al. 1993
1,3-Dichlorobenzene	1.000	--	0.085	Parkerton et al. 1993
1,4-Dichlorobenzene	1.000	--	0.085	Parkerton et al. 1993

TABLE 14

Sediment Bioaccumulation Factors For Aquatic Plants and Frogs - Step 3

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Sediment-Plant BCF (dry weight)		Sediment-Frog BAF (dry weight)	
	Value	Reference	Value	Reference
Inorganics				
Arsenic	0.037	Bechtel Jacobs 1998a	0.126	Pascoe et al. 1996
Cadmium	0.514	Bechtel Jacobs 1998a	0.164	Pascoe et al. 1996
Chromium	0.048	Bechtel Jacobs 1998a	0.038	Krantzberg and Boyd 1992
Copper	0.123	Bechtel Jacobs 1998a	0.100	Krantzberg and Boyd 1992
Lead	0.038	Bechtel Jacobs 1998a	0.070	Krantzberg and Boyd 1992
Mercury	0.344	Bechtel Jacobs 1998a	3.250	Cope et al. 1990
Nickel	0.034	Bechtel Jacobs 1998a	1.000	--
Selenium	0.567	Bechtel Jacobs 1998a	1.000	--
Silver	0.013	Bechtel Jacobs 1998a	1.000	--
Zinc	0.358	Bechtel Jacobs 1998a	0.147	Pascoe et al. 1996
Pesticides/PCBs				
4,4'-DDD	0.0115	Travis and Arms 1988	2.250	Oliver and Niimi 1988
4,4'-DDE	0.0048	Travis and Arms 1988	26.20	Oliver and Niimi 1988
4,4'-DDT	0.0065	Travis and Arms 1988	8.800	Oliver and Niimi 1988
Aldrin	0.0068	Travis and Arms 1988	1.000	--
alpha-BHC	0.2464	Travis and Arms 1988	1.000	--
alpha-Chlordane	0.0086	Travis and Arms 1988	1.000	--
Aroclor-1016	0.0224	Travis and Arms 1988	12.94	Oliver and Niimi 1988
Aroclor-1221	0.0744	Travis and Arms 1988	12.94	Oliver and Niimi 1988
Aroclor-1232	0.0437	Travis and Arms 1988	12.94	Oliver and Niimi 1988
Aroclor-1242	0.0224	Travis and Arms 1988	12.94	Oliver and Niimi 1988
Aroclor-1248	0.0101	Travis and Arms 1988	12.94	Oliver and Niimi 1988
Aroclor-1254	0.0068	Travis and Arms 1988	12.94	Oliver and Niimi 1988
Aroclor-1260	0.0045	Travis and Arms 1988	12.94	Oliver and Niimi 1988
PCBs (total)	0.0068	Travis and Arms 1988	12.94	Oliver and Niimi 1988
beta-BHC	0.2431	Travis and Arms 1988	1.000	--
delta-BHC	0.1653	Travis and Arms 1988	1.000	--
Dieldrin	0.0305	Travis and Arms 1988	1.000	--
Endosulfan I	0.2367	Travis and Arms 1988	1.000	--
Endosulfan II	0.0945	Travis and Arms 1988	1.000	--
Endrin	0.0461	Travis and Arms 1988	1.000	--
gamma-BHC (Lindane)	0.2704	Travis and Arms 1988	6.200	Oliver and Niimi 1988
gamma-Chlordane	0.0086	Travis and Arms 1988	1.000	--

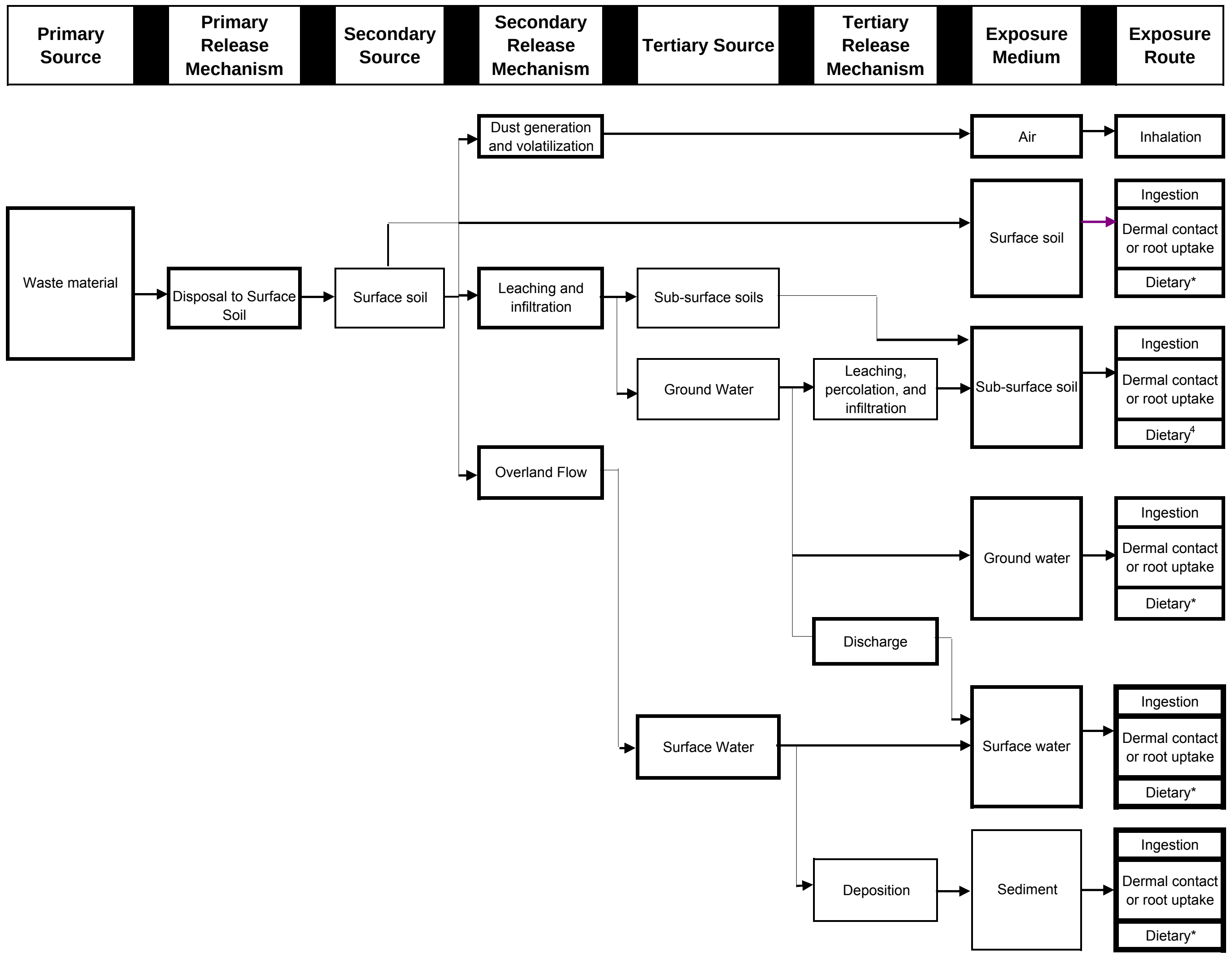
TABLE 14

Sediment Bioaccumulation Factors For Aquatic Plants and Frogs - Step 3

Site 66, Naval Support Facility - Indian Head, Indian Head, Maryland

Chemical	Sediment-Plant BCF (dry weight)		Sediment-Frog BAF (dry weight)	
	Value	Reference	Value	Reference
Heptachlor	0.0093	Travis and Arms 1988	1.000	--
Heptachlor epoxide	0.0499	Travis and Arms 1988	1.000	--
Methoxychlor	0.0448	Travis and Arms 1988	1.000	--
Toxaphene	0.0256	Travis and Arms 1988	1.000	--
Semivolatile Organics				
4-Bromophenyl-phenylether	0.0499	Travis and Arms 1988	1.000	--
4-Chlorophenyl-phenylether	0.0533	Travis and Arms 1988	1.000	--
Acenaphthene	0.2100	Travis and Arms 1988	1.000	--
Acenaphthylene	0.1653	Travis and Arms 1988	1.000	--
Anthracene	0.0908	Travis and Arms 1988	1.000	--
Benzo(a)anthracene	0.0197	Travis and Arms 1988	1.000	--
Benzo(a)pyrene	0.0114	Travis and Arms 1988	1.000	--
Benzo(b)fluoranthene	0.0101	Travis and Arms 1988	1.000	--
Benzo(g,h,i)perylene	0.0052	Travis and Arms 1988	1.000	--
Benzo(k)fluoranthene	0.0101	Travis and Arms 1988	1.000	--
Chrysene	0.0197	Travis and Arms 1988	1.000	--
Dibenz(a,h)anthracene	0.0053	Travis and Arms 1988	1.000	--
Fluoranthene	0.0425	Travis and Arms 1988	1.000	--
Fluorene	0.1428	Travis and Arms 1988	1.000	--
Hexachlorobenzene	0.0153	Travis and Arms 1988	0.940	Oliver and Niimi 1988
Hexachlorobutadiene	0.0642	Travis and Arms 1988	0.384	Parkerton et al. 1993
Hexachlorocyclopentadiene	0.0297	Travis and Arms 1988	1.000	--
Hexachloroethane	0.1888	Travis and Arms 1988	1.000	--
Indeno(1,2,3-cd)pyrene	0.0056	Travis and Arms 1988	1.000	--
Pentachlorophenol	0.0443	Travis and Arms 1988	1.000	--
Phenanthrene	0.0908	Travis and Arms 1988	1.000	--
Pyrene	0.0431	Travis and Arms 1988	1.000	--
Volatile Organics				
1,1,2,2-Tetrachloroethane	1.6091	Travis and Arms 1988	1.000	--
1,2,4-Trichlorobenzene	0.1863	Travis and Arms 1988	0.074	Parkerton et al. 1993
1,2-Dichlorobenzene	0.4031	Travis and Arms 1988	0.085	Parkerton et al. 1993
1,3-Dichlorobenzene	0.3673	Travis and Arms 1988	0.085	Parkerton et al. 1993
1,4-Dichlorobenzene	0.4085	Travis and Arms 1988	0.085	Parkerton et al. 1993

Figure 1. Conceptual Site Model for the Ecological Risk Assessment - Site 66



Ecological Receptors

Exposure Medium	Exposure Route	Plants: Terrestrial Plants	Plants: Aquatic Plants	Invertebrates: Soil	Invertebrates: Aquatic	Fish	Amphibians/Reptiles: Amphibians	Amphibians/Reptiles: Reptiles	Birds: Predator (Eastern Screech Owl)	Birds: Wading Piscivore (Great Blue Heron)	Birds: Semi-aquatic Insectivore (Sandpiper)	Birds: Vermivore (Woodcock)	Mammals: Terrestrial Insectivore (Short-tailed shrew)	Mammals: Semi-aquatic burrowing herbivore (Muskrat)	Mammals: Predator (Red Fox)	Mammals: Semi-aquatic omnivore (Racoon)
Air	Inhalation	x	x	x	x	x	x	x	i	i	i	i	i	i	i	i
Surface soil	Ingestion	x	x	●	x	x	i	i	i	i	i	i	○	○	i	i
	Dermal contact or root uptake	●	x	i	x	x	i	i	i	i	i	i	○	○	i	i
	Dietary*	x	x	○	x	x	x	x	●	x	i	●	●	i	●	i
Sub-surface soil	Ingestion	x	x	x	x	x	x	x	x	x	x	x	x	○	i	x
	Dermal contact or root uptake	●	x	x	x	x	x	x	x	x	x	x	x	i	i	x
	Dietary*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Ground water	Ingestion	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Dermal contact or root uptake	○	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Dietary*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Surface water	Ingestion	x	x	x	i	i	i	i	i	i	i	i	i	i	i	i
	Dermal contact or root uptake	x	i	x	i	i	i	i	i	i	i	i	i	i	i	i
	Dietary*	x	x	x	i	i	i	i	i	i	i	i	i	i	i	i
Sediment	Ingestion	x	x	x	x	i	i	i	i	i	i	i	i	i	i	i
	Dermal contact or root uptake	x	●	x	●	x	○	○	i	i	i	i	i	i	i	i
	Dietary*	x	x	x	i	●	●	●	x	●	●	x	x	●	x	●

Notes

● = Complete and significant pathway - A Complete and significant pathway means there is a potential for a contaminant to reach a receptor via the proposed route and there is a high potential that the receptor will receive a significant proportion of the contamination.

○ = Complete and significance unknown - means there is a potential for a contaminant to reach a receptor via the proposed route and that it is unknown if the receptor will receive a significant proportion of the contamination.

i = Complete and insignificant pathway - means there is a potential for a contaminant to reach a receptor via the proposed route and there is a low potential that the receptor will receive a significant proportion of the contamination.

x = Incomplete pathway - An Incomplete pathway means there is no potential for a contaminant to reach a receptor via the proposed route.

*Dietary = Uptake from food items and trophic transfer.

Appendix B
Field Standard Operating Procedures

Standard Operating Procedure

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 <u>24 hours</u> 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.

A national listing of the "One Call" service centers for each state is presented on the web at http://www.underspace.com/refs/ocdir.htm. 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

1. 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.

[1]Equipment 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

[2]Other 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

STANDARD OPERATING PROCEDURE

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, 3-inch diameter guard posts.

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 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 #2) 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 and hydrate 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 Morie #00) 1-foot thick will be placed above the primary sand pack.

- Annular well seals will consist of 2 feet of pelletized 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 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 94 pounds (lbs) of cement (1 bag) per 6 gallons of water and 2 to 3 lbs of powdered bentonite 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 bottom of the space to be grouted to the 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 abruptly stopping flow and allowing water in the well column to fall back into the well.
- 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 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, 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.

STANDARD OPERATING PROCEDURE

Civil Surveying

I. Purpose and Scope

The SOP describes survey procedures to be used on CLEAN projects. Modified third-order survey procedures will be used for most surveying. Geographic Positioning System techniques will be used for measurement of some horizontal coordinates.

II. Records and Definitions

All field notes should be kept in bound books. Each book should have an index. Each page of field notes should be numbered and dated and should show the initials of all crew members. The person taking field notes will be identified in the log. Information on weather (wind speed/wind direction, cloud cover, etc.) and on other site conditions should also be entered in the notes. Notes should also include instrument field identification number and environmental settings. Graphite pencils or waterproof ballpoint pens should be used. Erasing is not acceptable; use a single-strike-through and initial it. The notekeeping format should conform to the *Handbook of Survey Notekeeping* by William Pafford. A survey work drawing with grid lines and at the scale of the topographic map should be prepared for all survey field work. Field notebooks will be available on site.

The following terms are defined to clarify discussion in this SOP:

- North American Datum (NAD) -The standard geodetic datum on the North American continent.
- National Geodetic Vertical Datum (NGVD) - The vertical-control datum used (1929 or later) by the National Geodetic Survey for vertical control.
- Horizontal Control - Horizontal location of an object from surveyed corners or other features on permanent land monuments in the immediate site area. Will be based on North American Datum (NAD) 1983 and state plane grid systems.
- Vertical Control - Vertical location of an object compared to the adjacent ground surface.
- Bench Mark - Precisely determined elevation above or below sea level. May also have horizontal control (northing, easting) determined for location.

III. Surveying

Horizontal Survey

Horizontal angular measurements shall be made with a 20-second or better theodolite or transit. When using a 20-second instrument the horizontal angles shall be turned four times (two each direct and inverted) with the mean of the fourth angle being within 5 seconds of the mean of the second angle. When using a 10-second or better instrument the angles shall be doubled (once each direct and inverted), with the mean of the second angle within 5 seconds of the first angle. The minimum length of any traverse courses shall be 300 feet.

Distance measurements shall be made with a calibrated steel tape corrected for temperature and tension or a calibrated electronic distance meter (EDM). When using an EDM the parts per million (PPM), curvature and refraction corrections shall be made. Vertical angle measurements used for distance slope corrections shall be recorded to the nearest 20 seconds of arc deviation from the horizontal plane. Horizontal locations will be surveyed to within 0.05-foot of the true location.

Horizontal traverse stations shall be established and referenced for future use. All stations shall be described in the field notes with sufficient detail to facilitate their recovery at a later date. The station shall consist of a permanent mark scribed on facilities such as sidewalks, curbs, concrete slabs, or iron rod and cap.

The horizontal location will be referenced to NAD83 and the appropriate state plane grid system.

Some horizontal coordinates will be measured using Geographic Positioning System (GPS) equipment. This approach will be used in particular for determining the coordinates of surface-water and sediment sampling locations, and may be used also for determining the locations of piezometers and monitoring wells. The GPS survey will be performed by staff trained in the use of the equipment and will conform to guidance provided by the manufacturer.

Vertical Survey

When practical, vertical control will be referenced to the National Geodetic Vertical Datum (NGVD) of 1929, obtained from a permanent benchmark. If practical, level circuits should close on a known benchmark other than the starting benchmark. The following criteria shall be met in conducting the survey:

- Instruments shall be pegged weekly or after any time it is dropped or severely jolted.
- Foresight and backsight distances shall be reasonably balanced and shall not be greater than 250 feet in length.
- No side shot shall be used as a beginning or ending point in another level loop.
- Rod readings shall be made to 0.01-foot and estimated to 0.005-foot.
- Elevations shall be adjusted and recorded to 0.01-foot.

Temporary benchmarks (TBMs) shall be established and referenced for future use. All TBMs shall be described in the field notes with sufficient detail to facilitate their recovery at a later date. The TBMs shall consist of a permanent mark scribed on facilities such as sidewalks, curbs, concrete slabs, etc. or spikes set in the base of trees (not power poles), or tops of anchor bolts for transmission line towers, etc.

(Horizontal traverse stations will not be considered as a TBM, but may be used as a permanent turning point.)

Traverse Computations and Adjustments

Traverses will be closed and adjusted in the following manner:

- Step One—Coordinate closures will be computed using unadjusted bearings and unadjusted field distances.
- Step Two—Coordinate positions will be adjusted (if the traverse closes within the specified limits) using the compass rule.
- Step Three—Final adjusted coordinates will be labeled as "adjusted coordinates." Field coordinates should be specifically identified as such.
- Step Four—The direction and length of the unadjusted error of closure, the ratio of error, and the method of adjustment shall be printed with the final adjusted coordinates.

Level Circuit Computations and Adjustments

Level circuits will be closed and adjusted in the following manner:

- For a single circuit, elevations will be adjusted proportionally, provided the raw closure is within the prescribed limits for the circuit.
- In a level net where the elevation of a point is established by more than one circuit, the method of adjustment should consider the length of each circuit, the closure of each circuit, and the combined effect of all the separate circuit closures on the total net adjustments.

Piezometer and Monitoring-Well Surveys

Piezometer and monitoring-well locations will be surveyed only after the installation of the protective casing, which is set in concrete. The horizontal plane survey accuracy is ±0.05-foot and is measured to any point on the protective-casing cover. The vertical plane survey must be accurate to ±0.01-foot. The following two elevations will be measured at piezometers and monitoring wells:

- Top of the piezometer or well riser (not on the protective casing), preferably on the north side
- Ground surface, preferably on the north side of the well

If no notch or mark exists, the point at which the elevation was measured on the inner casing shall be described so that water-level measurements may be taken from the same location.

Grid Surveys

Selected soil boring locations may be located by the survey crew after the soil borings are complete. The selected borings will be staked in the field by the field team leader. The stake will be marked with the boring number for reference. The horizontal plane survey accuracy is $\pm$ 1 foot and is measured to any point on the ground surface immediately adjacent to the stake.

Exhibit A
STANDARDS FOR MODIFIED THIRD-ORDER PLANE SURVEYS

Traverse

Max Number of bearing courses between azimuth checks	30
Astronomical bearings: standard error of results	6"
Azimuth closure at azimuth checkpoint not to exceed	20" $\sqrt{N}$
Standard error of the mean for length measurements	1 in 50,000
Position closure per loop in feet before azimuth adjustment	1:10,000

Leveling

Levels error of closure per loop in feet	0.05 $\sqrt{M}$

N = the number of stations for carrying bearing
M = the distance in miles

STANDARD OPERATING PROCEDURE

Direct-Push Soil Sample Collection

I. Purpose

To provide a general guideline for the collection of soil samples using direct-push (e.g., Geoprobe®) sampling methods.

II. Scope

Standard direct-push (e.g., Geoprobe®) soil sampling methods.

III. Equipment and Materials

- Truck-mounted hydraulic percussion hammer.
- Sampling rods
- Sampling tubes and acetate liners
- Pre-cleaned sample containers and stainless-steel sampling implements
- Clean latex or surgical gloves.

IV. Procedures and Guidelines

1. Decontaminate sampling tubes and other non-dedicated downhole equipment in accordance with SOP *Decontamination of Personnel and Equipment*.
2. Drive sampling tube to the desired sampling depth using the truck-mounted hydraulic percussion hammer. If soil above the desired depth is not to be sampled, first drive the lead rod, without a sampling tube, to the top of the desired depth.
3. Remove the rods and sampling tube from the borehole and remove the sample from the tube.
4. Fill all sample containers, beginning with the containers for VOC analysis, using a decontaminated or dedicated sampling implement.
5. Decontaminate all non-dedicated downhole equipment (rods, sampling tubes, etc.) in accordance with SOP *Decontamination of Personnel and Equipment*.
6. Backfill borehole at each sampling location with grout or bentonite and repair the surface with like material (bentonite, asphalt patch, concrete, etc.), as required.

V. Key Checks and Items

1. Verify that the hydraulic percussion hammer is clean and in proper working order.

2. Ensure that the direct-push operator thoroughly completes the decontamination process between sampling locations.

3. Verify that the borehole made during sampling activities has been properly backfilled.

Shallow Soil Sampling

I. Purpose

To provide general guidelines for the collection and handling of surface soil samples during field operations.

II. Scope

The method described for surface soil sampling is applicable for loosely packed earth and is used to collect disturbed-soil samples.

III. Equipment and Materials

- Sample jars.
- A hand auger or other device that can be used to remove the soil from the ground. Only stainless steel, Teflon, or glass materials should be used. The only exception is split spoons, which are most commonly available in carbon steel; these are acceptable for use only if they are not rusty.
- A stainless steel spatula should be used to remove material from the sampling device.
- Unpainted wooden stakes or pin flags
- Fiberglass measuring tape (at least 200 feet in length)
- GPS Unit (if available)

IV. Procedures and Guidelines

A. Wear protective gear, as specified in the Health and Safety Plan.

B. To locate samples, identify the correct location using the pin flags or stakes. Proceed to collect a sample from the undisturbed soil adjacent to the marker following steps C and D. If markers are not present, the following procedures will be used.

1. For samples on a grid:

    a. Use measuring tape to locate each sampling point on the first grid line as prescribed in the sampling plan. As each point is located, drive a numbered stake in the ground and record its location on the site map and in the logbook.

b. Proceed to sample the points on the grid line.

c. Measure to location where next grid line is to start and stake first sample. For subsequent samples on the line take two orthogonal measurements: one to the previous grid line, and one to the previous sample on the same grid line.

d. Proceed to sample the points on the grid line as described in Section C below.

e. Repeat 1c and 1d above until all samples are collected from the area.

f. Or, a GPS unit can be used to identify each location based on map coordinated, if available.

2. For non-grid samples:

a. Use steel measuring tape to position sampling point at location described in the sampling plan by taking two measurements from fixed landmarks (e.g., corner of house and fence post).

b. Note measurements, landmarks, and sampling point on a sketch in the field notebook, and on a site location map.

c. Proceed to sample as described in Section C below.

d. Repeat 2a through 2c above until all samples are collected from the area.

e. Or, a GPS unit can be used to identify each location based on map coordinated, if available.

C. To the extent possible, differentiate between fill and natural soil. If both are encountered at a boring location, sample both as prescribed in the field sampling plan. Do not locate samples in debris, tree roots, or standing water. In residential areas, do not sample in areas where residents' activities may impact the sample (e.g., barbecue areas, beneath eaves of roofs, driveways, garbage areas). If an obstacle prevents sampling at a measured grid point, move as close as possible, but up to a distance of one half the grid spacing in any direction to locate an appropriate sample. If an appropriate location cannot be found, consult with the Field Team Leader (FTL). If the FTL concurs, the sampling point will be deleted from the program. The FTL will contact the CH2M HILL project manager (PM) immediately. The PM and Navy Technical Representative (NTR) will discuss whether the point should be deleted from the program. If it is deleted, the PM will follow-up with the NTR in writing.

D. To collect samples:

1. Use a decontaminated stainless steel scoop/trowel to scrape away surficial organic material (grass, leaves, etc.) adjacent to the stake. New disposable scoops or trowels may also be used to reduce the need for equipment blanks.

2. If sampling:

a. Surface soil: Obtain soil sample by scooping soil using the augering scoop/trowel, starting from the surface and digging down to a depth of about 6 inches, or the depth specified in the workplan.

b. Subsurface soil: Obtain the subsurface soil sample using an auger down to the depths prescribed in the field sampling plan.

3. Take a photoionizaton detector (PID) reading of the sampled soil if organics are anticipated to be present and record the response in the field notebook. Also record lithologic description and any pertinent observations (such as discoloration) in the logbook.

4. Empty the contents of the scoop/trowel into a decontaminated stainless steel pan.

5. Repeat this procedure until sufficient soil is collected to meet volume requirements.

6. For TCL VOC and field GC aliquots, fill sample jars directly with the trowel/ scoop and cap immediately upon filling. DO NOT HOMOGENIZE.

7. For TCL pesticides/PCBs and SVOCs, TAL metals, and field XRF aliquots, homogenize cuttings in the pan using a decontaminated stainless steel utensil in accordance with SOP *Decontamination of Drilling Rigs and Equipment*.

8. Transfer sample for analysis into appropriate containers with a decontaminated utensil.

9. Backfill the hole with soil removed from the borehole. To the extent possible, replace topsoil and grass and attempt to return appearance of sampling area to its pre-sampled condition. For samples in non-residential, unmowed areas, mark the sample number on the stake and leave stake in place. In mowed areas, remove stake.

V. Attachments

None.

VI. Key Checks and Items

- Use phthalate-free latex or surgical gloves and other personal protective equipment.
- Transfer volatiles first, avoid mixing.
- Decontaminate utensils before reuse, or use dedicated, disposable utensils.

STANDARD OPERATING PROCEDURE

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 the 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, 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.

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 initial and full 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 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.

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, CH2M HILL Form D1586, and a completed example

ASTM D 2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)*

ASTM 1586 *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*

Tables 1 through 4

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*.

STANDARD OPERATING PROCEDURE

Low-Flow Groundwater Sampling from Monitoring Wells

I. Purpose and Scope

This procedure 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

- Flow-through cell with inlet/outlet ports for purged groundwater and watertight ports for each probe
- Meters to monitor pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature (e.g., Horiba® U-22 or similar)
- Water-level indicator
- In-line disposable 0.45µm filters (QED® FF8100 or equivalent)
- Adjustable-rate positive-displacement pump, submersible pump, or peristaltic pump
- Generator
- Disposable polyethylene tubing
- Plastic sheeting
- Well-construction information
- Calibrated bucket or other container and watch with second indicator to determine flow rate
- Sample containers
- Shipping supplies (labels, coolers, and ice)
- Field book

III. Procedures and Guidelines

A. Setup and Purging

1. For the well to be sampled, information is obtained on well location, diameter(s), depth, and screened interval(s), and the method for disposal of purged water.

2. Instruments are calibrated 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 SOP *Water Level Measurements*. **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 installation log.

7. Attach and secure the polyethylene 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 at least 2 feet above the bottom of the well to avoid mobilization of any sediment present in the bottom. Preferably, the pump should be in the middle of the screen.

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. 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.

10. 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 0.5-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.

11. During purging, the field parameters are measured frequently (every 3 to 5 minutes) until the parameters have stabilized. Field parameters are considered stabilized 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 or as low as practicable given sampling conditions
- ORP: within 10 mV

B. Sample Collection

Once purging has been completed, the well is ready to be sampled. The elapsed time between completion of purging and collection of the groundwater sample from the well 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 bottles that are appropriate to the respective analysis and that have been cleaned to laboratory standards. Each bottle typically will have been previously prepared with the appropriate preservative, if any.

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

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; whether the sample is filtered or not; 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 (preservatives added; laboratory sent to, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)

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 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. Samples may be field filtered before transfer to the sample bottle. Filtration must occur in the field immediately upon collection. Inorganics, including metals, are to be collected and preserved in the filtered form as well as the unfiltered form. The recommended method is through the use of a disposable in-line filtration module (0.45-micron

filter) using the pressure provided by the pumping device for its operation.

4. Samples for analysis for volatile organic compounds should be collected first, if such samples are required.

5. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to overflowing and capped.

6. The bottle is capped, then labeled clearly and carefully following the procedures in SOP *Packaging and Shipping Procedures*.

7. Samples are placed in appropriate containers and, if necessary, packed with ice in coolers as soon as practical.

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. It may not be possible to prevent drawdown in the well if the water-bearing unit has sufficiently low permeability. If the water level was in the screen to start with, do not worry about it because there is no stagnant water in the riser above the screen to begin with.

   If the water level in the well is in the riser above the screen at the beginning of purging, then be sure you pump out sufficient volume from the well to remove the volume of water in the riser above the screen. For a 2-inch diameter well, each foot of riser contains 0.163 gallons; for a 4-inch riser, each foot of riser contains 0.653 gallons; for a 6-inch riser, each foot of riser contains 1.47 gallons.

   Alternatively, the water in the riser above the screen can be removed by lowering the pump into the well until the pump intake is just below the water level, starting the pump, running it at a low rate, and slowly lowering the pump as the water level in the riser declines. This approach can be terminated when the water level reaches the top of the screen, at which time the stagnant water in the riser has been removed. This may not be a practical approach for dedicated sampling equipment. As with typical low-flow sampling, the flow rate should be kept as low as practicable.

3. There may be circumstances where a positive-displacement or submersible pump cannot be used. An example is at isolated, hard-to-reach locations where the required power supply cannot be brought. In this case, a peristaltic pump may be used. Samples can be collected by the procedures described above for all but those for VOC analysis. The water to be placed in the vials for VOC analysis should not be run

through the peristaltic pump but instead should be collected by the following:

- Stop the pump when it is time to collect the VOC sample.
- Disconnect the tubing upstream from the pump (a connector must be installed in the line to do this).
- Pinching the tubing to keep the water in the tubing, remove the tubing from the well. Be sure that the tubing does not contact other than clean surfaces.
- Place the end of the tubing that was in the well into each VOC vial and fill the vial by removing the finger from the other end of the tube.
- Once the vials are filled, return the tubing to the well and collect any other samples required.

4. Nondedicated sampling equipment is removed from the well, cleaned, and decontaminated in accordance with SOP *Decontamination of Personnel and Equipment*. Disposable polyethylene 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 it’s 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.

STANDARD OPERATING PROCEDURE

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 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. 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.

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (specifically, ASTM Type II water or lab-grade DI water)
- Distilled water
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Liquinox® (or Alconox®)and water solution
- Concentrated (V/V) pesticide grade methanol (DO NOT USE ACETONE)
- Large plastic pails or tubs for Liquinox® and water, scrub brushes, squirt bottles for Liquinox® solution, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Phthalate-free gloves such as Nitrile
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in Liquinox® solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with Liquinox® solution, remove, and discard into DOT-approved 55-gallon drum.

2. Wash outer gloves in Liquinox® solution, rinse, remove, and discard into DOT-approved 55-gallon drum.

3. Remove disposable coveralls ("Tyveks") and discard into DOT-approved 55-gallon drum.

4. Remove respirator (if worn).

5. Remove inner gloves and discard.

6. At the end of the work day, shower entire body, including hair, either at the work site or at home.

7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.

2. Spread plastic on the ground to keep equipment from touching the ground

3. Turn off pump after sampling. Remove pump from well and remove and dispose of tubing. Place pump in decontamination tube.

4. Turn pump back on and pump 1 gallon of Liquinox® solution through the sampling pump.

5. Rinse with 1 gallon of 10% methanol solution pumped through the pump. (DO NOT USE ACETONE).

6. Rinse with 1 gallon of tap water.

7. Rinse with 1 gallon of deionized water.

8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.

9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.

10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Liquinox® solution.
5. Rinse with potable water.
6. Rinse with distilled or potable water and methanol solution (DO NOT USE ACETONE).
7. Air dry.
8. Rinse with deionized water.
9. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
10. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
11. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Liquinox® solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with Liquinox® solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.
2. Dispose of all used paper towels in a DOT-approved 55-gallon drum.

F. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the Facility
2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Liquinox®, methanol, and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

STANDARD OPERATING PROCEDURE

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. References

A. *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001, U.S. Environmental Protection Agency, Washington, D.C., 1987.

B. *Data Quality Objectives for Remedial Activities - Development Process*, EPA/540/G-87/003, U.S. Environmental Protection Agency, Washington, D.C., 1987.

C. Annual Book of ASTM Standards, *Standard Recommended Practices for Sampling Industrial Chemicals*, ASTM-E-300, 1986.

D. *Test Method for Evaluating Solid Waste*, SW-846, Volume II, Field Methods, Second Edition, U.S. Environmental Protection Agency, Washington, D.C., 1982.

E. U.S. Environmental Protection Agency, *Characterization of Hazardous Waste Sites – A Method Manual: Volume II, Available Sampling Methods*, USEPA Environmental Monitoring Systems Laboratory, Las Vegas, EPA-600/4-84-076, December, 1984.

F. *Environmental Surveillance Procedures*, Quality Control Program, Martin Marietta Energy Systems, ESH/Sub/87-21706/1, Oak Ridge, TN, September 1988.

III. 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 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.

IV. 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.

V. 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.

VI. 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:

<u>Drum</u>

Glass tube	—	Procedure 1
COLIWASA	—	Procedure 2

<u>Storage Tank and Tank Trailer</u>

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

VII. 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. Field Checklist

_______ Sampling Instruments

_______ Tools

_______ Rubber Mallet

_______ Logbook

_______ Safety Glasses or Monogoggles

_______ Safety Shoes

_______ Ice/Cooler, as required

_______ Custody Seals, as required

_______ Chain-of-Custody Forms

_______ Drum Labels, as required

_______ Paint Marker, if drum sampling

_______ Black Indelible Pen

_______ Monitoring Instruments

_____ Labels

_____ Sampling and Analysis Plan

_____ Health and Safety Plan

_____ Decontamination Equipment

_____ Lab Wipes

_____ Lab Spatulas or Stainless Steel Spoons

_____ Chemical Preservatives, as required

_____ Appropriate Containers for Waste and Equipment

_____ Duct Tape

_____ Plastic Sheeting

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, dimethylforamide, mesityloxide, 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 volumemetric capacity is 8, 16, or 32 oz (237, 473, or 946 ml).

<u>Uses</u>

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.

<u>Procedures for Use</u>

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 he 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 PFTE 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 though 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.

[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.

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 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.

STANDARD OPERATING PROCEDURE

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 potentially hazardous 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 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.

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 fenced drum storage area by the drilling services subcontractor. Drums should be stored on pallets on plastic sheeting 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. Prior to disposal to the sanitary sewer system, 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.

STANDARD OPERATING PROCEDURE

Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, ORP, and Temperature Using the Horiba® U-22 with Flow-through Cell

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for using the Horiba® U-22 for field measurements of pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature of groundwater samples. The operator's manual should be consulted for detailed operating procedures.

II. Equipment and Materials

- Horiba® U-22 Water Quality Checker with flow-though cell
- Distilled water in squirt bottle
- Horiba® U-22 Auto-Calibration Standard Solution

III. Procedures and Guidelines

A. Parameters and Specifications:

Parameter	Range of measurement	Accuracy
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 Horiba® Standard Solution. Calibration procedure:

1. Fill the calibration beaker to about 2/3 with the pH 4 standard solution.

2. Fit 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.

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, pH will read 4.0 +/- 3%, conductivity will read 4.49 +/- 3%, and turbidity will read 0 +/- 3%

C. Sample Measurement:

As water passes through the flow-through Cell, press MEAS to obtain reading; record in the field notebook.

IV. Key Checks and Preventive Maintenance

- Calibrate meter
- Clean probe with deionized water when done
- Refer to operations manual for recommended maintenance
- 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.

STANDARD OPERATING PROCEDURE

Multi RAE Photoionization Detector (PID)

I. Purpose

The purpose of this SOP is to provide general reference information for using the Multi RAE PID in the field. Calibration and operation, along with field maintenance, will be included in this SOP.

II. Scope

This procedure provides information into the field operation and general maintenance of the Multi 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

Carbon Monoxide Sensor (CO) - Expresses the Carbon Monoxide concentration in parts per million (ppm).

Volatile Organic Compound (VOC) – Expresses the VOC concentration in parts per million (ppm)

Lower Explosive Limit (LEL) - Combustible gas is expressed as a percent of the lower explosive limit.

Hydrogen Sulfide Sensor (H_2S) - Expresses the Hydrogen Sulfide concentration in parts per million (ppm).

Oxygen Sensor (OXY) - Expresses the Oxygen concentration as a percentage.

ppm - parts per million: parts of vapor or gas per million parts of air by volume.

IV. Responsibilities

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Health and Safety Coordinator - The Health and Safety Coordinator is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the field team performing air monitoring activities have been briefed and trained to execute these procedures before the start of site operations.

Safety Coordinator-Hazard Worker (SC-HW)- The SC-HW is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the field personnel. The SC-HW will coordinate these activities with the Field Team Leader if the SC-HW is not the Field Team Leader as well.

Field team - It is the responsibility of the field team to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/ Safety Coordinator-Hazard Worker. The field personnel are responsible for documenting all air monitoring results in the field logbook during each field investigation.

V. Procedures

The Multi RAE utilizes the principle of detecting sensors. The PID operates on the principle that most organic compounds and some inorganic compounds are be ionized when they are bombarded by high-energy ultraviolet light. These compounds absorb the energy of the light, which excites the molecule 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 ionization potential (IP). 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.

The following subsections will discuss Multi RAE calibration, operation, and maintenance. These sections, however, do not take the place of the instruction manual.

A. Calibration

For Multi RAE configured with O_2, LEL, H_2S, CO, sensors and a 10.6eV PID Lamp.

Start up Instrument

- Press **Mode** button
- Observe displays:

On!……..

Multi RAE Version X.XX

Model Number SN XXXX

Date Time Temp

Checking Sensor Ids….

VOC Installed

CO Installed

H_2S Installed

OXY Installed

LEL Installed

H_2S VOC CO LEL OXY

Alarm Limits=

XX XX.X XX XX High XX.X

XX XX.X XX XX Low XX.X

XX XX.X XX STEL

XX XX.X XX TWA

Battery = X.XV
Shut off at 4.2V

User Mode=

Alarm Mode=

Datalog Time Left

Datalog Mode

Datalog Period

Unit ready in…..
10 Seconds

- 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?

- If "Zero Air" is necessary, attach the calibration adapter over the inlet port of the Multi RAE Monitor and connect the other end of the tube to the gas regulator (HAZCO loaner regulator LREG.5, RAE Systems P/N 008-3011 or suitable .5 LPM regulator) on the Zero Air bottle (HAZCO P/N SGZA, RAE P/N 600-0024). If no Zero Air is available, perform the Fresh Air Calibration in an area free of any detectable vapor.
- Press the **[Y/+]** key
- Display will read:

Zero….
In progress…

CO Zeroed!
Reading = X

VOC Zeroed! Reading = X

LEL Zeroed! Reading = X

OXY Zeroed! Reading = X

Zero Cal done!
H_2S Zeroed! Reading = X

In each of the above screens, "X" is equal to the reading of the sensor before it was zeroed.

- Display will then read:

Multiple Sensor Calibration?

- Press the **[Y/+]** key
- The display shows all of the pre-selected sensors and the "OK?" question:

CO H_2S LEL OK? OXY

- 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.
- Press the **[Y/+]** key. Display will read:

Apply Mixed gas

Calibration In progress …

- The display will count down showing the number of remaining seconds:

CO cal'ed Reading=50

H_2S cal'ed Reading=25

LEL cal'ed Reading=50

OXY cal'ed Reading=20.9

Calibration done Turn off gas!

- Display will read:

Single Sensor Calibration?

- Press the **[Y/+]**.
- Display will read:

CO VOC H_2S LEL pick? OXY

- Attach 100 ppm Isobutylene (HAZCO P/N r-SGISO or Rae P/N 600-0002) using a 1.0 LPM regulator (HAZCO P/N LR10HS or Rae P/N 008-3021). Open regulator.
- Press the **[Mode]** key once, the V of VOC will be highlighted.
- Press the **[Y/+]**. The display will read:

Apply VOC Gas

Calibration In progress…

- The display will count down showing the number of remaining seconds:, then display:

VOC cal'd Reading=100

Calibration done Turn off gas!

Single Sensor Calibration?

- Press **[Mode]** key twice to return to main screen.
- **CALIBRATION IS COMPLETE!**

B. Operation

Due to the Multi 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 9 to 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

Function	Frequency
Check alarm and settings	Monthly/before each use
Clean screens and gaskets around sensors	Monthly
Replace sensors	Biannually or when calibration is unsuccessful

VI. 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, Multi RAE had wide range fluctuations during air monitoring activities.)

VII. References

Multi RAE Plus Multiple Gas Monitor User Manual, RAE Systems, Revision B1, November 2003.

STANDARD OPERATING PROCEDURE

Preparing Field Log Books

I. Purpose

To provide general guidelines for entering field data into log books during site investigation and remediation field 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 of 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, orange-covered 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. Heath 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.

STANDARD OPERATING PROCEDURE

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 following procedures for dangerous-goods shipping specified by the intended shipper (e.g., Federal Express).

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 several additional restrictions. 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.

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

Appendix C
Health and Safety Plan

Health and Safety Plan

Indian Head – Site 66

UFP-SAP for Remedial Investigation

Prepared for

Department of the Navy

Naval Facilities Engineering Command Washington

April 2010

CH2MHILL

Dayton Office
One South Main Street, Suite 1100
Dayton, OH 45402-1828

Health and Safety Plan

Indian Head – Site 66

Submitted to

NAVFAC Washington

April 2010

Prepared By:

Carl Woods/BCN 7/16/09

Responsible Health and Safety Manager Date

Approved By:

Project Manager Date

Client Acceptance:

Responsible Authority Date

Contents

CH2M HILL HEALTH AND SAFETY PLAN

This Health and Safety Plan (HSP) will be kept on the site during field activities and will be reviewed as necessary. The plan will be amended or revised as project activities or conditions change or when supplemental information becomes available. The plan adopts, by reference, the Enterprise-wide Core Standards (CS) and Standard Operating Procedures (SOPs), as appropriate. In addition, this plan adopts procedures in the project Work Plan. The Safety Coordinator (SC) is to be familiar with the CSs and SOPs and the contents of these instructions. CH2M HILL's personnel and subcontractors must be trained on this plan and sign Attachment 1.

Project Information and Background

PROJECT NO: 386329

CLIENT: Dept. of the Navy, Naval Facilities Engineering Command Washington

PROJECT/SITE NAME: NSF-IH – Site 66 Remedial Investigation

SITE ADDRESS: Indian Head, Maryland

CH2M HILL PROJECT MANAGER: Christine Metcalf/WDC

CH2M HILL OFFICE: Chantilly, Virginia

DATE HEALTH AND SAFETY PLAN PREPARED: July 16, 2009

DATE(S) OF SITE WORK: January 2010 – January 2011

SITE ACCESS:	Access to the site is via the main gate located on Route 210 in Indian Head. Badges are required to access the restricted area of the base.
SITE SIZE:	Approximately 2,500 acres in main area of facility
SITE TOPOGRAPHY:	Local topography includes an upland area in the northern portion of the facility, extending northeast beyond the main gate. This upland area slopes to the north and northwest terminating as bluffs along the shore of the Potomac River. It gently slopes to the southeast toward the southern boundary of the facility, where low-lying swampy areas are present along Mattawoman Creek. Along the eastern part of the facility, the eroded edge of the upland forms several steep slopes along Mattawoman Creek.
PREVAILING WEATHER:	The climate of the Washington, D.C. area is characterized by warm and humid summers and mild winters. July is generally the warmest month, with average daily temperatures in the upper 80s. The lowest temperatures generally are recorded in late January and early February, when average high temperatures are in the middle 40s. Average annual precipitation is 41 inches; average annual snowfall is approximately 20 inches (Johnston, 1964). Because of the geographic location of NSF-IH, prevailing wind direction at and around the facility varies on a daily basis. Frontal systems approach the area primarily from the northwest or

southwest, bringing with them northwesterly or southwesterly winds, respectively. In addition, easterly winds blowing in off the Atlantic Ocean and Chesapeake Bay reach the facility due to its proximity to these bodies of water.

INSTALLATION DESCRIPTION: NSF-IH is a military facility consisting of the main area (on the Cornwallis Neck Peninsula) and the Stump Neck Annex, near Indian Head, in northwestern Charles County, Maryland, approximately 25 miles southwest of Washington D.C. The mission of NSF-IH is to provide primary technical capability in energetics for all warfare centers through engineering, fleet and operational support, manufacturing technology, limited production, and industrial base support. Secondary technical capability is provided through research, development, test and evaluation for energetic materials, ordnance devices and components, and related ordnance engineering standards including chemicals, propellants and their propulsion systems, explosives, pyrotechnics, warhead, and simulators.

Site 66: Site 66, the Turkey Run Disposal Area, is located west of West Caffee Road, extending approximately 900 feet north of Olsen Road along both sides of the unnamed creek that discharges into Mattawoman Creek, a tributary of the Potomac River (Figure 2-1). The site is defined as the area that includes obvious wastes present on the land surface, and is approximately 8.2 acres in size.

Site Map

This page is reserved for a Site Map.

Note locations of Support, Decontamination, and Exclusion Zones; site telephone; first aid station; evacuation routes; and assembly areas.

Emergency Contacts

24-hour CH2M HILL Serious Incident Reporting Contact/Pager – 720-286-4911

If injured on the job, notify your supervisor and then call 1-866-893-2514 to contact CH2M HILL'S Occupational Nurse

Medical Emergency – **On-base:** 301-744-4333 (If in restricted area, use red call boxes – no cell phone usage in restricted area!) **Off-base: 911**	• CH2M HILL- Medical Consultant • WorkCare • Dr. Peter Greaney M.D. • 300 S. Harbor Blvd, Suite 600 Anaheim , CA 92805 • 800-455-6155 714-978-7488
Fire/Spill Emergency – **On-base:** 301-744-4333 (If in restricted area, use red call boxes – no cell phone usage in restricted area!) **Off-base: 911**	• CH2M HILL Director Security Operations • Thomas Horton/DEN • 720/273-3100 (cell) or 720/286-0022 (office)
Security & Police – **On-base:** 301-744-4333 (If in restricted area, use red call boxes – no cell phone usage in restricted area!) **Off-base: 911**	• Responsible Health and Safety Manager (RHSM) • Name: Carl Woods/BCN Phone: (513) 337-9353
Utilities Emergency Contact Nicolas Carros, NSF-IH Phone: 301-744-2263	• Human Resources Department • Name: Sherri Huntley Phone: 703-376-5192
Safety Coordinator - Haz Waste (SC-HW) Name: TBD Phone: TBD	• Worker's Compensation: • Contact Business Group HR dept. to have form completed or contact Jennifer Rindahl after hours: (720)891-5382
Project Manager (PM) Name: Christine Metcalf/WDC Phone: 703-376-5193	• Media Inquiries Corporate Strategic Communications • Name: John Corsi Phone: (720) 286-2087
Federal Express Dangerous Goods Shipping Phone: 800-238-5355 **CH2M HILL Emergency Number for Shipping Dangerous Goods** Phone: 800-255-3924	• Automobile Accidents • Rental: Linda Anderson/COR 720/286-2401 • CH2M HILL owned vehicle: Linda George 720-286-2057
Federal Express Dangerous Goods Shipping Phone: 800/238-5355	**CH2M HILL Dangerous Goods Shipping** **Phone: 800/255-3924**

Facility Alarms: Since CH2M HILL personnel will not always be working in close proximity to each other, hand signals, voice commands, air horns, and two-way radios will comprise the mechanisms to alert site personnel of an emergency.

All onsite contractors must read and sign the "Hazard Control Briefing for Environmental Division Visitors IHDIVNAVSURFAWARCEN", and attend the "Pre-construction Safety Briefing" from the Safety Department prior to commencing work.

Evacuation Assembly Area(s): In the event that the site must be evacuated, all personnel will immediately stop activities and report to a safe place of refuge at the support zone area. The safe place of refuge may also serve as the telephone communication point, as communication with emergency response agencies may be necessary. Telephone communication points and safe places of refuge will be determined prior to the commencement of site activities.

Facility/Site Evacuation Route(s): Evacuation procedures will be discussed prior to the initiation of any work at the site. Primary and secondary evacuation routes will be conveyed to site personnel before initiation of work. Evacuation routes from the site are dependent upon the location at which work is being performed and the circumstances under which an evacuation is required. Additionally, site location and meteorological conditions (i.e. wind speed and direction) will influence the designation of evacuation routes. As a result, assembly points will be selected, and will be proceeded to by field personnel in the event of an emergency by the most direct route possible without further endangering themselves.

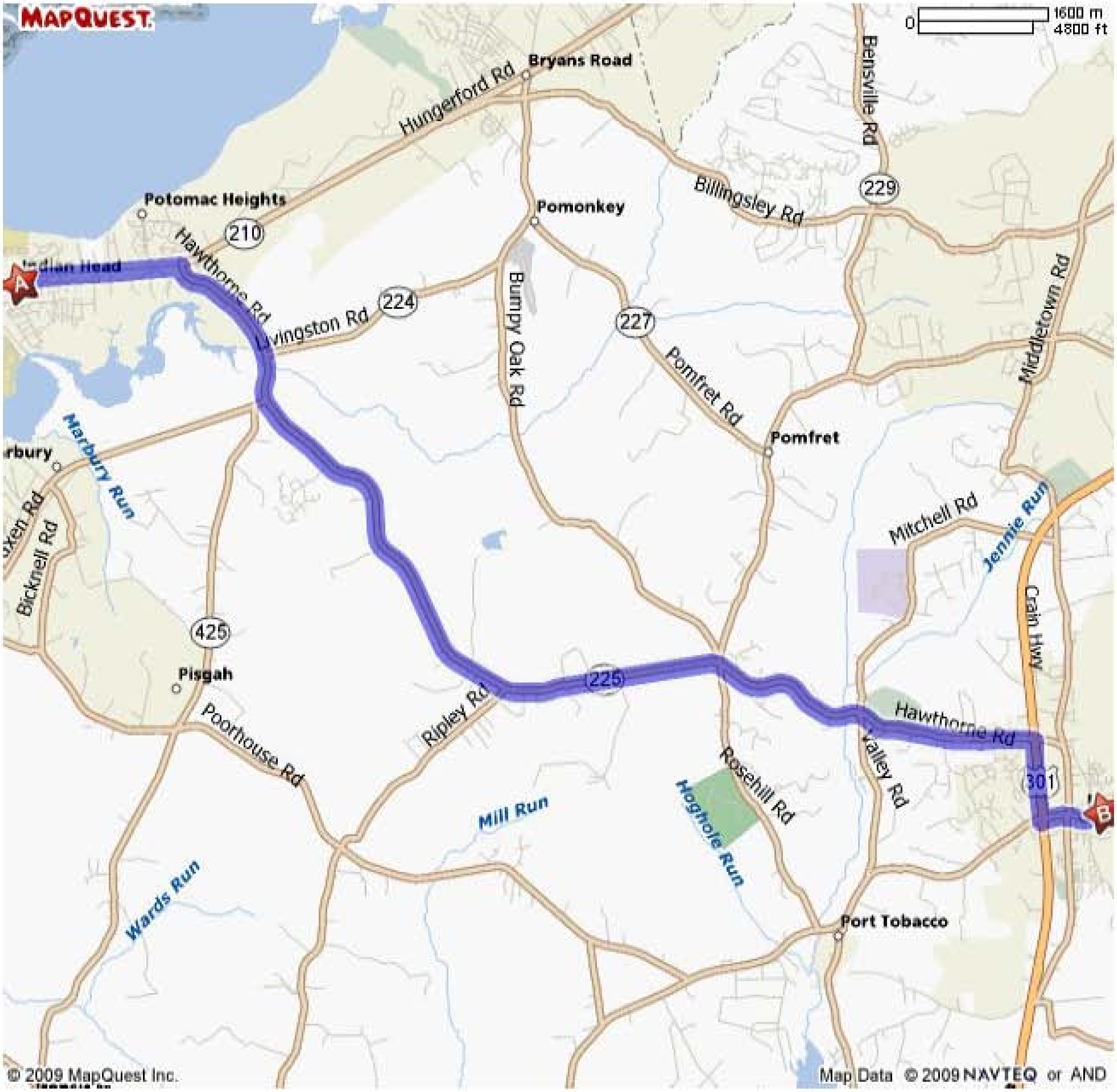
Directions to Local Hospital

Hospital Name/Address: Civista Medical Center
701 E. Charles St., LaPlata, MD 20646

Hospital Phone #: 301-609-4000

Civista Medical Center, located at 701 East Charles Street, La Plata, MD

1. 0.0 Start on STRAUSS AV. N. Drive 0.9 miles
2. At 0.9 miles, drive onto HWY 210. Drive 0.7 miles
3. At 1.5 miles, TURN RIGHT on INDIAN HEAD LAPLATA RD. Drive 8.9 miles.
4. At 10.4 miles, drive onto HAWTHORNE DR. Drive 1.7 miles.
5. At 12.1 miles, TURN RIGHT on US 301. Drive 0.7 miles.
6. At 12.8 miles, TURN LEFT on CHARLES ST. Continue 0.6 miles to the hospital.


MAPQUEST
0
1600 m
4800 ft
Bryans Road
Hungerford Rd
Bensville Rd
229
Billingsley Rd
Potomac Heights
210
Pomonkey
Hawthorne Rd
Indian Head
224
Livingston Rd
Bumpy Oak Rd
227
Pomfret Rd
Middletown Rd
Pomfret
Marbury Run
Mitchell Rd
Jennie Run
Bicknell Rd
Crain Hwy
425
Pisgah
225
Ripley Rd
Hawthorne Rd
Poorhouse Rd
Valley Rd
Rosehill Rd
301
Mill Run
Hoghole Run
Wards Run
Port Tobacco
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1 Tasks to be Performed under this Plan

1.1 Description of Tasks

Refer to project documents (i.e., Work Plan) for detailed task information. A health and safety risk analysis (Table 1) has been performed for each task and is incorporated in this plan through task-specific hazard controls and requirements for monitoring and protection. Tasks other than those listed below require an approved amendment or revision to this plan before tasks begin. Refer to Section 8.2 for procedures related to “clean” tasks that do not involve hazardous waste operations and emergency response (Hazwoper).

1.1.1 Hazwoper-Regulated Tasks

- Utility Clearance (GPR or similar)
- Monitoring Well Installation & Development (HSA)
- Monitoring Well Sampling (low flow technique)
- DPT borings and soil sampling
- DPT borings for soil lithology
- Sediment Sampling
- Ash sampling (grab samples from surface)
- IDW handling/sampling

1.1.2 Non-Hazwoper-Regulated Tasks

Under specific circumstances, the training and medical monitoring requirements of federal or state Hazwoper regulations are not applicable. It must be demonstrated that the tasks can be performed without the possibility of exposure in order to use non-Hazwoper-trained personnel. **Prior approval from the Responsible Health and Safety Manager (RHSM) is required before these tasks are conducted on regulated hazardous waste sites.**

Tasks	Controls
• None	• Brief on hazards, limits of access, and emergency procedures • Post contaminant areas as appropriate (refer to Section 8.2 for details) • Sample and monitor as appropriate (refer to Section 5.0)

1.2 Change Management

PROJECT HS&E Change Management Form			
*This evaluation form should be reviewed on a **continuous** basis to determine if the current site health and safety plan adequately addresses ongoing project work, and should be completed whenever new tasks are contemplated or changed conditions are encountered.*			
Project Task:	**Well installation, Drilling, Sampling**	Project/Task Manager: Christine Metcalf	
Project Number:	**386329**	Project Name: **Indian Head – Site 66**	

	Evaluation Checklist	Yes	No
1.	Has the CH2M HILL staff listed in the original HASP changed?		
2.	Has a new subcontractor been added to the project?		
3.	Is any chemical or product to be used that is not listed in Attachment 2 of the plan?		
4.	Have additional tasks been added which were not originally addressed in Section 1.1 of the plan?		
5.	Have new contaminants or higher than anticipated levels of original contaminants been encountered?		
6.	Has other safety, equipment, activity or environmental hazards been encountered that are not addressed in Section 2.1 of the plan?		

If the answer is "YES" to Questions 1-3, an HSP revision is NOT needed. Please take the following actions:

- Confirm that staff's medical and training status is current – check training records at: http://www.int.ch2m.com/hands (or contact your regional SPA), and confirm subcontractor qualifications.
- Confirm with the project KA that subcontractor safety performance has been reviewed and is acceptable.
- Confirm with H&S that subcontractor safety procedures have been reviewed and are acceptable.

If the answer is "YES" to Questions 4-6, an HSP revision MAY BE NEEDED.

TABLE 1
Hazard Analysis
(Refer to Section 2.0 for Hazard Controls)

Potential Hazards	PROJECT ACTIVITIES						
	Utility Clearance (GPR)	Monitoring Well Installation and Development (HSA)	Monitoring Well Sampling & Survey	DPT Borings and Soil Sampling and for soil lithology	Sediment Sampling	Ash Sampling	IDW Handling and Sampling
Arsenic			X	X	X	X	X
Biological Hazards	X	X	X	X	X	X	X
Drilling		X		X			
Drum Handling							X
Electrical Safety		X	X				
Field Vehicles	X	X	X	X	X	X	X
Fire Prevention	X	X	X	X	X	X	X
Groundwater Sampling			X	X	X	X	
Hand & Power Tools	X	X	X	X	X	X	X
Heavy Equipment		X		X			
Hexavalent Chromium			X	X	X	X	
IDW Drum Sampling							X
Knife Use		X	X	X	X	X	
Lead			X	X	X	X	
Manual Lifting	X	X	X	X	X	X	X
Noise		X	X	X			
Pressure Washing/Equip Decon		X		X			
Pressurized Lines/Equipment		X		X			
Radar Hazards	X						
Utilities (underground/ overhead)	X	X		X			
Visible Lighting	X	X	X	X	X	X	X
Work Over Water					X		

2 Hazard Controls

This section provides safe work practices and control measures used to reduce or eliminate potential hazards. These practices and controls are to be implemented by the party in control of either the site or the particular hazard. CH2M HILL employees and subcontractors must remain aware of the hazards affecting them regardless of who is responsible for controlling the hazards. CH2M HILL employees and subcontractors who do not understand any of these provisions should contact the RHSM for clarification.

The health and safety hazards posed by field activities have been identified for each project activity and are provided in the Hazard Analysis Table (Table 1). Hazard control measures for project-specific and general H&S hazards are provided in Sections 2.1, 2.2, and 2.3.

In addition to the controls specified in this section, Project-Activity Self-Assessment Checklists are contained in Attachment 4. These checklists are to be used to assess the adequacy of CH2M HILL and subcontractor site-specific safety requirements. The objective of the self-assessment process is to identify gaps in project safety performance and prompt corrective actions in addressing these gaps. Self-assessment checklists should be completed early in the project, when tasks or conditions change, or when otherwise specified by the RHSM. The self-assessment checklists, including documented corrective actions, should be made part of the permanent project records.

Applicable project activity self-assessment checklists (see Attachment 4) shall be completed **weekly** by a CH2M HILL representative during the course of the project depending on the work performed at the time.

2.1 Project-Specific Hazards

2.1.1 Arsenic

(Reference CH2M HILL, SOP HSE-501, *Arsenic*)

- Do not enter regulated work areas unless training, medical monitoring, and PPE requirements established by the competent person have been met.
- Do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas.
- Avoid skin and eye contact with liquid and particulate arsenic or arsenic trichloride.
- Arsenic is considered a "Confirmed Human Carcinogen."
- Arsenic particulates (inorganic metal dust) are odorless. Vapor and gaseous odor varies depending upon specific organic arsenic compound.
- Respiratory protection and other exposure controls selection shall be based on the most recent exposure monitoring results obtained from the competent person.

2.1.2 Compressed Gas Cylinders

(Reference CH2M HILL SOP HSE-403, *Hazardous Materials Handling*)

- Valve caps must be in place when cylinders are transported, moved, or stored.
- Cylinder valves must be closed when cylinders are not being used and when cylinders are being moved.
- Cylinders must be secured in an upright position at all times.
- Cylinders must be shielded from welding and cutting operations and positioned to avoid being struck or knocked over; contacting electrical circuits; or exposed to extreme heat sources.
- Cylinders must be secured on a cradle, basket, or pallet when hoisted; they may not be hoisted by choker slings.
- See Attachment 4 for the Self-Assessment Checklist (hazardous materials handling)

2.1.3 Drilling Safety

- The drill rig is not to be operated in inclement weather.
- The driller is to verify that the rig is properly leveled and stabilized before raising the mast.
- Personnel should be cleared from the sides and rear of the rig before the mast is raised.
- The driller is not to drive the rig with the mast in the raised position.
- The driller must check for overhead power lines before raising the mast. A minimum distance of 15 feet between mast and overhead lines (<50 kV) is recommended. Increased separation may be required for lines greater than 50 kV.
- Personnel should stand clear before rig startup.
- The driller is to verify that the rig is in neutral when the operator is not at the controls.
- Become familiar with the hazards associated with the drilling method used (cable tool, air rotary, hollow-stem auger, etc.).
- Do not wear loose-fitting clothing, watches, etc., that could get caught in moving parts.
- Do not smoke or permit other spark-producing equipment around the drill rig.
- The drill rig must be equipped with a kill wire or switch, and personnel are to be informed of its location.
- Be aware and stand clear of heavy objects that are hoisted overhead.
- The driller is to verify that the rig is properly maintained in accordance with the drilling company's maintenance program.
- The driller is to verify that all machine guards are in place while the rig is in operation.
- The driller is responsible for housekeeping (maintaining a clean work area).
- The drill rig should be equipped with at least one fire extinguisher.

- If the drill rig comes into contact with electrical wires and becomes electrically energized, do not touch any part of the rig or any person in contact with the rig, and stay as far away as possible. Notify emergency personnel immediately

2.1.4 Drum Handling

- Ensure that personnel are trained in proper lifting and moving techniques to prevent back injuries.
- Provide equipment to keep the operator removed from the drums to lessen the likelihood of injury. Such equipment might include: a drum grappler attached to a hydraulic excavator; a small front-end loader, which can be either loaded manually or equipped with a bucket sling; a rough terrain forklift; Roller conveyor equipped with solid rollers; drum carts designed specifically for drum handling.
- Make sure the vehicle selected has sufficient rated load capacity to handle the anticipated loads, and make sure the vehicle can operate smoothly on the available road surface.
- Ensure there are Plexiglas cab shields on loaders, backhoes, etc., when handling drums containing potentially explosive materials.
- Equipment cabs should be supplied with fire extinguishers, and should be air-conditioned to increase operator efficiency.
- Supply operators with appropriate respiratory protective equipment when needed.
- Ensure that drums are secure and are not in the operator's view of the roadway.
- Prior to handling, all personnel should be warned about hazards of handling.
- Throughout handling, personnel should be alert for information leading to the identity of new hazards. Exercise extreme caution in handling drums that are not intact and tightly sealed.
- Before moving anything, determine the most appropriate sequence in which the various drums and other containers should be moved (e.g. small containers may have to be removed first to permit heavy equipment to enter and move the drums.
- Overpack drums and an adequate volume of absorbent should be kept near areas where minor spills may occur.

2.1.5 Electrical

(Reference CH2M HILL SOP HSE-206, *Electrical Safety*)

General Electrical Safety

- Only qualified personnel are permitted to work on unprotected energized electrical systems.
- Only authorized personnel are permitted to enter high-voltage areas.
- Do not tamper with electrical wiring and equipment unless qualified to do so. All electrical wiring and equipment must be considered energized until lockout/tagout procedures are implemented.

- Inspect electrical equipment, power tools, and extension cords for damage prior to use. Do not use defective electrical equipment, remove from service.
- CH2M HILL has selected Ground Fault Circuit Interrupters (GFCIs) as the standard method for protecting employees from the hazards associated with electric shock.
  - GFCIs shall be used on all 120-volt, single phase 15 and 20-amphere receptacle outlets which are not part of the permanent wiring of the building or structure.
- An assured equipment grounding conductor program may be required under the following scenarios:
  - GFCIs can not be utilized
  - Client requires such a program to be implemented
  - Business group decides to implement program in addition to GFCI protection
- Extension cords must be equipped with third-wire grounding. Cords passing through work areas must be covered, elevated or protected from damage. Cords should not be routed through doorways unless protected from pinching. Cords should not be fastened with staples, hung from nails, or suspended with wire.
- Electrical power tools and equipment must be effectively grounded or double-insulated UL approved.
- Operate and maintain electric power tools and equipment according to manufacturers' instructions.
- Maintain safe clearance distances between overhead power lines and any electrical conducting material unless the power lines have been de-energized and grounded, or where insulating barriers have been installed to prevent physical contact. Maintain at least 10 feet from overhead power lines for voltages of 50 kV or less, and 10 feet plus ½ inch for every 1 kV over 50 kV.
- Temporary lights shall not be suspended by their electric cord unless designed for suspension. Lights shall be protected from accidental contact or breakage.
- Protect all electrical equipment, tools, switches, and outlets from environmental elements.

Portable Generator Hazards

- Portable generators are useful when temporary or remote electric power is needed, but they also can be hazardous. The primary hazards to avoid when using a generator are carbon monoxide (CO) poisoning from the toxic engine exhaust, electric shock or electrocution, and fire.
- NEVER use a generator indoors or in similar enclosed or partially-enclosed spaces. Generators can produce high levels of carbon monoxide (CO) very quickly. When you use a portable generator, remember that you cannot smell or see CO. Even if you can’t smell exhaust fumes, you may still be exposed to CO.
- If you start to feel sick, dizzy, or weak while using a generator, get to fresh air RIGHT AWAY. DO NOT DELAY. The CO from generators can rapidly lead to full incapacitation and death.

- If you experience serious symptoms, get medical attention immediately. Inform project staff that CO poisoning is suspected. If you experienced symptoms while indoors have someone call the fire department to determine when it is safe to re-enter the building.
- Follow the instructions that come with your generator. Locate the unit outdoors and away from doors, windows, and vents that could allow CO to come indoors.
- Keep the generator dry and do not use in rain or wet conditions. To protect from moisture, operate it on a dry surface under an open, canopy-like structure. Dry your hands if wet before touching the generator.
- Plug appliances directly into the generator. Or, use a heavy duty, outdoor-rated extension cord that is rated (in watts or amps) at least equal to the sum of the connected appliance loads. Check that the entire cord is free of cuts or tears and that the plug has all three prongs, especially a grounding pin.
- Most generators come with Ground Fault Circuit Interrupters (GFCI). Test the GFCIs daily to determine whether they are working
- If the generator is not equipped with GFCI protected circuits plug a portable GFCI into the generator and plug appliances, tools and lights into the portable GFCI.
- Never store fuel near the generator or near any sources of ignition.
- Before refueling the generator, turn it off and let it cool down. Gasoline spilled on hot engine parts could ignite.

2.1.6 Field Vehicles

- Field vehicles may be personal vehicles, rental vehicles, fleet vehicles or project vehicles.
- Fleet vehicles are equipped with emergency supplies. It is a project responsibility to equip all project vehicles with emergency equipment.
- Maintain both a First Aid kit and Fire Extinguisher in the field vehicle at all times.
- Utilize a rotary beacon on vehicle if working adjacent to active roadway.
- Car rental must meet the following requirements:
    - Dual air bags
    - Antilock brakes
    - Be midsize or larger
- Familiarize yourself with rental vehicle features:
    - Mirror adjustments
    - Seat adjustments
    - Cruise control features, if offered
    - Pre-program radio stations
- Always wear seatbelt while operating vehicle.
- Adjust headrest to proper position.
- Tie down loose items if utilizing a van.

- Pull off the road, put the car in park and turn on flashers before talking on a mobile phone.
- Close car doors slowly and carefully. Fingers can get pinched in doors.
- Park vehicle in a location where it can be accessed easily in the event of an emergency. If not possible, carry a phone.
- Have a designated place for storing the field vehicle keys when not in use.

2.1.7 Fire Prevention

- Fire extinguishers shall be provided so that the travel distance from any work area to the nearest extinguisher is less than 100 feet. When 5 gallons or more of a flammable or combustible liquid is being used, an extinguisher must be within 50 feet. Extinguishers must:
  - be maintained in a fully charged and operable condition,
  - be visually inspected each month, and
  - undergo a maintenance check each year.
- The area in front of extinguishers must be kept clear.
- Post "Exit" signs over exiting doors, and post "Fire Extinguisher" signs over extinguisher locations.
- Combustible materials stored outside should be at least 10 feet from any building.
- Solvent waste and oily rags must be kept in a fire resistant, covered container until removed from the site.
- Flammable/combustible liquids must be kept in approved containers, and must be stored in an approved storage cabinet.

2.1.8 Groundwater Sampling/Water Level Measurements

- Wear the appropriate PPE when sampling, including safety glasses, nitrile gloves, and steel toe boots (refer to Section 4).
- Monitor headspace of wells prior to sampling to minimize any vapor inhalation (refer to Section 5 on air monitoring).
- Use caution when opening well lids. Wells may contain poisonous spiders and hornet or wasp nests.
- Use the appropriate lifting procedures (see CH2M HILL SOP HSE-112) when unloading equipment and sampling at each well.
- Avoid sharp edges on well casings.
- If dermal contact with the groundwater and acid used in sample preservation, wash exposed skin thoroughly with soap and water.
- Avoid eating and drinking on site and during sampling.
- Use ear plugs during sampling if sampling involves a generator.
- Containerize all purge water and transport to the appropriate storage area.

2.1.9 Hand and Power Tools

(Reference CH2M HILL, SOP HSE-210, *Hand and Power Tools*)

- Tools shall be inspected prior to use and damaged tools will be tagged and removed from service.
- Hand tools will be used for their intended use and operated in accordance with manufacturer's instructions and design limitations;
- Maintain all hand and power tools in a safe condition.
- Use PPE (such as gloves, safety glasses, earplugs, and face shields) when exposed to a hazard from a tool.
- Do not carry or lower a power tool by its cord or hose.
- Portable power tools will be plugged into GFCI protected outlets; and
- Portable power tools will be Underwriters Laboratories (UL) listed and have a three-wire grounded plug or be double insulated.
- Disconnect tools from energy sources when they are not in use, before servicing and cleaning them, and when changing accessories (such as blades, bits, and cutters).
- Safety guards on tools must remain installed while the tool is in use and must be promptly replaced after repair or maintenance has been performed.
- Store tools properly in a place where they will not be damaged or come in contact with hazardous materials.
- If a cordless tool is connected to its recharge unit, both pieces of equipment must conform strictly with electrical standards and manufacturer's specifications.
- Tools used in an explosive environment must be rated for work in that environment (that is, intrinsically safe, spark-proof, etc.).
- When using a knife or blade tool, stroke or cut away from the body with a smooth motion. Be careful not to use excessive force that could damage the tool, the material being cut or unprotected hands.
- Working with manual and pistol-grip hand tools may involve highly repetitive movement, extended elevation, constrained postures, and/or awkward positioning of body members (for example, hand, wrist, arm, shoulder, neck, etc.). Consider alternative tool designs, improved posture, the selection of appropriate materials, changing work organization, and sequencing to prevent muscular, skeletal, repetitive motion, and cumulative trauma stressors.

Machine Guarding

- Ensure that all machine guards are in place to prevent contact with drive lines, belts, chains, pinch points or any other sources of mechanical injury.
- Unplugging jammed equipment will only be performed when equipment has been shut down, all sources of energy have been isolated and equipment has been locked/tagged and tested.

- Maintenance and repair of equipment that results in the removal of guards or would otherwise put anyone at risk requires lockout of that equipment prior to work.

2.1.10 Heavy Equipment (earthmoving/excavating machinery)

(Reference CH2M HILL, SOP HSE-306, *Earthmoving Equipment*)

- CH2M HILL authorizes only those employees qualified by training or previous experience to operate material handling equipment. CH2M HILL employees must be evaluated prior to operating earthmoving equipment by a CH2M HILL earthmoving equipment operator evaluation designated person. This evaluation will be documented according to SOP HSE-306.
- Equipment must be checked at the beginning of each shift to ensure the equipment is in safe operating condition and free of apparent damage. The check should include: service brakes, parking brakes, emergency brakes, tires, horn, back-up alarm, steering mechanism, coupling devices, seat belts and operating controls. All defects shall be corrected before the equipment is placed in service. Documentation of this inspection must be maintained onsite at all times.
- Equipment must be on a stable foundation such as solid ground or cribbing; outriggers are to be fully extended.
- Equipment must not be used to lift personnel; loads must not be lifted over the heads of personnel.
- Equipment, or parts thereof, which are suspended must be substantially blocked or cribbed to prevent shifting before personnel are permitted to work under or between them. All controls shall be in a neutral position, with the motors stopped and brakes set.
- Equipment which is operating in reverse must have a reverse signal alarm distinguishable from the surrounding noise or a signal person when the operators view is obstructed.
- When equipment is used near energized powerlines, the closest part of the equipment must be at least 10′ from the powerlines < 50 kV. Provide an additional 4′ for every 10 kV over 50 kV. A person must be designated to observe clearances and give timely warning for all operations where it is difficult for the operator to maintain the desired clearance by visual means. All overhead powerlines must be considered to be an energized until the electrical utility authorities indicate that it is not an energized line and it has been visibly grounded.
- Underground utility lines must be located before excavation begins.
- Operators loading/unloading from vehicles are responsible for seeing that vehicle drivers are in the vehicle cab or in a safe area.

2.1.11 Hexavalent Chromium (Cr VI) Exposure

(Reference the CH2M HILL SOP HSE-513, *Hexavalent Chromium - Chromium VI*)

The OSHA permissible exposure limit (PEL) and ACGIH Threshold Limit Value (TLV) for Chromium VI is 5 ug/m^3 (insoluble) and 1 ug/m^3 (soluble) with an action level (AL) of 2.5 ug/m3 for insoluble and 0.5 ug/ m^3 for soluble. Hexavalent Chromium is considered a Human Carcinogen.

The precautions listed below shall be followed when exposed to Cr VI:

- Exposure assessments must be performed for workers who may be exposed to Cr VI above the AL.
- Avoid exposure by inhalation, skin and eye contact with fume, liquid and/or particulate Cr VI.
- Respiratory protection and other exposure controls selection shall be based on the most recent exposure monitoring results obtained from the competent person.
- Do not enter regulated work areas unless training, medical monitoring, and PPE requirements established by the competent person have been met.
- Do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas.

2.1.12 Drum Sampling Safety

Personnel are permitted to handle and/or sample drums containing certain types of waste (drilling waste, investigation-derived waste, waste from known sources) only; handling or sampling drums with unknown contents requires a plan revision or amendment approved by the CH2M HILL RHSM. The following control measures will be taken when sampling drums:

- Minimize transportation of drums.
- Sample only labeled drums or drums known to contain IDW.
- Use caution when sampling bulging or swollen drums. Relieve pressure slowly.
- If drums contain, or potentially contain, flammable materials, use non-sparking tools to open.
- Picks, chisels, and firearms may not be used to open drums.
- Reseal bung holes or plugs whenever possible.
- Avoid mixing incompatible drum contents.
- Sample drums without leaning over the drum opening.
- Transfer the content of drums using a method that minimizes contact with material.
- PPE and air monitoring requirements specified in Sections 4 and 5 must address IDW drum sampling.
- Spill-containment procedures specified in Section 7 must be appropriate for the material to be handled.
- All drums and liquid transfer equipment should be grounded to reduce the potential of a static discharge.

2.1.13 Knife Use

Open-bladed knives (e.g., box cutters, utility knives, pocket knives, machetes, and multi-purpose tools with fixed blades such as a Leathermen™) are prohibited at worksites except where the following three conditions are met:

- The open-bladed knife is determined to be the best tool for the job.

- An approved Activity Hazard Analysis (AHA) or written procedure is in place that covers the necessary safety precautions (work practices, PPE, and training).
- Knife users have been trained and follow the AHA.

Responsibilities	• Supervisors with assistance from the FTL/SC are responsible for funding and ensuring the correct tool is being used, employees wear the proper PPE when using knives, and they have reviewed this policy. • Employees are responsible for having and utilizing the proper PPE while performing an activity requiring the use of a knife. Employees are also responsible for understanding the proper use of a knife.
Glove Requirements	• In general, Kevlar cut resistant gloves are to be worn when using a knife in an occupational setting. • Other types of gloves may be required and will be identified within the AHA / written procedure. Example - Leather gloves may be worn when using the acetate sleeve cutter.

Training (Ref. VO for additional hand safety topics)	• All employees that will use a knife must be trained in the proper use. • When using a knife always cut away from yourself. • Many tasks using a utility knife require a knife edge but not a sharp point. For these tasks you can add protection against puncture wounds by using a rounded-tip blade. • If you use a folding knife, it must be a locking blade type. • Never use a knife that will fold under pressure. • If you use a fixed blade knife, make sure there is a handle guard to keep your hand from slipping forward. Also, make sure the handle is dry and non- greasy/slippery to assure a better grip. • When cutting, make the force of the cut carry the blade away from any part of your body. If you have a peculiar situation where this is not possible, protect yourself with a leather apron, or other material placed between you and the blade. Consider putting the material to be cut in a vise, or other holding device. • If you carry a fixed blade knife, use a sheath or holder. • Store utility knives safely, retract the blade or sheath an open blade before storing. Never, leave a knife with the blade exposed on the floor, on a pallet, on a work surface, or in a drawer or cabinet. • Keep your knife sharp. A dull blade requires you to use more force to cut, and consequently increases the risk of slip or mistake. • Knives used on the job, but not carried with you , must be properly stored when not in use • Never use a defective knife. • Utility knife blades are brittle and can snap easily. Don’t bend them or apply side loads to them by using them to open cans or pry loose objects. Use the knife only to cut. It was not designed to work as a prybar, screw driver, hole punch, and other assorted things that make it seem so easy. • If you do get cut, seek medical attention to treat the injury by notifying your supervisor and contacting WorkCare at 1-866-893-2514.

Examples of preferred tools and Kevlar cut resistant gloves:

A safety spring provides for automatic blade "shoot-back" into the handle when contact w/cutting surface is lost

Stay focused on the cutting job. It only takes a second of inattention with a sharp blade to produce a serious cut. Letting the mind wander or talking with others while using a knife greatly increases the risk of an accident and injury. If you are interrupted while working with a knife, stop cutting, retract the blade, and place the knife down on a secure surface before dealing with the interruption. You should never continue cutting while distracted!

As always, utilize the hierarchy of controls and first attempt to engineer out the hazard and frequently ask ourselves do we have the right tool for the job.

2.1.14 Lead

(Reference CH2M HILL SOP HSE-508, *Lead*)

CH2M HILL is required to control employee exposure to lead when exposures are at or above 30 $\mu g/m^3$ by implementing a program that meets the requirements of the OSHA Lead standard, 29 CFR 1910.1025 and 29 CFR 1926.62.

The Lead Competent Person, provided by the subcontractor, is required to identify existing and potential lead hazards in the work environment and take prompt corrective action to eliminate or control such hazards. The designated “competent person” must be, at a minimum, able to:

- Establish regulated areas and ensure that access to and from those areas is limited to authorized employees.
- Ensure the adequacy of any employee exposure monitoring.
- Ensure that all employees exposed to airborne lead levels above the PEL wear the appropriate personal protective equipment and are trained to use appropriate methods to control lead exposure.
- Ensure that proper hygiene facilities are provided and that workers are trained to use these facilities.
- Ensure that required engineering controls are implemented, maintained in proper operating condition, and functioning properly.

Exposure Monitoring

When airborne concentrations of lead are anticipated during work activities such as remediation, construction or demolition, an initial exposure assessment shall be conducted to determine employees' exposure to lead. Where objective data is available (within the last 12 months using the same methods/materials) that demonstrates that employee exposures to lead will not exceed airborne concentrations at or above the AL under expected site conditions, initial monitoring is not required.

- Initial exposure monitoring is conducted to document employees' breathing-zone exposures over the course of a full shift. A representative 8-hour TWA sample shall be collected for each job classification in each work area.
- When initial monitoring results are below the AL, monitoring may be suspended.
- Additional monitoring is required when there has been a change in production process, control equipment, personnel, or work practices that may result in new or additional exposures.
- Employees shall be informed in writing of exposure monitoring results within 5 working days after receipt of the results.
- Air sampling will also be performed outside the regulated area to verify that lead is not being generated outside the regulated area. One sample shall originate upwind from the work and one downwind from the work.

Respiratory Protection

- Respiratory protection must be used during the following: periods when employee exposure to lead exceeds the PEL; work operations for which engineering and work-practice controls are not sufficient to reduce employee exposure to or below the PEL; periods when an employee requests a respirator; and periods when respirators are required to provide interim protection during initial exposure assessments.
- Respiratory protection selection shall be based on the most relevant exposure monitoring results.
- A respiratory protection program, including respirator selection, shall be implemented in accordance to OSHA 29 CFR 1910.134 and with CH2M HILL SOP HSE-121, Respiratory Protection. Subcontractor respiratory protection programs shall meet or exceed these requirements.
- When air-purifying respirators are utilized, the HEPA filters shall be replaced at the beginning of each shift.
- Powered air-purifying respirators (PAPR) shall be provided to employees who request such a respirator and where it will provide adequate protection.
- If an exposure assessment for this type of removal is not available, the assumption is that this is an abrasive blasting operation. It will be assumed that concentrations of airborne lead will be in excess of 2,500 ug/m^3 and supplied air respiratory protection will be required within the regulated area.

TABLE FROM 29 CFR 1926.62 - RESPIRATORY PROTECTION FOR LEAD AEROSOLS

Airborne Concentration of Lead or Condition of Use	Required respirator[1]
Not in excess of 500 ug/m3	- 1/2 mask air purifying respirator with high efficiency filters2,3. - 1/2 mask supplied air respirator operated in demand (negative pressure) mode.
Not in excess of 1,250 ug/m3	Loose fitting hood or helmet powered air purifying respirator with high efficiency filters3. - Hood or helmet supplied air respirator operated in a continuous-flow mode - e.g., type CE abrasive blasting respirators operated in a continuous-flow mode.
Not in excess of 2,500 ug/m3	Full facepiece air purifying respirator with high efficiency filters3. - Tight fitting powered air purifying respirator with high efficiency filters3. - Full facepiece supplied air respirator operated in demand mode. - 1/2 mask or full facepiece supplied air respirator operated in a continuous-flow mode. - Full facepiece self-contained breathing apparatus (SCBA) operated in demand mode.
Not in excess of 50,000 ug/m3	1/2 mask supplied air respirator operated in pressure demand or other positive-pressure mode.
Not in excess of 100,000 ug/m3	- Full facepiece supplied air respirator operated in pressure demand or other positive-pressure mode - e.g., type CE abrasive blasting respirators operated in a positive-pressure mode.
Greater than 100,000 ug/m3 unknown concentration, or fire fighting	Full facepiece SCBA operated in pressure demand or other positive-pressure mode.

[1]Respirators specified for higher concentrations can be used at lower concentrations of lead.
[2]Full facepiece is required if the lead aerosols cause eye or skin irritation at the use concentrations.
[3]A high efficiency particulate filter (HEPA) means a filter that is a 99.97 percent efficient against particles of 0.3 micron size or larger.

PPE

- Personnel shall wear disposable coveralls, booties and inner and outer gloves when inside the regulated area and exercise enhanced personal hygiene (for example, frequent hand washing prior to eating, drinking, and smoking; separation of work and street clothing and footwear; etc.).
- Contact lenses should not be worn when working with lead.
- Employee shall not be allowed to leave the regulated area wearing any protective clothing or equipment that is required during the work shift.
- All clothing requiring laundering will be packaged in a sealed container. Containers shall be labeled as follows: "Caution: Clothing contaminated with lead; do not remove dust by blowing or shaking. Dispose of lead-contaminated wash water in accordance with applicable local, state, or federal regulations."

Written Lead Compliance Program

When employee exposures are greater than the PEL, a written lead compliance program shall be established and implemented prior to commencement of operations. The written program shall outline the plans for maintaining employee exposure below the PEL. The compliance program shall be based on the most recent exposure monitoring data. The program shall be revised when exposure monitoring data is updated or at least annually to reflect the status of the program.

Regulated Areas

- Regulated areas shall be documented as part of the written lead compliance program.
- Regulated areas are those where airborne concentrations of lead are above the PEL without regard to the use of respirators. Personnel shall not enter regulated areas unless training, medical monitoring, and PPE, including respirator protection, requirements have been met.
- Regulated areas shall be demarcated and entry to these areas shall be limited. Only authorized personnel are allowed in these areas.
- The entrance to regulated areas shall be posted with signs that read "WARNING-LEAD WORK AREA-POISON-NO SMOKING OR EATING" so that necessary protective steps can be taken before entering regulated areas.
- Where feasible, shower facilities shall be installed and employees who work in regulated areas shall be required to shower at the end of the work shift. These facilities must be provided with an adequate supply of cleaning agents and towels.
- Hand washing facilities shall be provided for employees working in regulated areas. Furthermore, employees shall be required to wash their hands and face at the end of each work shift and prior to eating or entering eating facilities, drinking, smoking, or applying cosmetics.
- Employees shall not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in any areas where exposure to lead is above the PEL (that is, regulated areas).
- In addition to the posting requirements, written or verbal notification to owners, contractors, and other personnel working in the area shall be made.

Housekeeping

- Where airborne lead concentrations exceed the PEL, housekeeping procedures shall be documented in the written lead compliance program.
- All surfaces shall be maintained as free as possible of accumulations of lead. Methods selected for cleaning of surfaces and floors shall be those that minimize the likelihood of lead becoming airborne (for example, vacuuming).
- Where vacuuming methods are selected, the vacuums shall be used and emptied in a manner that minimizes the reentry of lead into the workplace.
- Compressed air shall not be used to remove lead from any surface unless used in conjunction with a ventilation system designed to capture the airborne dust created by the compressed air.
- Waste containing significant amounts of lead may be subject to hazardous waste regulations and the corresponding generation, treatment and disposal requirements.

Medical Monitoring

- CH2M HILL shall make available initial medical surveillance (baseline) to employees occupationally exposed on any day to lead at or above the AL. Initial medical surveillance consists of biological monitoring in the form of blood sampling and analysis for lead and zinc protoporphyrin (ZPP) levels.

Training

- CH2M HILL employees must complete the on-line Lead Exposure Module located on the HSSE web page of the virtual office and project-specific lead-exposure-control training.

Project-specific lead-exposure-control training shall include the following:

- Discussion of site-specific lead hazards and associated control measures,
- Information contained in the Lead Fact Sheet
- Quantity, location, manner of use, storage, sources of exposure, and the specific nature of operations that could result in exposure to lead, as well as any necessary protective steps,
- Purpose, proper use, and limitation of respirators,
- Purpose and a description of the medical surveillance program,
- Engineering controls and work practices associated with the employee's job assignment, and
- A review of the OSHA Lead Standard and appendices if requested by an employee See SOP-508, Lead, for further requirements.

2.1.15 Lockout/Tagout Activities

(Reference CH2M HILL SOP HSE-310, *Lockout and Tagout*)

- Only qualified personnel may work on energized equipment that has not been deenergized by lockout/tagout procedures.
- When CH2M HILL controls the work, CH2M HILL must verify that subcontractors affected by the unexpected operation of equipment develop a written lockout/tagout program, provide training on lockout/tagout procedures and coordinate its program with other affected subcontractors. This may include compliance with the owner or facility lockout/ tagout program.
- When CH2M HILL personnel are affected by the unexpected operation of equipment they must complete the lockout/tagout training course in the Basic Program. Project training may also be required on site specific lockout procedures.
- Standard lockout/tagout procedures include the following six steps: 1) notify all personnel in the affected area of the lockout/tagout, 2) shut down the equipment using normal operating controls, 3) isolate all energy sources, 4) apply individual lock and tag to each energy isolating device, 5) relieve or restrain all potentially hazardous stored or residual energy, and 6) verify that isolation and deenergization of the equipment has been accomplished. Once verified that the equipment is at the zero energy state, work may begin.

- All safe guards must be put back in place, all affected personnel notified that lockout has been removed and controls positioned in the safe mode prior to lockout removal. Only the individual who applied the lock and tag may remove them.

2.1.16 Manual Lifting

(Reference CH2M HILL SOP HSE-112, *Manual Lifting*)

- Back injuries are the leading cause of disabling work and most back injuries are the result of improper lifting techniques or overexertion. Office or field tasks and activities involving manual lifting are to be identified and a program implemented to assist employees to mitigate the risks associated with manual lifting.
- When possible, the task should be modified to minimize manual lifting hazards.
- Lifting of loads weighing more than 40 pounds (18 kilograms) should be evaluated by the SC using the Lifting Evaluation Form contained in SOP HSE-112.
- Using mechanical lifting devices is the preferred means of lifting heavy objects such as forklifts; cranes, hoists, and rigging; hand trucks; and trolleys.
- Personnel shall seek assistance when performing manual lifting tasks that appear beyond their physical capabilities.
- In general, the following steps must be practiced when planning and performing manual lifts: Assess the situation before you lift; ensure good lifting and body positioning practices; ensure good carrying and setting down practices.
- All employees must receive training for the correct procedures to lift safely using the computer-based health and safety training or project-specific training.

2.1.17 Noise

(Reference CH2M HILL SOP HSE-108, *Hearing Conservation*)

- A noise assessment shall be conducted by the RHSM or designee based on potential to emit noise above 85 dBA.
- Areas or equipment emitting noise at or above 90dBA shall be evaluated to determine feasible engineering controls. When engineering controls are not feasible, administrative controls can be developed and appropriate hearing protection will be provided.
- Areas or equipment emitting noise levels at or above 85 dBA, hearing protection must be worn.
- Employees exposed to 84 dBA or a noise dose of 50% must participate in the Hearing Conservation program including initial and annual (as required) audiograms.
- The RHSM will evaluate appropriate controls measures and work practices for employees who have experienced a standard threshold shift (STS) in their hearing.
- Hearing protection is selected based upon noise levels and specific tasks to be performed.
- Employees are trained in the hazards of noise and how to properly wear and maintain their hearing protection.

- Hearing protection will be maintained in a clean and reliable condition, inspected prior to use and after any occurrence to identify any deterioration or damage, and damaged or deteriorated hearing protection repaired or discarded.
- In work areas where actual or potential high noise levels are present at any time, hearing protection must be worn by employees working or walking through the area.
- Areas where tasks requiring hearing protection are taking place may become hearing protection required areas as long as that specific task is taking place.
- High noise areas requiring hearing protection should be posted or employees must be informed of the requirements in an equivalent manner.

2.1.18 Pressure Washing Operations

- Only trained, authorized personnel may operate the high-pressure washer.
- Follow manufacturer's safety and operating instructions.
- Inspect pressure washer before use and confirm deadman switch fully operational
- The wand must always be pointed at the work area.
- The trigger should never be tied down
- Never point the wand at yourself or another worker.
- The wand must be at least 42 inches from the trigger to the tip.
- The operator must maintain good footing.
- Non-operators must remain a safe distance from the operator.
- No unauthorized attachment may be made to the unit.
- Do not modify the wand.
- All leaks or malfunctioning equipment must be repaired immediately or the unit taken out-of-service.
- Polycoated Tyvek or equivalent, 16-inch-high steel-toed rubber boots, safety glasses, hard hat with face shield, and inner and outer nitrile gloves will be worn, at a minimum.

2.1.19 Utilities (underground)

Do not begin subsurface construction activities (e.g., trenching, excavation, drilling, etc.) until a check for underground utilities and similar obstructions has been conducted. 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 to identify additional and undiscovered buried utilities.

Examples of the type of geophysical technologies include:

- **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.

Procedure

The following procedures shall be used to identify and mark underground utilities during subsurface construction activities on the project:

- The survey contractor shall determine the most appropriate geophysical technique or combinations of techniques to identify the buried utilities on the project, based on the survey contractor's experience and expertise, types of utilities anticipated to be present, and specific site conditions.
- The survey contractor shall employ the same geophysical techniques used on the project to identify the buried utilities, to survey the proposed path of subsurface construction work, and to confirm no buried utilities are present.
- Identify customer specific permit and/or procedural requirements for excavation and drilling activities. For military installations contact the Base Civil Engineer and obtain the appropriate form to begin the clearance process.
- Contact utility companies or the state/regional utility protection service at least two (2) working days prior to excavation 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.
- Schedule the independent survey.
- Obtain utility clearances for subsurface work on both public and private property.
- Clearances are to be in writing, signed by the party conducting the clearance.
- Underground utility locations must be physically verified by hand digging using wood or fiberglass-handled tools when any adjacent subsurface construction activity (e.g. mechanical drilling, excavating) work is expected to come within 5 feet of the marked underground system. If subsurface construction activity is within 5 feet and parallel to a marked existing utility, the utility location must be exposed and verified by hand digging every 100 feet.
- 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.

- Conduct a site briefing for employees 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.

2.1.20 Utilities (overhead)

Proximity to Power Lines

No work is to be conducted within 50 feet of overhead power lines without first contacting the utility company to determine the voltage of the system. No aspect of any piece of equipment is to be operated within 50 feet of overhead power lines without first making this determination.

Operations adjacent to overhead power lines are PROHIBITED unless one of the following conditions is satisfied:

- Power has been shut off, positive means (such as lockout) have been taken to prevent the lines from being energized, lines have been tested to confirm the outage, and the utility company has provided a signed certification of the outage.
- The minimum clearance from energized overhead lines is as shown in the table below, or the equipment will be repositioned and blocked to ensure that no part, including cables, can come within the minimum clearances shown in the table.

MINIMUM DISTANCES FROM POWERLINES

Powerlines Nominal System Kv	Minimum Required Distance, Feet
0-50	10
51-100	12
101-200	15
201-300	20
301-500	25
501-750	35
751-1000	45

(These distances have been determined to eliminate the potential for arcing based on the line voltage.)

- The power line(s) has been isolated through the use of insulating blankets which have been properly placed by the utility. If insulating blankets are used, the utility will determine the minimum safe operating distance; get this determination in writing with the utility representative's signature.
- All inquiries regarding electric utilities must be made in writing and a written confirmation of the outage/isolation must be received by the Project Manager/Construction Manager prior to the start of work.

2.1.21 Visible Lighting

- While work is in progress outside construction areas shall have at least 33 lux (lx).
- Construction work conducted inside buildings should be provided with at least 55 lux light.

- The means of egress shall be illuminated with emergency and non-emergency lighting to provide a minimum 11 lx measured at the floor. Egress illumination shall be arranged so that the failure of any single lighting unit, including the burning out of an electric bulb will not leave any area in total darkness.

2.1.22 Mercury (Health Risk & Safety Tips)

Mercury releases present a serious environmental and health problem. Inhaling mercury vapors, which are colorless and odorless, can cause irreversible damage to the brain and kidneys. The relatively small quantity of mercury found in a common medical thermometer (approximately one gram) has the potential to cause adverse health effects if released and not cleaned up appropriately.

Health impacts will increase over time if the mercury is not properly removed. Mercury vapors are heavier than air and tend to remain near the floor or mercury source, but can get into the ventilation system and be spread throughout a house or business. Indoors, mercury vapors will accumulate in the air. People can absorb mercury into their bodies when they breathe the vapors.

2.1.23 Common Mistakes To Avoid When Dealing With A Mercury Release

- Never use a vacuum cleaner to clean up mercury. The vacuum will put mercury into the air and increase exposure.
- Never use a broom to clean up mercury. It will break the mercury into smaller droplets and spread them.
- Never pour mercury down a drain. It may lodge in the plumbing and cause future problems during plumbing repairs. If discharged, it can cause pollution of the septic tank or sewage treatment plant.
- Never wash clothing or other items that have come in direct contact with mercury in a washing machine, because mercury may contaminate the machine and/or pollute sewage. Clothing that has come into direct contact with mercury should be discarded. By "direct contact," we mean that mercury was (or has been) spilled directly on the clothing.
- Never walk around if your shoes might be contaminated with mercury. Contaminated clothing can also spread mercury around.

2.1.24 Working over Water

If any activities pose a risk to drowning do the following during the activity:

- Fall protection should be provided to prevent personnel from falling into water. Where fall protection systems are not provided and the danger of drowning exists, U.S. Coast Guard-approved personal flotation devices (PFDs), or a life jacket, shall be worn.
- Provide employees with an approved (USCG for U.S. operations) life jacket or buoyant work vest.
  - Employees should inspect life jackets or work vests daily before use for defects. Do not use defective jackets or vests.

- Post ring buoys with at least 90 feet of of 3/8-inch solid-braid polypropylene (or equal) line next to the work area. If the work area is large, post extra buoys 200 feet or less from each other.
- Provide at least one life saving skiff, immediately available at locations where employees are working over or adjacent to water.
  - Ensure the skiff is in the water and capable of being launched by one person and is equipped with both motor and oars.
- Designate at least one employee on site to respond to water emergencies and operate the skiff at times when there are employees above water.
  - If the designated skiff operator is not within visual range of the water, provide him or her with a radio or provide some form of communication to inform them of an emergency.
  - Designated employee should be able to reach a victim in the water within three to four minutes.
- Ensure at least one employee trained in CPR and first aid is on site during work activities.
- No smoking is permitted on board vessels or during refueling operations.
- The boat skipper has the final authority with regard to boat safety and navigational safety.
- Use the checklist below to evaluate vessel integrity.

Marine Vessel Checklist		
	Yes	**N/A**
Personal Flotation Devices (PFDs)		
Visual Distress Signals		
Anchor and Anchor Line		
Sound-Producing Devices		
Navigation Lights and Shapes		
Fire Extinguishers		
Alternative Propulsion (for example, paddles)		
Overall Vessel Condition Satisfactory		
State Requirements		
Marine Sanitation Device		
Navigation Rules		
Ropes and Buoys		
First Aid Kit and Bloodborne Pathogen Kit		
Nonslip Deck		
Personnel Access Ladder		

2.2 General Hazards

2.2.1 General Practices and Housekeeping

- Site work should be performed during daylight hours whenever possible.
- Good housekeeping must be maintained at all times in all project work areas.
- Common paths of travel should be established and kept free from the accumulation of materials.
- Keep access to aisles, exits, ladders, stairways, scaffolding, and emergency equipment free from obstructions.
- Provide slip-resistant surfaces, ropes, and/or other devices to be used.
- Specific areas should be designated for the proper storage of materials.
- Tools, equipment, materials, and supplies shall be stored in an orderly manner.
- As work progresses, scrap and unessential materials must be neatly stored or removed from the work area.
- Containers should be provided for collecting trash and other debris and shall be removed at regular intervals.
- All spills shall be quickly cleaned up. Oil and grease shall be cleaned from walking and working surfaces.
- Review the safety requirements of each job you are assigned to with your supervisor. You are not expected to perform a job that may result in injury or illness to yourself or to others.
- Familiarize yourself with, understand, and follow jobsite emergency procedures.
- Do not fight or horseplay while conducting the firm’s business.
- Do not use or possess firearms or other weapons while conducting the firm’s business.
- Report unsafe conditions or unsafe acts to your supervisor immediately.
- Report occupational illnesses, injuries, and vehicle accidents.
- Do not remove or make ineffective safeguards or safety devices attached to any piece of equipment.
- Report unsafe equipment, defective or frayed electrical cords, and unguarded machinery to your supervisor.
- Shut down and lock out machinery and equipment before cleaning, adjustment, or repair. Do not lubricate or repair moving parts of machinery while the parts are in motion.
- Do not run in the workplace.
- When ascending or descending stairways, use the handrail and take one step at a time.
- Do not apply compressed air to any person or clothing.
- Do not wear steel taps or shoes with metal exposed to the sole at any CH2M HILL project location.

- Do not wear finger rings, loose clothing, wristwatches, and other loose accessories when within arm's reach of moving machinery.
- Remove waste and debris from the workplace and dispose of in accordance with federal, state, and local regulations.
- Note the correct way to lift heavy objects (secure footing, firm grip, straight back, lift with legs), and get help if needed. Use mechanical lifting devices whenever possible.
- Check the work area to determine what problems or hazards may exist.

2.2.2 Personal Hygiene

- Keep hands away from nose, mouth, and eyes.
- Keep areas of broken skin (chapped, burned, etc.) covered.
- Wash hands with hot water and soap frequently prior to eating and smoking.

2.2.3 Substance Abuse

(Reference CH2M HILL SOP HSE-105, *Drug-Free Workplace*)

Employees who work under the influence of controlled substances, drugs, or alcohol may prove to be dangerous or otherwise harmful to themselves, other employees, clients, the company, the company's assets and interests, or the public. CH2M HILL does not tolerate illegal drug use, or any use of drugs, controlled substances, or alcohol that impairs an employee's work performance or behavior. Drug and/or alcohol testing is applicable under CCI and munitions response projects performed in the United States. In addition, employees may be required to submit to drug and/or alcohol testing as required by clients. When required, this testing is performed in accordance with SOP HSE-105, Drug-Free Workplace. Employees who are enrolled in drug or alcohol testing are required to complete annual training located on the VO.

Prohibitions onsite include:

- Use or possession of intoxicating beverages while performing CH2M HILL work.
- Abuse of prescription or nonprescription drugs.
- Use or possession of illegal drugs or drugs obtained illegally.
- Sale, purchase, or transfer of legal, illegal or illegally obtained drugs.
- Arrival at work under the influence of legal or illegal drugs or alcohol.

2.2.4 Driving

- Always be aware of surroundings while operating a vehicle. Avoid intellectual stress & worries, talking on a cellular phone, eating, drinking, smoking, reading a map, adjusting controls or looking at a passenger while driving.
- Use prudent speed limits, assure that backup warning devices are working, be aware of blind spots or other hazards associated with low visibility, etc. Use a spotter if necessary.
- Do no drive while drowsy. Drowsiness can occur at any time, but is most likely after 18 hours or more without sleep.

2.2.5 Hazard Communication

(Reference CH2M HILL SOP HSE-107, *Hazard Communication)*

The Hazard Communication Coordinator is to perform the following:

- Complete an inventory of chemicals brought on site by CH2M HILL using Attachment 2.
- Confirm that an inventory of chemicals brought on site by CH2M HILL subcontractors is available.
- Request or confirm locations of Material Safety Data Sheets (MSDSs) from the client, contractors, and subcontractors for chemicals to which CH2M HILL employees potentially are exposed.
- Before or as the chemicals arrive on site, obtain an MSDS for each hazardous chemical.
- Label chemical containers with the identity of the chemical and with hazard warnings, and store properly.
- Give employees required chemical-specific HAZCOM training using Attachment 3.
- Store all materials properly, giving consideration to compatibility, quantity limits, secondary containment, fire prevention, and environmental conditions.

2.2.6 Inclement Weather

Sudden inclement weather can rapidly encroach upon field personnel. Preparedness and caution are the best defenses. Field crew members performing work outdoors should carry clothing appropriate for inclement weather. Personnel are to take heed of the weather forecast for the day and pay attention for signs of changing weather that indicate an impending storm. Signs include towering thunderheads, darkening skies, or a sudden increase in wind. If stormy weather ensues, field personnel should discontinue work and seek shelter until the storm has passed.

Protective measures during a lightning storm include seeking shelter; avoiding projecting above the surrounding landscape (don't stand on a hilltop--seek low areas) and ceasing intrusive work inside a building (i.e. DPT), staying away from open water, metal equipment, railroad tracks, wire fences, and metal pipes; and positioning people several yards apart. Some other general precautions include:

- Know where to go and how long it will take to get there. If possible, take refuge in a large building or vehicle. Do not go into a shed in an open area.
- The inclination to see trees as enormous umbrellas is the most frequent and most deadly mistake. Do not go under a large tree that is standing alone. Likewise, avoid poles, antennae and towers.
- If the area is wide open, go to a valley or ravine, but be aware of flash flooding.
- If you are caught in a level open area during an electrical storm and you feel your hair stand on end, drop to your knees, bend forward and put your hands on your knees or crouch. The idea is to make yourself less vulnerable by being as low to the ground as possible and taking up as little ground space as possible. Lying down is dangerous, since the wet earth can conduct electricity. Do not touch the ground with your hands.

- Do not use telephones during electrical storms, except in the case of emergency

Remember that lightning may strike several miles from the parent cloud, so work should be stopped/restarted accordingly. The lightning safety recommendation is 30-30: Seek refuge when thunder sounds within 30 seconds after a lightning flash; and do not resume activity until 30 minutes after the last thunder clap.

High winds can cause unsafe conditions, and activities should be halted until wind dies down. High winds can also knock over trees, so walking through forested areas during high-wind situations should be avoided. If winds increase, seek shelter or evacuate the area. Proper body protection should be worn in case the winds hit suddenly, because body temperature can decrease rapidly.

2.2.7 Shipping and Transportation of Chemical Products

(Reference CH2M HILL's Procedures for Shipping and Transporting Dangerous Goods)

Chemicals brought to the site might be defined as hazardous materials by the U.S. Department of Transportation (DOT). All staff who ship the materials or transport them by road must receive CH2M HILL training in shipping dangerous goods. All hazardous materials that are shipped (e.g., via Federal Express) or are transported by road must be properly identified, labeled, packed, and documented by trained staff. Contact the RHSM or the Warehouse Coordinator for additional information.

2.2.8 Ultraviolet (UV) Radiation (sun exposure)

Health effects regarding UV radiation are confined to the skin and eyes. Overexposure can result in many skin conditions, including erythema (redness or sunburn), photoallergy (skin rash), phototoxicity (extreme sunburn acquired during short exposures to UV radiation while on certain medications), premature skin aging, and numerous types of skin cancer.

Acute overexposure of UV radiation to the eyes may lead to photokeratitis (inflammation of the cornea), also known as snow blindness. Symptoms include redness of the eyes and a gritty feeling, which progresses to pain and an inability to tolerate any kind of light. This condition can also occur when working in or around water and other UV radiation reflectors. In addition, long-term exposure to sunlight is thought to cause cataracts or clouding of the lens of the eye.

Limit Exposure Time

- Rotate staff so the same personnel are not exposed all of the time.
- Limit exposure time when UV radiation is at peak levels (approximately 2 hours before and after the sun is at its highest point in the sky).
- Avoid exposure to the sun, or take extra precautions when the UV index rating is high.

Provide Shade

- Take lunch and breaks in shaded areas.
- Create shade or shelter through the use of umbrellas, tents, and canopies.

- Fabrics such as canvas, sailcloth, awning material and synthetic shade cloth create good UV radiation protection.
- Check the UV protection of the materials before buying them. Seek protection levels of 95 percent or greater, and check the protection levels for different colors.

Clothing

- Reduce UV radiation damage by wearing proper clothing; for example, long sleeved shirts with collars, and long pants. The fabric should be closely woven and should not let light through.
- Head protection should be worn to protect the face, ears, and neck. Wide-brimmed hats with a neck flap or "Foreign Legion" style caps offer added protection.
- Wear UV-protective sunglasses or safety glasses. These should fit closely to the face. Wrap-around style glasses provide the best protection.

Sunscreen

- Apply sunscreen generously to all exposed skin surfaces at least 20 minutes before exposure, allowing time for it to adhere to the skin.
- Re-apply sunscreen at least every 2 hours, and more frequently when sweating or performing activities where sunscreen may be wiped off.
- Choose a sunscreen with a high sun protection factor (SPF). Most dermatologists advocate SPF 30 or higher for significant sun exposure.
- Waterproof sunscreens should be selected for use in or near water, and by those who perspire sufficiently to wash off non-waterproof products.
- Check for expiration dates, because most sunscreens are only good for about 3 years. Store in a cool place out of the sun.
- Remember—no sunscreen provides 100% protection against UV radiation. Other precautions must be taken to avoid overexposure.

2.2.9 Temperature Extremes

Each employee is responsible for the following:

- Recognizing the symptoms of heat or cold stress
- Taking appropriate precautionary measures to minimize their risk of exposure to temperature extremes
- Communicating any concerns regarding heat and cold stress to their supervisor or SC

Heat Stress

General

Physical fitness influences a person's ability to perform work under heat loads. At a given level of work, the more fit a person is, the less the physiological strain, the lower the heart rate, the lower the body temperature (indicates less retrained body heat—a rise in internal temperature precipitates heat injury), and the more efficient the sweating mechanism.

Acclimatization is the degree to which a worker's body has physiologically adjusted or acclimatized to working under hot conditions. Acclimatization affects their ability to do work. Acclimatized individuals sweat sooner and more profusely than unacclimatized individuals. Acclimatization occurs gradually over 1 to 2 weeks of continuous exposure, but it can be lost in as little as 3 days in a cooler environment.

Dehydration reduces body water volume. This reduces the body's sweating capacity and directly affects its ability to dissipate excess heat.

The ability of a body to dissipate heat depends on the ratio of its surface area to its mass (surface area/weight). **Heat dissipation** is a function of surface area, while heat production depends on body mass. Therefore, overweight individuals (those with a low ratio) are more susceptible to heat-related illnesses because they produce more heat per unit of surface area than if they were thinner. Monitor these persons carefully if heat stress is likely.

When wearing **impermeable clothing**, the weight of an individual is not as important in determining the ability to dissipate excess heat because the primary heat dissipation mechanism, evaporation of sweat, is ineffective.

SYMPTOMS AND TREATMENT OF HEAT STRESS					
	Heat Syncope	**Heat Rash**	**Heat Cramps**	**Heat Exhaustion**	**Heat Stroke**
Signs and Symptoms	Sluggishness or fainting while standing erect or immobile in heat.	Profuse tiny raised red blister-like vesicles on affected areas, along with prickling sensations during heat exposure.	Painful spasms in muscles used during work (arms, legs, or abdomen); onset during or after work hours.	Fatigue, nausea, headache, giddiness; skin clammy and moist; complexion pale, muddy, or flushed; may faint on standing; rapid thready pulse and low blood pressure; oral temperature normal or low	Red, hot, dry skin; dizziness; confusion; rapid breathing and pulse; high oral temperature.
Treatment	Remove to cooler area. Rest lying down. Increase fluid intake. Recovery usually is prompt and complete.	Use mild drying lotions and powders, and keep skin clean for drying skin and preventing infection.	Remove to cooler area. Rest lying down. Increase fluid intake.	Remove to cooler area. Rest lying down, with head in low position. Administer fluids by mouth. Seek medical attention.	Cool rapidly by soaking in cool–but not cold–water. Call ambulance, and get medical attention immediately!

Precautions

- Drink 16 ounces of water before beginning work. Disposable cups and water maintained at 50°F to 60°F should be available. Under severe conditions, drink 1 to 2 cups every 20 minutes, for a total of 1 to 2 gallons per day. Do not use alcohol in place of water or other nonalcoholic fluids. Decrease your intake of coffee and caffeinated soft drinks during working hours.
- Acclimate yourself by slowly increasing workloads (e.g., do not begin with extremely demanding activities).

- Use cooling devices, such as cooling vests, to aid natural body ventilation. These devices add weight, so their use should be balanced against efficiency.
- Use mobile showers or hose-down facilities to reduce body temperature and cool protective clothing.
- Conduct field activities in the early morning or evening and rotate shifts of workers, if possible.
- Avoid direct sun whenever possible, which can decrease physical efficiency and increase the probability of heat stress. Take regular breaks in a cool, shaded area. Use a wide-brim hat or an umbrella when working under direct sun for extended periods.
- Provide adequate shelter/shade to protect personnel against radiant heat (sun, flames, hot metal).
- Maintain good hygiene standards by frequently changing clothing and showering.
- Observe one another for signs of heat stress. Persons who experience signs of heat syncope, heat rash, or heat cramps should consult the SC to avoid progression of heat-related illness.

Thermal Stress Monitoring

The following procedures should be implemented when the ambient air temperature exceeds 70° F, the relative humidity is high (greater than 50 percent), or when the workers exhibit symptoms of heat stress.

- The heart rate should be measured by the radial pulse for 30 seconds, as early as possible in the resting period.
- The heart rate at the beginning of the rest period should not exceed 110 beats per minute, or 20 beats per minute above resting pulse.
- If the heart rate is higher, the next work period should be shortened by 33 percent, while the length of the rest period stays the same.
- If the pulse rate still exceeds 110 beats per minute at the beginning of the next rest period, the following work cycle should be further shortened by 33 percent.
- Continue this procedure until the rate is maintained below 110 beats per minute, or 20 beats per minute above resting pulse.
- Alternately, the oral temperature can be measured before the workers have something to drink.
- If the oral temperature exceeds 99.6 degrees F at the beginning of the rest period, the following work cycle should be shortened by 33 percent.
- Continue this procedure until the oral temperature is maintained below 99.6 degrees F. While an accurate indication of heat stress, oral temperature is difficult to measure in the field.

Cold

General

Low ambient temperatures increase the heat lost from the body to the environment by radiation and convection. In cases where the worker is standing on frozen ground, the heat loss is also due to conduction.

Wet skin and clothing, whether because of water or perspiration, may conduct heat away from the body through evaporative heat loss and conduction. Thus, the body cools suddenly when chemical protective clothing is removed if the clothing underneath is perspiration soaked.

Movement of air across the skin reduces the insulating layer of still air just at the skin's surface. Reducing this insulating layer of air increases heat loss by convection.

Non-insulating materials in contact or near-contact with the skin, such as boots constructed with a metal toe or shank, conduct heat rapidly away from the body.

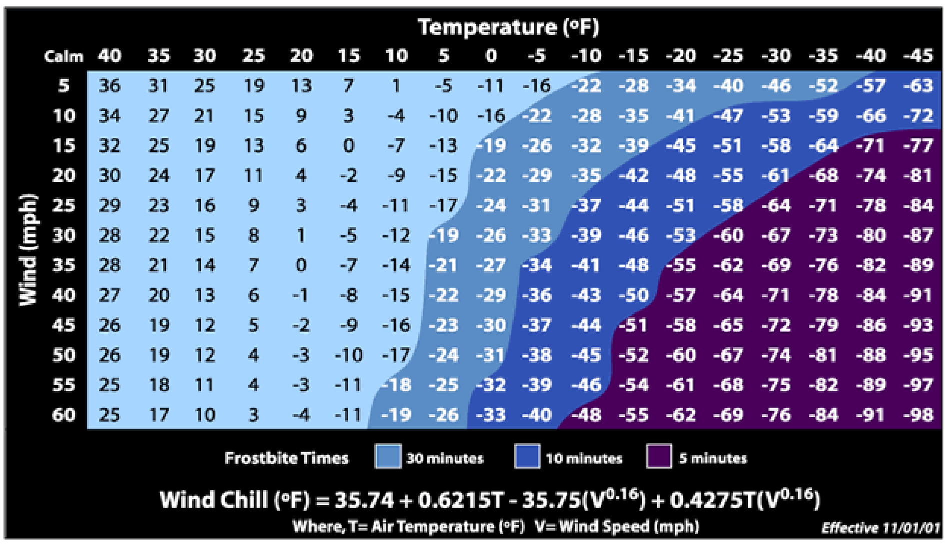
Certain common drugs, such as alcohol, caffeine, or nicotine, may exacerbate the effects of cold, especially on the extremities. These chemicals reduce the blood flow to peripheral parts of the body, which are already high-risk areas because of their large surface area to volume ratios. These substances may also aggravate an already hypothermic condition.

Precautions

- Be aware of the symptoms of cold-related disorders, and wear proper, layered clothing for the anticipated fieldwork. Appropriate rain gear is a must in wet weather.
- Consider monitoring the work conditions and adjusting the work schedule using guidelines developed by the U.S. Army (wind-chill index) and the National Safety Council (NSC).
- Wind-Chill Index (below) is used to estimate the combined effect of wind and low air temperatures on exposed skin. The wind-chill index does not take into account the body part that is exposed, the level of activity, or the amount or type of clothing worn. For those reasons, it should only be used as a guideline to warn workers when they are in a situation that can cause cold-related illnesses.
- NSC Guidelines for Work and Warm-Up Schedules can be used with the wind-chill index to estimate work and warm-up schedules for fieldwork. The guidelines are not absolute; workers should be monitored for symptoms of cold-related illnesses. If symptoms are not observed, the work duration can be increased.
- Persons who experience initial signs of immersion foot, frostbite, and/or hypothermia should report it immediately to their supervisor/PM to avoid progression of cold-related illness.
- Observe one another for initial signs of cold-related disorders.
- Obtain and review weather forecast – be aware of predicted weather systems along with sudden drops in temperature, increase in winds, and precipitation.

SYMPTOMS AND TREATMENT OF COLD STRESS			
	Immersion (Trench) Foot	**Frostbite**	**Hypothermia**
Signs and Symptoms	Feet discolored and painful; infection and swelling present.	Blanched, white, waxy skin, but tissue resilient; tissue cold and pale.	Shivering, apathy, sleepiness; rapid drop in body temperature; glassy stare; slow pulse; slow respiration.
Treatment	Seek medical treatment immediately.	Remove victim to a warm place. Re-warm area quickly in warm–but **not** hot–water. Have victim drink warm fluids, but **not** coffee or alcohol. Do not break blisters. Elevate the injured area, and get medical attention.	Remove victim to a warm place. Have victim drink warm fluids, but **not** coffee or alcohol. Get medical attention.

Wind Chill Chart



Wind (mph)	Temperature (°F)																	
Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T = Air Temperature (°F) V = Wind Speed (mph)

Effective 11/01/01

2.3 Biological Hazards and Controls

2.3.1 Bees and Other Stinging Insects

Bees and other stinging insects may be encountered almost anywhere and may present a serious hazard, particularly to people who are allergic. Watch for and avoid nests. Keep exposed skin to a minimum. Carry a kit if you have had allergic reactions in the past, and inform your supervisor and/or buddy. If a stinger is present, remove it carefully with tweezers. Wash and disinfect the wound, cover it, and apply ice. Watch for allergic reaction; contact the occupational nurse at 1-866-893-2514 immediately if a reaction develops or 911 if the reaction is severe.

2.3.2 Bloodborne Pathogens

(Reference CH2M HILL SOP HSE-202, *Bloodborne Pathogens*)

Exposure to bloodborne pathogens may occur when rendering first aid or CPR, or when coming into contact with landfill waste or waste streams containing potentially infectious material (PIM).

- Employees trained in first-aid/CPR or those exposed to PIM must complete CH2M HILL's 1-hour bloodborne computer-based training module annually.
- Hepatitis B vaccine (HBV) is offered to employees who may be exposed to PIM when they complete training and within 10 working days of assignment. (Note: Employees whose exposure stems only from rendering first aid as a collateral duty receives the vaccine after exposure.)
- Employees who decline the HBV vaccine must sign the declination form (contact regional Safety Program Assistant [SPA]) indicating they declined the vaccination. Anyone who declines the vaccination and chooses to receive the vaccination at a later time may still receive the vaccination by contacting the SPA.
- Hepatitis B and tetanus vaccinations can be requested by completing the medical portion of the enrollment form, located under Tools & Forms at the HS&E web page, or by contacting the regional SPA.

Work Controls

- Observe universal precautions to prevent contact with blood or other PIMs. Where differentiation between body fluid types is difficult or impossible, consider all body fluids to be potentially infectious materials.
- Consider all sharps encountered at industrial, medical, dental, or biological waste facilities or sampling locations to be contaminated and PIMs.
- Always wash your hands and face with soap and running water after contacting PIMs. If washing facilities are unavailable, use an antiseptic cleanser with clean paper towels or moist towelettes. These must be provided for employees who have been exposed to PIMs. When antiseptic cleansers or towelettes are used, always rewash your hands and face with soap and running water as soon as available. Do not consume food or beverages until after thoroughly washing your hands and face.
- Decontaminate all potentially contaminated equipment and environmental surfaces with chlorine bleach as soon as possible. Clean and decontaminate on a regular basis (and immediately upon visible contamination) all bins, pails, cans, and other receptacles intended for reuse that have the potential for becoming contaminated.
- Use one part chlorine bleach (5.25 percent sodium hypochlorite solution) diluted with 10 parts water for decontaminating equipment or surfaces after initially removing blood or other PIMs. Remove contaminated PPE as soon as possible before leaving a work area.
- Place regulated waste in containers that are closable; are constructed to contain all contents and prevent leakage of fluids during handling, storage, transport or shipping; are labeled with a Biological warning label or color-coded; and are tightly closed prior to removal to prevent spillage or protrusion of contents during handling, storage, transport, or shipping.

Employees who participate in waste characterization studies, sort or sample refuse, or contact medical, dental, or biological waste streams should follow these procedures:

- If exposure is anticipated, this group of employees should wear safety goggles or glasses, puncture-resistant utility gloves with inner latex glove liners, Tyvek coveralls or cotton coveralls with a rubber apron, and puncture-resistant shoes or boots.
- If splash potential is present, employees should wear a full-face shield.
- If a respiratory hazard is present, a full-face respirator with HEPA filters should be worn.

Post Exposure

CH2M HILL will provide exposed employees with a confidential medical examination should an exposure to PIM occur. This examination includes the following procedures:

- Documenting the exposure
- Testing the exposed employee's and the source individual's blood (with consent)
- Administering post-exposure prophylaxis

2.3.3 Mosquito Bites

Due to the recent detection of the West Nile Virus in the Southwestern United States it is recommended that **preventative measures** be taken to reduce the probability of being bitten by mosquitoes whenever possible. Mosquitoes are believed to be the primary source for exposure to the West Nile Virus as well as several other types of encephalitis. The following guidelines should be followed to reduce the risk of these concerns for working in areas where mosquitoes are prevalent.

- Stay indoors at dawn, dusk, and in the early evening.
- Wear long-sleeved shirts and long pants whenever you are outdoors.
- Spray clothing with repellents containing permethrin or DEET since mosquitoes may bite through thin clothing.
- Apply insect repellent sparingly to exposed skin. An effective repellent will contain 35% DEET (N,N-diethyl-meta-toluamide). Repellents may irritate the eyes and mouth, so avoid applying repellent to the hands.
- Whenever you use an insecticide or insect repellent, be sure to read and follow the manufacturer's DIRECTIONS FOR USE, as printed on the product.
- Note: Vitamin B and "ultrasonic" devices are NOT effective in preventing mosquito bites.

Symptoms of Exposure to the West Nile Virus

Most infections are mild, and symptoms include fever, headache, and body aches, occasionally with skin rash and swollen lymph glands. More severe infection may be marked by headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, paralysis, and, rarely, death.

The West Nile Virus incubation period is from 3-15 days.

Contact the project RHSM with questions, and immediately report any suspicious symptoms to your supervisor/PM and contact the occupational nurse at 1-866-893-2514.

2.3.4 Poison Ivy, Poison Oak, and Poison Sumac

Poison ivy, poison oak, and poison sumac typically are found in brush or wooded areas. They are more commonly found in moist areas or along the edges of wooded areas. Shrubs are usually 12 to 30 inches high, or can also be a tree-climbing vine, with triple leaflets and short, smooth hair underneath. Plants are red and dark green in Spring and Summer, with yellowing leaves anytime especially in dry areas. Leaves may achieve bright reds in Fall, but plants lose its (yellowed, then brown) leaves in Winter, leaving toxic stems. All parts of the plant remain toxic throughout the seasons. These plants contain urushiol (you-ROO-shee-ol), a colorless or pale yellow oil that oozes from any cut or crushed part of the plant, including the roots, stems and leaves and causes allergic skin reactions when contacted. The oil is active year round.

Become familiar with the identity of these plants (see below). Wear protective clothing that covers exposed skin and clothes. Avoid contact with plants and the outside of protective clothing. If skin contacts a plant, wash the area with soap and water immediately. If the reaction is severe or worsens, seek medical attention.

Poison Ivy

Poison Sumac

Poison Oak

Contamination with poison ivy, sumac or oak can happen through several pathways, including:

- Direct skin contact with any part of the plant (even roots once above ground foliage has been removed).
- Contact with clothing that has been contaminated with the oil.
- Contact from removing shoes that have been contaminated (shoes are coated with urishol oil).
- Sitting in a vehicle that has become contaminated.
- Contact with any objects or tools that have become contaminated.
- Inhalation of particles generated by weed whacking, chipping, vegetation clearing.

If you must work on a site with poison ivy, sumac or oak the following precautions are necessary:

- Do not drive vehicles onto the site where it will come into contact with poison ivy, sumac or oak. Vehicles which need to work in the area, such as drill rigs or heavy equipment must be washed as soon as possible after leaving the site.
- All tools used in the poison ivy, sumac or oak area, including those used to cut back poison oak, surveying instruments used in the area, air monitoring equipment or other test apparatus must be decontaminated before they are placed back into the site vehicle. If on-site decontamination is not possible, use plastic to wrap any tools or equipment until they can be decontaminated.
- Personal protective equipment, including Tyvek coveralls, gloves, and boot covers must be worn. PPE must be placed into plastic bags and sealed if they are not disposed immediately into a trash receptacle.
- As soon as possible following the work, shower to remove any potential contamination. Any body part with suspected or actual exposure should be washed with "Tecnu" or other product designed for removing urushiol. If you do not have Tecnu wash with cold water. Do not take a bath, as the oils can form and invisible film on top of the water and contaminate your entire body upon exiting the bath.
- Tecnu may also be used to decontaminate equipment.
- Use IvyBlock or similar products to prevent poison oak, ivy and sumac contamination. Check with the closest CH2M HILL warehouse to see if these products are available. Follow all directions for application.

If you do come into contact with one of these poisonous plants and a reaction develops, contact your supervisor and the occupational nurse 1-866-893-2514.

2.3.5 Snakes

Snakes typically are found in underbrush and tall grassy areas. If you encounter a snake, stay calm and look around; there may be other snakes. Turn around and walk away on the same path you used to approach the area. If a person is bitten by a snake, wash and immobilize the injured area, keeping it lower than the heart if possible. Call the occupational nurse at 1-866-893-2514 immediately. **DO NOT** apply ice, cut the wound, or apply a tourniquet. Try to identify the type of snake: note color, size, patterns, and markings.

2.3.6 Spiders - Brown Recluse

It is regarded by many as the most dangerous spider in the United States. Because of interstate shipping/transportation, the Brown Recluse spider can be found most anywhere in the United States. Brown Recluse Spiders are usually 1 inch or larger in size, including the legs and can grow as large as 3 inches. Young Brown Recluse spiders are smaller. Brown recluse spider bites don't always hurt right away. away. In fact, you may not know that you have been bitten until other symptoms appear. Symptoms of a brown recluse spider bite may include the following:

- Reddened skin followed by a blister that forms at the bite site.
- Mild to intense pain and itching for 2 to 8 hours following the bite.
- An open sore with a breakdown of tissue (necrosis) that develops within a few hours to 3 to 4 days following the bite and the area may become painful, itchy, hot, swollen, red and tender. An irregular ulcerous sore, caused by necrosis, will often appear that is from 1/4 inch to 10 inches in diameter. Prompt attention is the best defense against preventing the necrosis. The wound is often described as being reddish and surrounded by a bluish area with a narrow whitish separation in between the red and the blue. This gives it the famous "bull's eye" pattern. In just hours, a bite from the highly venomous Brown Recluse spider can create blisters and cause tissue damage.

Some people have a severe, systemic (whole-body) reaction to brown recluse spider bites, including the rapid destruction of red blood cells and anemia. Signs and symptoms include:

- Fever and chills.
- Skin rash all over the body with many tiny, flat purple and red spots.
- Nausea or vomiting.
- Joint pain.

If you think you have been bitten by a brown recluse spider:

- Remain calm. Too much excitement or movement will increase the flow of venom into the blood.
- Try to collect the spider, without being bitten, (even a mangled specimen has diagnostic value), if possible, for positive identification by a spider expert. A plastic bag, small jar, or pill vial is useful and no preservative is necessary, but rubbing alcohol helps to preserve the spider.
- Apply a cool, wet cloth to the bite or cover the bite with a cloth and apply an ice bag to the bite.
- Do not apply a tourniquet. It may cause more harm than benefit.
- Try to positively identify the spider to confirm its type.
- Seek prompt medical attention.

A brown recluse bite can be serious and will likely require immediate medical care. Seek medical attention if you believe you have been bitten by a recluse spider, especially if severe symptoms develop throughout your body or an open sore and necrosis develop. A brown recluse spider bite is diagnosed through a physical examination and questions about the bite. You should be prepared to describe the spider, where and when the bite took place, and what you were doing at the time. Your health professional will ask what your main symptoms are, when they began, and how they have developed, progressed, or changed since the bite.

2.3.7 Widow Spiders

The Northern Black Widow spider may be encountered in Northern Regions of the United States. Other similar widow spiders are the Red Widow and the Brown Widow. Female widow spiders range from 8-15 mm in body length; males are smaller, sometimes very small (2 mm).

Most have globose, shiny abdomens that are predominantly black with red markings (although some may be pale and/or have lateral stripes), with moderately long, slender legs. These spiders are nocturnal and build a three-dimensional tangled web, often with a conical tent of dense silk in a corner where the spider hides during the day. In nature, most species are found under rocks and logs, but they readily adapt to human-altered environments, where they are most commonly found in outbuildings (sheds, barns, privies), water meter holes, nursery cans, and under any item or structure (*e.g.*, barbeque grill, slide, sand box) that has been undisturbed for a lengthy period. Formerly, most bites by black widows (almost all by female spiders) occurred in outhouses, but presently, widow bites occur most frequently when the spider is trapped against human skin, either by reaching under objects where the spider is hiding or when putting on clothing, gloves or shoes containing the spider. Widow spiders are generally very timid and only bite in self-defense when they accidentally contact humans.

Black Widow

Red Widow

Brown Widow

Bite symptoms are systemic, spreading through the lymphatic system, and usually start about 1-3 hours after the bite. The most common symptoms are intense pain, rigid abdominal muscles, muscle cramping, malaise, local sweating, nausea, vomiting, and hypertension. Other symptoms may includetremors, labored breathing, restlessness, increased blood pressure, and fever. If left untreated, widow bite symptoms usually last 3-5 days.

If bitten, remain calm, and immediately seek medical attention (contact your physician, hospital and/or poison control center). Apply an ice pack directly to the bite area to relieve swelling and pain. Try to collect the spider, without being bitten, (even a mangled specimen has diagnostic value), if possible, for positive identification by a spider expert. A plastic bag, small jar, or pill vial is useful and no preservative is necessary, but rubbing alcohol helps to preserve the spider. A hospital stay may be recommended, particularly for those with a heart condition or with health problems. A physician may administer a specific antivenin to counteract the venom or calcium gluconate to relieve pain. Calcium gluconate and/or antivenin may be administered to relieve or counteract symptoms.

2.3.8 Ticks

Every year employees are exposed to tick bites at work and at home putting them at risk of illness. Ticks typically are in wooded areas, bushes, tall grass, and brush. Ticks are black, black and red, or brown and can be up to one-quarter inch in size.

In some geographic areas exposure is not easily avoided. Wear tightly woven light-colored clothing with long sleeves and pant legs tucked into boots; spray **only outside** of clothing with permethrin or permanone and spray skin with only DEET; and check yourself frequently for ticks.

Where site conditions warrant (vegetation above knee height, tick endemic area) or when tasks warrant (e.g., having to sit/kneel in vegetation) that diminish the effectiveness of the other controls mentioned above, bug-out suits (obtained from MKE warehouse)/Tyvek shall be used. Bug-out suits are more breathable than Tyvek.

Take precautions to avoid exposure by including pre-planning measures for biological hazards prior to starting field work. Contact the MKE Warehouse for preventative equipment such as repellants, protective clothing and tick removal kits. Use the buddy system and perform tick inspections prior to entering the field vehicle. If ticks were not planned to be encountered and are observed, do not continue field work until these controls can be implemented.

See Tick Fact Sheet attached to this HSP for further precautions and controls to implement when ticks are present. Information includes the procedure for submitting a removed tick for testing. If bitten by a tick, follow the removal procedures found in the tick fact sheet, call the occupational nurse at 1-866-893-2514.

Be aware of the symptoms of Lyme disease or Rocky Mountain spotted fever (RMSF). Lyme: a rash might appear that looks like a bullseye with a small welt in the center. RMSF: a rash of red spots under the skin 3 to 10 days after the tick bite. In both RMSF and Lyme disease, chills, fever, headache, fatigue, stiff neck, and bone pain may develop. If symptoms appear, again contact the occupational nurse at 1-866-893-2514.

Be sure to complete an Incident Report (either use the HITS system on the VO) or see Attachment 5 if you do come in contact with a tick. For more detailed information go to HSSE website or contact the RHSM.

2.4 Radiological Hazards and Controls

Refer to CH2M HILL's Core Standard, Radiological Control and Radiological Controls Manual for additional requirements.

Hazards	Controls
None Known	None Required

2.5 Contaminants of Concern

Contaminant	Location and Maximum[a] Concentration (ppm)	Exposure Limit[b]	IDLH[c]	Symptoms and Effects of Exposure	PIP[d] (eV)
Arsenic	GW: SB: SS:	0.01 mg/m^3	5 Ca	Ulceration of nasal septum, respiratory irritation, dermatitis, gastrointestinal disturbances, peripheral neuropathy, hyperpigmentation	NA
Chromium (as Cr(II) & Cr(III))	GW: SB: SS:	0.5 mg/m^3	25	Irritated eyes, sensitization dermatitis, histologic fibrosis of lungs	NA
Chromium (hexavalent)	GW: SB: SS:	0.005 mg/m^3	15 Ca	Irritated respiratory system, nasal septum perforation, liver and kidney damage, leucytosis, leupen, monocytosis, eosinophilla, eye injury, conjunctivitis, skin ulcer, sensitization dermatitis	NA
Hexavalent Chromium	GW: SB: SS:	5 ug/m^3 (insoluble) 1 ug/m^3 (soluble)	ND	Acute: Coughing, sneezing, chest pain, breathing difficulty, itching and burning sensation to skin and lungs. Long term (Chronic): Allergic (asthma like symptoms) respiratory reaction, skin and eye irritation, nosebleeds, contact dermatitis, allergic like skin reaction, ulceration and perforation of the nasal septum.	NA
Lead	GW: SB: SS:	0.05 mg/m^3	100	Weakness lassitude, facial pallor, pal eye, weight loss, malnutrition, abdominal pain, constipation, anemia, gingival lead line, tremors, paralysis of wrist and ankles, encephalopathy, kidney disease, irritated eyes, hypertension	NA
Mercury	GW: SB: SS:	0.025 mg/m^3	10	Skin and eye irritation, cough, chest pain, difficult breathing, bronchitis, pneumontitis, tremors, insomnia, irritability, indecision, headache, fatigue, weakness, GI disturbance	UK
PCBs (Limits as Aroclor 1254)	GW: SB: SS:	0.5 mg/m^3	5 Ca	Eye and skin irritation, acne-form dermatitis, liver damage, reproductive effects	UK
PNAs (Limits as Coal Tar Pitch)	GW: SB: SS:	02 mg/m^3	80 Ca	Dermatitis and bronchitis	UK

Footnotes:

[a] Specify sample-designation and media: SB (Soil Boring), A (Air), D (Drums), GW (Groundwater), L (Lagoon), TK (Tank), S (Surface Soil), SL (Sludge), SW (Surface Water).
[b] Appropriate value of PEL, REL, or TLV listed.
[c] IDLH = immediately dangerous to life and health (units are the same as specified "Exposure Limit" units for that contaminant); NL = No limit found in reference materials; CA = Potential occupational carcinogen.
[d] PIP = photoionization potential; NA = Not applicable; UK = Unknown.

Potential Routes of Exposure

Dermal: Contact with contaminated media. This route of exposure is minimized through proper use of PPE, as specified in Section 4.	**Inhalation:** Vapors and contaminated particulates. This route of exposure is minimized through proper respiratory protection and monitoring, as specified in Sections 4 and 5, respectively.	**Other:** Inadvertent ingestion of contaminated media. This route should not present a concern if good hygiene practices are followed (e.g., wash hands and face before drinking or smoking).

3 Project Organization and Personnel

3.1 CH2M HILL Employee Medical Surveillance and Training

(Reference CH2M HILL- SOPs HSE-113, *Medical Surveillance*, and HSE-110, *Training*)

3.1.1 Hazardous Waste Operations Training

All employees engaging in hazardous waste operations or emergency response shall receive appropriate training as required by 29 CFR 1910.120 and 29 CFR 1926.65. At a minimum, the training shall have consisted of instruction in the topics outlined in the 29 CFR 1910.120 and 29 CFR 1926.65. Personnel who have not met these training requirements shall not be allowed to engage in hazardous waste operations or emergency response activities.

Initial Training

General site workers engaged in hazardous waste operations shall, at the time of job assignment, have received a minimum of 40 hours of initial health and safety training for hazardous waste site operations, unless otherwise noted in the above-referenced standards.

Employees who may be exposed to health hazards or hazardous substances at treatment, storage, and disposal (TSD) operations shall receive a minimum of 24 hours of initial training to enable the employee to perform their assigned duties and functions in a safe and healthful manner.

Employees engaged in emergency response operations shall be trained to the level of required competence in accordance with 29 CFR 1910.120.

Three-Day Actual Field Experience

General site workers for hazardous waste operations shall have received three days of actual experience (on-the-job training) under the direct supervision of a trained, qualified supervisor and shall be documented. If the field experience has not already been received and documented at a similar site, this supervised experience shall be accomplished and documented at the beginning of the assignment of the project.

Refresher Training

General site workers and TSD workers shall receive 8-hours of refresher training annually (within the previous 12-month period) to maintain qualifications for fieldwork. Employees engaged in emergency response operations shall receive annual refresher training of sufficient content and duration to maintain their competencies or shall demonstrate competency in those areas at least annually.

Eight-Hour Supervisory Training

On site management or supervisors who will be directly responsible for, or supervise employees engaged in hazardous waste site operations, will have received at least 8 hours of additional specialized training on managing such operations. Employees designated as SC-HW employees are considered 8-hour HAZWOPER Site Safety Supervisor trained.

The employees listed meet state and federal hazardous waste operations requirements for 40-hour initial training, 3-day on-the-job experience, and 8-hour annual refresher training.

Employees designated "SC" have completed a 12-hour site safety coordinator course, and have documented requisite field experience. An SC with a level designation (D, C, B) equal to or greater than the level of protection being used must be present during all tasks performed in exclusion or decontamination zones. Employees designated "FA-CPR" are currently certified by the American Red Cross, or equivalent, in first aid and CPR. At least one FA-CPR designated employee must be present during all tasks performed in exclusion or decontamination zones. The employees listed below are currently active in a medical surveillance program that meets state and federal regulatory requirements for hazardous waste operations. Certain tasks (e.g., confined-space entry) and contaminants (e.g., lead) may require additional training and medical monitoring.

Pregnant employees are to be informed of and are to follow the procedures in CH2M HILL-SOP HSE-120, *Reproductive Health*, including obtaining a physician's statement of the employee's ability to perform hazardous activities before being assigned fieldwork.

Employee Name	Office	Responsibility	SC/FA-CPR
TBD	TBD	TBD	TBD

3.2 Field Team Chain of Command and Communication Procedures

3.2.1 Client

Contact Name: Nathan Delong – NAFVAC Washington RPM
Phone: 202-685-3279
Facility Contact Name: Nicolas Carros – NSF-IH
Phone: 301-744-2263

3.2.2 CH2M HILL

Project Manager (PM): Christine Metcalf/WDC
Responsible Health and Safety Manager (RHSM): Carl Woods/BCN
Field Team Leader: TBD
Safety Coordinator (SC): TBD

The PM is responsible for providing adequate resources (budget and staff) for project-specific implementation of the HS&E management process. The PM has overall management responsibility for the tasks listed below. The PM may explicitly delegate specific tasks to other staff, as described in sections that follow, but retains ultimate responsibility for completion of the following in accordance with this SOP:

- Include standard terms and conditions, and contract-specific HS&E roles and responsibilities in contract and subcontract agreements (including flow-down requirements to lower-tier subcontractors).
- Select safe and competent subcontractors by:
  - Obtaining, reviewing and accepting or rejecting subcontractor pre-qualification questionnaires.
  - Ensuring that acceptable certificates of insurance, including CH2M HILL as named additional insured, are secured as a condition of subcontract award.
  - Including HS&E submittals checklist in subcontract agreements, and ensuring that appropriate site-specific safety procedures, training and medical monitoring records are reviewed and accepted prior to the start of subcontractor's field operations.
- Maintain copies of subcontracts and subcontractor certificates of insurance (including CH2M HILL as named additional insured), bond, contractor's license, training and medical monitoring records, and site-specific safety procedures in the project file accessible to site personnel.
- Provide oversight of subcontractor HS&E practices per the site-specific safety plan.
- Manage the site and interfacing with 3rd parties in a manner consistent with our contract and subcontract agreements and the applicable standard of reasonable care.
- Ensure that the overall, job-specific, HS&E goals are fully and continuously implemented.

The CH2M HILL RHSM is responsible for:

- Review and accept or reject subcontractor pre-qualification questionnaires that fall outside the performance range delegated to the Contracts Administrator (KA).

- Review and accept or reject subcontractor training records and site-specific safety procedures prior to start of subcontractor's field operations.
- Support the oversight of subcontractor (and lower-tier subcontractors) HS&E practices and interfaces with on-site 3rd parties per the site-specific safety plan.

The SC is responsible for verifying that the project is conducted in a safe manner including the following specific obligations:

- Verify this HSP is current and amended when project activities or conditions change.
- Verify CH2M HILL site personnel and subcontractor personnel read the HSP and sign Attachment 1, Employee Sign-Off Form, prior to commencing field activities.
- Verify CH2M HILL site personnel and subcontractor personnel have completed any required specialty training (e.g., fall protection, confined space entry) and medical surveillance as identified in Section 2.
- Verify compliance with the requirements of this HSP and applicable subcontractor health and safety plan(s).
- Act as the project "Hazard Communication Coordinator" and perform the responsibilities outlined in Section 2.2.2.
- Act as the project "Emergency Response Coordinator" and perform the responsibilities outlined in Section 9.
- Post OSHA job-site poster; the poster is required at sites where project field offices, trailers, or equipment-storage boxes are established.
- Verify that safety meetings are conducted and documented in the project file initially and as needed throughout the course of the project (e.g., as tasks or hazards change).
- Verify that project H&S forms and permits, found in Attachment 4 and 5, are being used as outlined in Section 2.
- Perform oversight and/or assessments of subcontractor HS&E practices per the site-specific safety plan and verify that project activity self-assessment checklists, found in Attachment 4, are being used as outlined in Section 2.
- Verify that project files available to site personnel include copies of executed subcontracts and subcontractor certificates of insurance (including CH2M HILL as named additional insured), bond, contractors license, training and medical monitoring records, and site-specific safety procedures prior to start of subcontractor's field operations.
- Manage the site and interfacing with 3rd parties in a manner consistent with our contract/subcontract agreements and the applicable standard of reasonable care.
- Coordinate with the RHSM regarding CH2M HILL and subcontractor operational performance, and 3rd party interfaces.
- Ensure that the overall, job-specific, HS&E goals are fully and continuously implemented.

The training required for the SC is as follows:

- SC-Initial and SC-Construction
- OSHA 10-hour course for Construction
- First Aid and CPR
- Relevant Competent Person Courses (excavation, confined space, scaffold, fall protection, etc.).

The SC is responsible for contacting the Field Team Leader and Project Manager. In general, the Project Manager will contact the client. The RHSM should be contacted as appropriate.

3.2.3 CH2M HILL Subcontractors

(Reference CH2M HILL SOP HSE-215, *Contracts and Subcontracts)*

Subcontractor**: TBD – Insert here**
Subcontractor Contact Name: **TBD – Insert here**
Telephone:

Subcontractor:
Subcontractor Contact Name: **TBD – Insert here**
Telephone:

The subcontractors listed above are required to submit their own Site-Specific HSP. Other plans, such as Lead or Asbestos Abatement Compliance plans may be required as well. Subcontractors are responsible for the health and safety procedures specific to their work, and are required to submit their plans to CH2M HILL for review before the start of field work.

Subcontractors are also required to prepare an Activity Hazard Analysis (AHA) before beginning each activity posing H&S hazards to their personnel using the AHA form provided in Attachment 5 as a guide. The AHA shall identify the principle steps of the activity, potential H&S hazards for each step and recommended control measures for each identified hazard. In addition, a listing of the equipment to be used to perform the activity, inspection requirements and training requirements for the safe operation of the equipment listed must be identified.

CH2M HILL should continuously endeavor to observe subcontractors' safety performance and adherence to their Accident Prevention Plan and AHAs. This endeavor should be reasonable, and include observing for hazards or unsafe practices that are both readily observable and occur in common work areas. CH2M HILL is not responsible for exhaustive observation for hazards and unsafe practices. Self-assessment checklists contained in Attachment 4 are to be used by CH2M HILL personnel to review subcontractor performance. CH2M HILL oversight does not relieve subcontractors of their responsibility for effective implementation and compliance with the established plan(s).

Health and safety related communications with CH2M HILL subcontractors should be conducted as follows:

- Brief subcontractors on the provisions of this plan, and require them to sign the Employee Signoff Form included in Attachment 1.

- Request subcontractor(s) to brief project team on the hazards and precautions related to their work.
- When apparent non-compliance/unsafe conditions or practices are observed, notify the subcontractor safety representative and require corrective action – the subcontractor is responsible for determining and implementing necessary controls and corrective actions.
- When repeat non-compliance/unsafe conditions are observed, notify the subcontractor safety representative and stop affected work until adequate corrective measures are implemented.
- When an apparent imminent danger exists, immediately remove all affected CH2M HILL employees and subcontractors, notify subcontractor safety representative, and stop affected work until adequate corrective measures are implemented. Notify the PM and RHSM as appropriate.
- Document all oral health and safety related communications in project field logbook, daily reports, or other records.

4 Personal Protective Equipment (PPE)

(Reference CH2M HILL- SOP HSE-117, *Personal Protective Equipment*)

4.1 Required PPE

- PPE must be worn by employees when actual or potential hazards exist and engineering controls or administrative practices cannot adequately control those hazards.
- A PPE assessment has been conducted by the RHSM based on project tasks (see PPE specifications below). Verification and certification of assigned PPE by task is completed by the RHSM or designee.
- Employees must be trained to properly wear and maintain the PPE.
- In work areas where actual or potential hazards are present at any time, PPE must be worn by employees working or walking through the area.
- Areas requiring PPE should be posted or employees must be informed of the requirements in an equivalent manner.
- PPE must be inspected prior to use and after any occurrence to identify any deterioration or damage.
- PPE must be maintained in a clean and reliable condition.
- Damaged PPE shall not be used and must either be repaired or discarded.
- PPE shall not be modified, tampered with, or repaired beyond routine maintenance.

The table below outlines PPE to be used according to task based on project-specific hazard assessment. If a task other than the tasks described in this table needs to be performed, contact the RHSM so this table can be updated.

Project-Specific PPE Requirements[a]

Task	Level	Body	Head	Respirator [b]
• General site entry • Surveying • Observation of material loading for offsite disposal • Utility Clearance	D	Work clothes; safety toed leather work boots and gloves	Hardhat [c] Safety glasses with side shields Ear protection [d]	None required
• Monitoring Well Install, Survey, Sampling & Development (HSA) • Ash Sampling (Surface) • Sediment sampling Surface soil sampling Hand augering Geoprobe boring	Modified D	Work clothes or cotton coveralls **Boots:** Safety-toe, chemical-resistant boots OR Safety -toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Safety glasses with side shields Ear protection [d]	None required

Project-Specific PPE Requirements[a]

Task	Level	Body	Head	Respirator [b]
• DPT Soil boring & sampling • Investigation-derived waste (drum) sampling and disposal	Modified D	**Coveralls:** Uncoated Tyvek® **Boots:** Safety -toe, chemical-resistant boots OR Safety -toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] Safety glasses with side shields Ear protection [d]	None required.
Work near vehicular traffic ways or earth moving equipment.	All	Appropriate level of ANSI/ISEA 107-2004 high-visibility safety vests.	Work near vehicular traffic ways or earth moving equipment.	
Equipment decontamination if using pressure washer	Modified D with splash protection	**Coveralls:** Polycoated Tyvek® **Boots:** 16-inch-high steel-toed rubber boots **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] over safety glasses with side shields or splash goggles Ear protection [d]	None required.
Tasks requiring upgrade	C	**Coveralls:** Polycoated Tyvek® **Boots:** Safety -toe, chemical-resistant boots OR Safety -toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] Ear protection [d] Spectacle inserts	APR, full face, MSA Ultratwin or equivalent; with GME-H cartridges or equivalent[e].
Tasks requiring upgrade	B	**Coveralls:** Polycoated Tyvek® **Boots:** Safety -toe, chemical-resistant boots OR Safety -toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] Ear protection [d] Spectacle inserts	Positive-pressure demand self-contained breathing apparatus (SCBA); MSA Ultralite, or equivalent.

Reasons for Upgrading or Downgrading Level of Protection

Upgrade[f]	Downgrade
• Request from individual performing tasks. • Change in work tasks that will increase contact or potential contact with hazardous materials. • Occurrence or likely occurrence of gas or vapor emission. • Known or suspected presence of dermal hazards. • Instrument action levels (Section 5) exceeded.	• New information indicating that situation is less hazardous than originally thought. • Change in site conditions that decrease the hazard. • Change in work task that will reduce contact with hazardous materials.

[a] Modifications are as indicated. CH2M HILL will provide PPE only to CH2M HILL employees.
[b] No facial hair that would interfere with respirator fit is permitted.
[c] Hardhat and splash-shield areas are to be determined by the SC.
[d] Ear protection should be worn when conversations cannot be held at distances of 3 feet or less without shouting.
[e] See cartridge change-out schedule in Section 4.2.
[f] Performing a task that requires an upgrade to a higher level of protection (e.g., Level D to Level C) is permitted only when the PPE requirements have been approved by the RHSM, and an SC qualified at that level is present.

PPE Certification

I certify that the PPE requirements listed in the table above for the associated tasks are based upon the project-specific hazard assessment I performed.

Carl Woods	7/16/09	7/16/09
Name	**Date of Certification**	**Date(s) of Project Hazard Assessment**

4.2 Respiratory Protection

(Reference CH2M HILL SOP HSE-121, *Respiratory Protection*)

- Respirator users must have completed appropriate respirator training within the past 12 months. Level C training is required for air-purifying respirators (APR) use and Level B training is required for supplied-air respirators (SAR) and self-contained breathing apparatus (SCBA) use. Specific training is required for the use of powered air-purifying respirators (PAPR).
- Respirator users must complete the respirator medical monitoring protocol and been approved for the specific type of respirator to be used.
- Tight-fitting facepiece respirator (negative or positive pressure) users must have passed an appropriate fit test within past 12 months.
- Respirator use shall be limited to those activities identified in this plan. If site conditions change that alters the effectiveness of the specified respiratory protection, the RHSM shall be notified to amend the written plan.
- Tight-fitting facepiece respirator users shall be clean-shaven and shall perform a user seal check before each use.
- Canisters/cartridges shall be replaced according to the change-out schedule specified in this plan. Respirator users shall notify the SC or RHSM of any detection of vapor or gas breakthrough. The SC shall report any breakthrough events to the RHSM for schedule upgrade.
- Respirators in regular use shall be inspected before each use and during cleaning
- Respirators in regular use shall be cleaned and disinfected as often as necessary to ensure they are maintained in a clean and sanitary condition.
- Respirators shall be properly stored to protect against contamination and deformation.
- Field repair of respirators shall be limited to routine maintenance. Defective respirators shall be removed from service.
- When breathing air is supplied by cylinder or compressor, the SC or RHSM shall verify the air meets Grade D air specifications.
- The SC or designee shall complete the H&S Self-Assessment Checklist – Respiratory Protection included in Attachment 4 of this plan to verify compliance with CH2M HILL's respiratory protection program.

Respirator Change-Out Schedule

Contaminant	Change-Out Schedule
None	N/A

5 Air Monitoring/Sampling

(Reference CH2M HILL SOP HSE-207, Exposure Monitoring for Airborne Chemical Hazards)

5.1 Air Monitoring Specifications

Instrument	Tasks	Action Levels[a]	Action to be Taken when Action Level reached	Frequency [b]	Calibration
PID/Toxic Gas Monitor: MultiRAE Plus with 10.6 eV lamp (VOCs, O_2, LEL, CO, H_2S)	All Intrusive, Sampling Activities and IDW Mgmt.	< 1 ppm → 1-5 ppm → > 5 ppm →	Level D Level C Level B, Notify HSM	Initially and periodically during task	Daily
Dust Monitor: Visual	All Activities	No Dust → Visible Dust→	Level D Level D. Practice dust suppression techniques/engineering controls	Initially and periodically during tasks	Zero Daily
Mercury Monitor: **Jerome 431-X Vapor Meter**	All sampling and intrusive activities where the potential for mercury exist	0-0.01 ppm 0.01-.99 ppm >1 ppm	Level D Level C Level B, not authorized, contact HSM	Initially and periodically during task	Daily
Nose-Level Monitor [d]	Drilling, Pressure Washing during Decon and Heavy Equipment Operations	<85 dB(A) 85-120 dB(A) 120 dB(A)	No action required Hearing protection required Stop; re-evaluate	Initially and periodically during task	Daily

[a] Action levels apply to sustained breathing-zone measurements above background.
[b] The exact frequency of monitoring depends on field conditions and is to be determined by the SC; generally, every 5 to 15 minutes if acceptable; more frequently may be appropriate. Monitoring results shall be recorded. Documentation should include instrument and calibration information, time, measurement results, personnel monitored, and place/location where measurement is taken (e.g., “Breathing Zone/MW-3”, “at surface/SB-2”, etc.).
[c] If the measured percent of O_2 is less than 10, an accurate LEL reading will not be obtained. Percent LEL and percent O_2 action levels apply only to ambient working atmospheres, and not to confined-space entry. More-stringent percent LEL and O_2 action levels are required for confined-space entry (refer to Section 2).
[d] Noise monitoring and audiometric testing also required.

5.2 Calibration Specifications

(Refer to the respective manufacturer's instructions for proper instrument-maintenance procedures)

Instrument	Gas	Span	Reading	Method
PID: MultiRAE Plus with 10.6 eV bulb	100 ppm isobutylene	CF = 100	100 ppm	1.5 lpm reg T-tubing
LEL/O_2/H_2S/CO Sensors				
	Methane	NA	2.5% (50% LEL)	1.5 lpm reg T-tubing/ tedlar bag
	Oxygen	NA	20.9%	1.5 lpm reg T-tubing/ tedlar bag
	Hydrogen Sulfide	NA	25	1.5 lpm reg T-tubing/ tedlar bag
	Carbon Monoxide	NA	50	1.5 lpm reg T-tubing/ tedlar bag
Jerome 431-X Vapor Meter	NA	NA	Zero	Media & Pump Sampling

5.3 Air Sampling

Sampling, in addition to real-time monitoring, may be required by other OSHA regulations where there may be exposure to certain contaminants. Air sampling typically is required when site contaminants include lead, cadmium, arsenic, asbestos, and certain volatile organic compounds. Contact the HSM immediately if these contaminants are encountered.

Method Description

None anticipated

Personnel and Areas

Results must be sent immediately to the RHSM. Regulations may require reporting to monitored personnel. Results reported to:

HSM: Mark Orman/MKE
Other: Carl Woods/BCN

6 Decontamination

(Reference CH2M HILL SOP HSE-218, *Hazardous Waste Operations*)

The SC must establish and monitor the decontamination procedures and their effectiveness. Decontamination procedures found to be ineffective will be modified by the SC. The SC must ensure that procedures are established for disposing of materials generated on the site.

6.1 Decontamination Specifications

Personnel	Sample Equipment	Heavy Equipment
• Boot wash/rinse • Glove wash/rinse • Outer-glove removal • Body-suit removal • Inner-glove removal • Respirator removal • Hand wash/rinse • Face wash/rinse • Shower ASAP • Dispose of PPE in municipal trash, or contain for disposal • Dispose of personnel rinse water to facility or sanitary sewer, or contain for offsite disposal	• Wash/rinse equipment • Solvent-rinse equipment • Contain solvent waste for offsite disposal	• Power wash • Steam clean • Dispose of equipment rinse water to facility or sanitary sewer, or contain for offsite disposal

6.2 Diagram of Personnel-Decontamination Line

No eating, drinking, or smoking is permitted in contaminated areas and in exclusion or decontamination zones. The SC should establish areas for eating, drinking, and smoking. Contact lenses are not permitted in exclusion or decontamination zones.

Figure 6-1 illustrates a conceptual establishment of work zones, including the decontamination line. Work zones are to be modified by the SC to accommodate task-specific requirements.

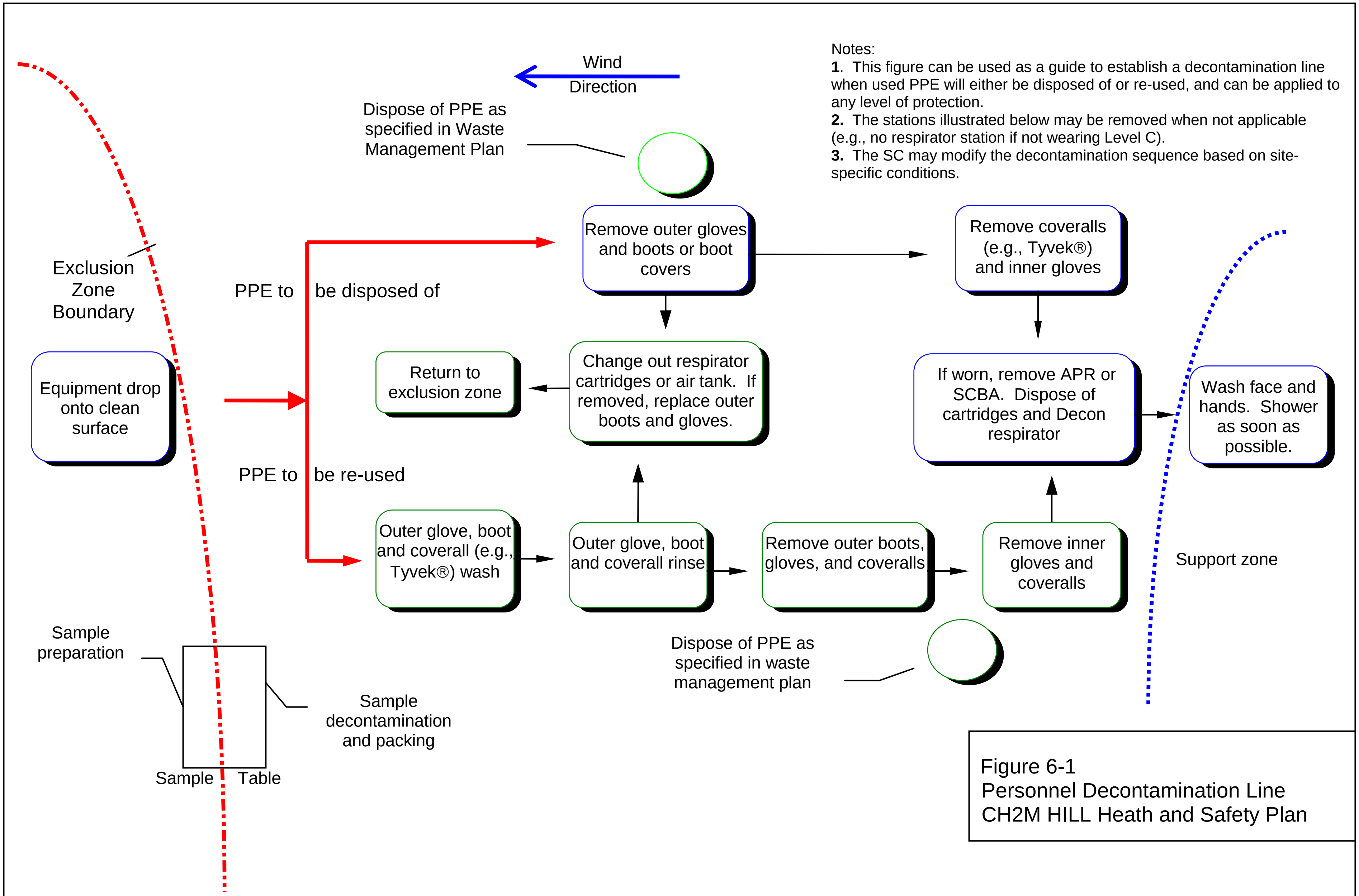


Figure 6-1
Personnel Decontamination Line
CH2M HILL Heath and Safety Plan

7 Spill Containment Procedures

Sorbent material will be maintained in the support zone. Incidental spills will be contained with sorbent and disposed of properly.

8 Site-Control Plan

8.1 Site-Control Procedures

(Reference CH2M HILL SOP HSE-218, *Hazardous Waste Operations)*

- The SC will conduct a site safety briefing (see below) before starting field activities or as tasks and site conditions change.
- Topics for briefing on site safety: general discussion of Health and Safety Plan, site-specific hazards, locations of work zones, PPE requirements, equipment, special procedures, emergencies.
- The SC records attendance at safety briefings in a logbook and documents the topics discussed.
- Post the OSHA job-site poster in a central and conspicuous location in accordance with CH2M HILL- Core Standard, *OSHA Postings*.
- Establish support, decontamination, and exclusion zones. Delineate with flags or cones as appropriate. Support zone should be upwind of the site. Use access control at entry and exit from each work zone.
- Establish onsite communication consisting of the following:
  - Line-of-sight and hand signals
  - Air horn
  - Two-way radio or cellular telephone if available
- Establish offsite communication.
- Establish and maintain the "buddy system."
- Initial air monitoring is conducted by the SC in appropriate level of protection.
- The SC is to conduct periodic inspections of work practices to determine the effectiveness of this plan – refer to Sections 2 and 3. Deficiencies are to be noted, reported to the HSM, and corrected.

8.2 Hazwoper Compliance Plan

(Reference CH2M HILL SOP HSE-220, Written Plans and HSE-218 Hazardous Waste Operations)

Certain parts of the site work are covered by state or federal Hazwoper standards and therefore require training and medical monitoring. Anticipated Hazwoper tasks (Section 1.1.1) might occur consecutively or concurrently with respect to non-Hazwoper tasks. This section outlines procedures to be followed when approved activities specified in Section 1.1.2 do not require 24- or 40-hour training. Non-Hazwoper-trained personnel also must be trained in accordance with all other state and federal OSHA requirements.

- In many cases, air sampling, in addition to real-time monitoring, must confirm that there is no exposure to gases or vapors before non-Hazwoper-trained personnel are allowed on the site, or while non-Hazwoper-trained staff is working in proximity to Hazwoper activities. Other data (e.g., soil) also must document that there is no potential for exposure. The RHSM must approve the interpretation of these data. Refer to Sections 2.0 and 5.0 for contaminant data and air sampling requirements, respectively.

- When non-Hazwoper-trained personnel are at risk of exposure, the SC must post the exclusion zone and inform non-Hazwoper-trained personnel of the:
  - nature of the existing contamination and its locations
  - limitations of their access
  - emergency action plan for the site
- Periodic air monitoring with direct-reading instruments conducted during regulated tasks also should be used to ensure that non-Hazwoper-trained personnel (e.g., in an adjacent area) are not exposed to airborne contaminants.
- When exposure is possible, non-Hazwoper-trained personnel must be removed from the site until it can be demonstrated that there is no longer a potential for exposure to health and safety hazards.
- Remediation treatment system start-ups: Once a treatment system begins to pump and treat contaminated media, the site is, for the purposes of applying the Hazwoper standard, considered a treatment, storage, and disposal facility (TSDF). Therefore, once the system begins operation, only Hazwoper-trained personnel (minimum of 24 hour of training) will be permitted to enter the site. All non-Hazwoper-trained personnel must not enter the TSDF area of the site.

9 Emergency Response Plan

(Reference CH2M HILL SOP HSE-106, *Emergency Planning*)

9.1 Pre-Emergency Planning

- The Emergency Response Coordinator (ERC) performs the applicable pre-emergency planning tasks before starting field activities and coordinates emergency response with CH2M HILL onsite parties, the facility, and local emergency-service providers as appropriate.
- Review the facility emergency and contingency plans where applicable.
- Determine what onsite communication equipment is available (e.g., two-way radio, air horn).
- Determine what offsite communication equipment is needed (e.g., nearest telephone, cell phone).
- Confirm and post emergency telephone numbers, evacuation routes, assembly areas, and route to hospital; communicate the information to onsite personnel.
- Field Trailers: Post "Exit" signs above exit doors, and post "Fire Extinguisher" signs above locations of extinguishers. Keep areas near exits and extinguishers clear.
- Review changed site conditions, onsite operations, and personnel availability in relation to emergency response procedures.
- Where appropriate and acceptable to the client, inform emergency room and ambulance and emergency response teams of anticipated types of site emergencies.
- Designate one vehicle as the emergency vehicle; place hospital directions and map inside; keep keys in ignition during field activities.
- Inventory and check site emergency equipment, supplies, and potable water.
- Communicate emergency procedures for personnel injury, exposures, fires, explosions, and releases.
- Rehearse the emergency response plan before site activities begin, including driving route to hospital. Drills should take place periodically but no less than once a year.
- Brief new workers on the emergency response plan.
- The ERC will evaluate emergency response actions and initiate appropriate follow-up actions.

9.2 Emergency Equipment and Supplies

The ERC should mark the locations of emergency equipment on the site map and post the map.

Emergency Equipment and Supplies	Location
20 (or two 10) class A,B,C fire extinguisher	Field Vehicle
First aid kit	Field Vehicle
Eye Wash	Field Vehicle
Emergency Shower	N/A or check with client
Potable water	Field Vehicle
Bloodborne-pathogen kit	Field Vehicle
Additional equipment (specify):	Field Vehicle or on SSC

9.3 Incident Response

In fires, explosions, or chemical releases, actions to be taken include the following:

- Notify appropriate response personnel.
- Shut down CH2M HILL operations and evacuate the immediate work area.
- Account for personnel at the designated assembly area(s).
- Assess the need for site evacuation, and evacuate the site as warranted.
- Implement HSE-111, Incident Notification, Reporting and Investigation.
- Notify and submit reports to clients as required in contract.

Small fires or spills posing minimal safety or health hazards may be controlled with onsite spill kits or fire extinguishers without evacuating the site. When in doubt evacuate. Follow the incident reporting procedures in Section 9.7.

9.4 Emergency Medical Treatment

Emergency medical treatment is needed when there is a life-threatening injury (such as severe bleeding, loss of consciousness, breathing/heart has stopped). When in doubt if an injury is life-threatening or not, treat it as needing emergency medical treatment.

- Notify 911 or other appropriate emergency response authorities as listed in Emergency Contacts at the front of this HSP.
- The ERC will assume charge during a medical emergency until the ambulance arrives or until the injured person is admitted to the emergency room.
- Prevent further injury, perform decontamination (if applicable) where feasible; lifesaving and first aid or medical treatment takes priority.
- Initiate first aid and CPR where feasible.
- Notify supervisor and if the injured person is a CH2M HILL employee, the supervisor will call the occupational nurse at 1-866-893-2514 and make other notifications as required by HSE SOP-111, *Incident Notification, Reporting and Investigation*.
- Make certain that the injured person is accompanied to the emergency room.

- Follow the Serious Incident Reporting process in HSE SOP-111, Incident Notification, Reporting and Investigation, and complete incident report forms in Attachment 5.
- Notify and submit reports to client as required in contract.

9.5 Evacuation

- Evacuation routes, assembly areas, and severe weather shelters (and alternative routes and assembly areas) are to be specified on the site map.
- Evacuation route(s) and assembly area(s) will be designated by the ERC or designee before work begins.
- Personnel will assemble at the assembly area(s) upon hearing the emergency signal for evacuation.
- The ERC and a "buddy" will remain on the site after the site has been evacuated (if safe) to assist local responders and advise them of the nature and location of the incident.
- The ERC will account for all personnel in the onsite assembly area.
- A designated person will account for personnel at alternate assembly area(s).
- The ERC will follow the incident reporting procedures in Section 9.7.

9.6 Evacuation Signals

Signal	Meaning
Grasping throat with hand	Emergency-help me.
Thumbs up	OK; understood.
Grasping buddy's wrist	Leave area now.
Continuous sounding of horn	Emergency; leave site now.

9.7 Incident Notification and Reporting

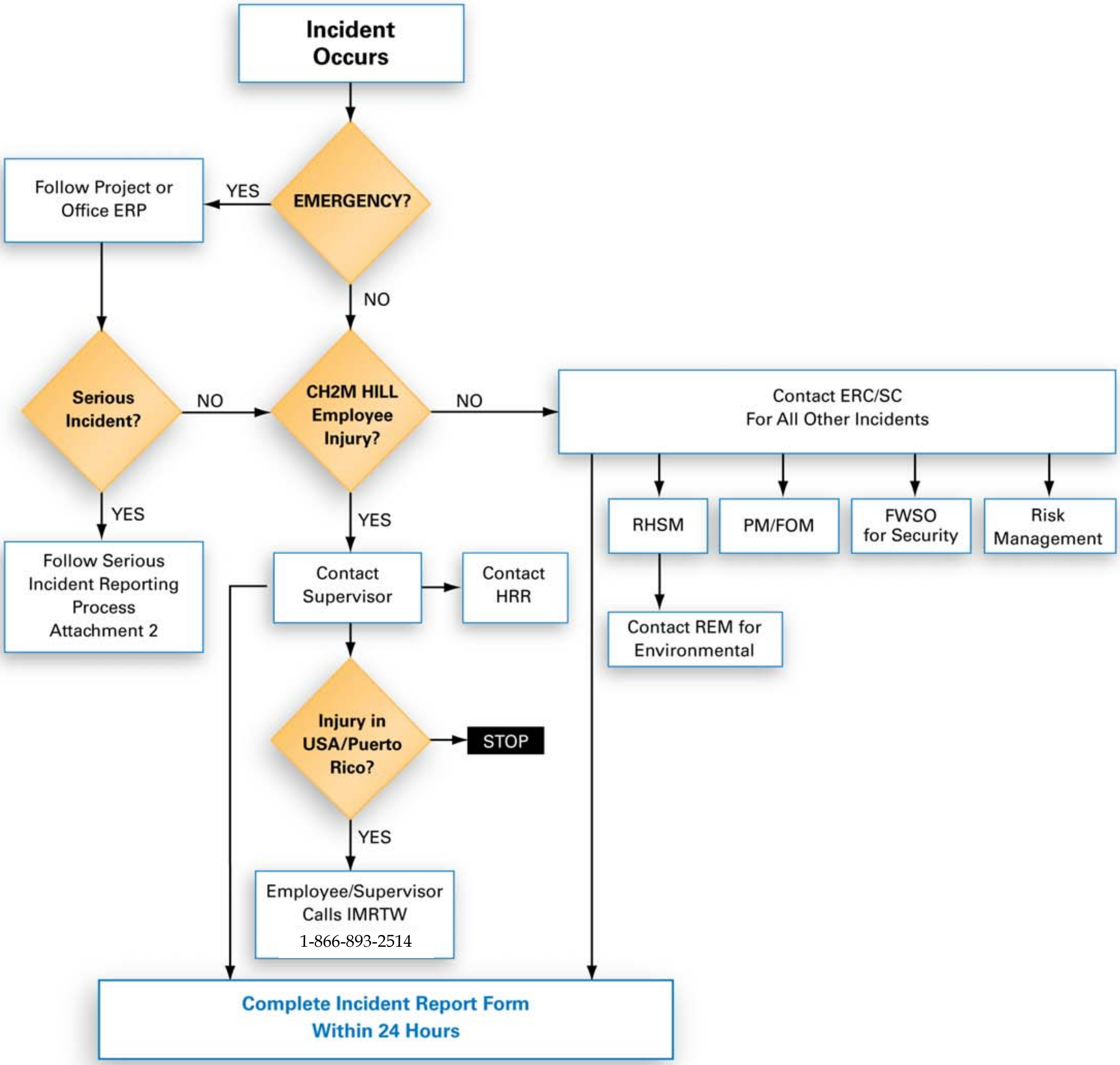
(Reference CH2M HILL SOP HSE-111, *Incident Notification, Reporting and Investigation*)

- If you are injured at work, notify your supervisor immediately and contact the Injury Management/Return-to-Work toll free number (for US and Puerto Rico) 1-866-893-2514. All supervisors must contact their Human Resources Representative and complete the employee injury/illness in the Incident Report Form (IRF) in the HITS database within 24 hours of the incident.
- Immediately notify the Project Manager (PM), Emergency Response Coordinator (ERC), and/or Responsible Health and Safety Manager (RHSM) for any project incident (fire, spill/release, injury/illness, near miss, property damage, or security-related).
- Report any **serious incidents** (life-threatening injury/illness, death, kidnap/missing person, terrorism, property damage greater than $500K, significant environmental release) **immediately** to your ERC, PM, or RHSM. The Serious Incident Reporting number is 720-286-4911.

- For serious incidents, the Corporate Legal Department will determine who completes the IRF.
- For CH2M HILL subcontractor incidents, immediately notify the ERC and HSM to complete and submit an IRF.
- The RHSM will inform the Responsible Environmental Manager (REM) of any environmental incidents.
- Evaluation and follow-up of the IRF will be completed by the type of incident by the RHSM, REM, or FWSO. The Business Group (BG) HSE Lead will review all BG incidents and modify as required.
- Incident Investigations must be initiated and completed as soon as possible but no later than 72 hours after the incident.
- See the following flowcharts for Immediate Incident Reporting and Serious Incident Reporting.

CH2MHILL

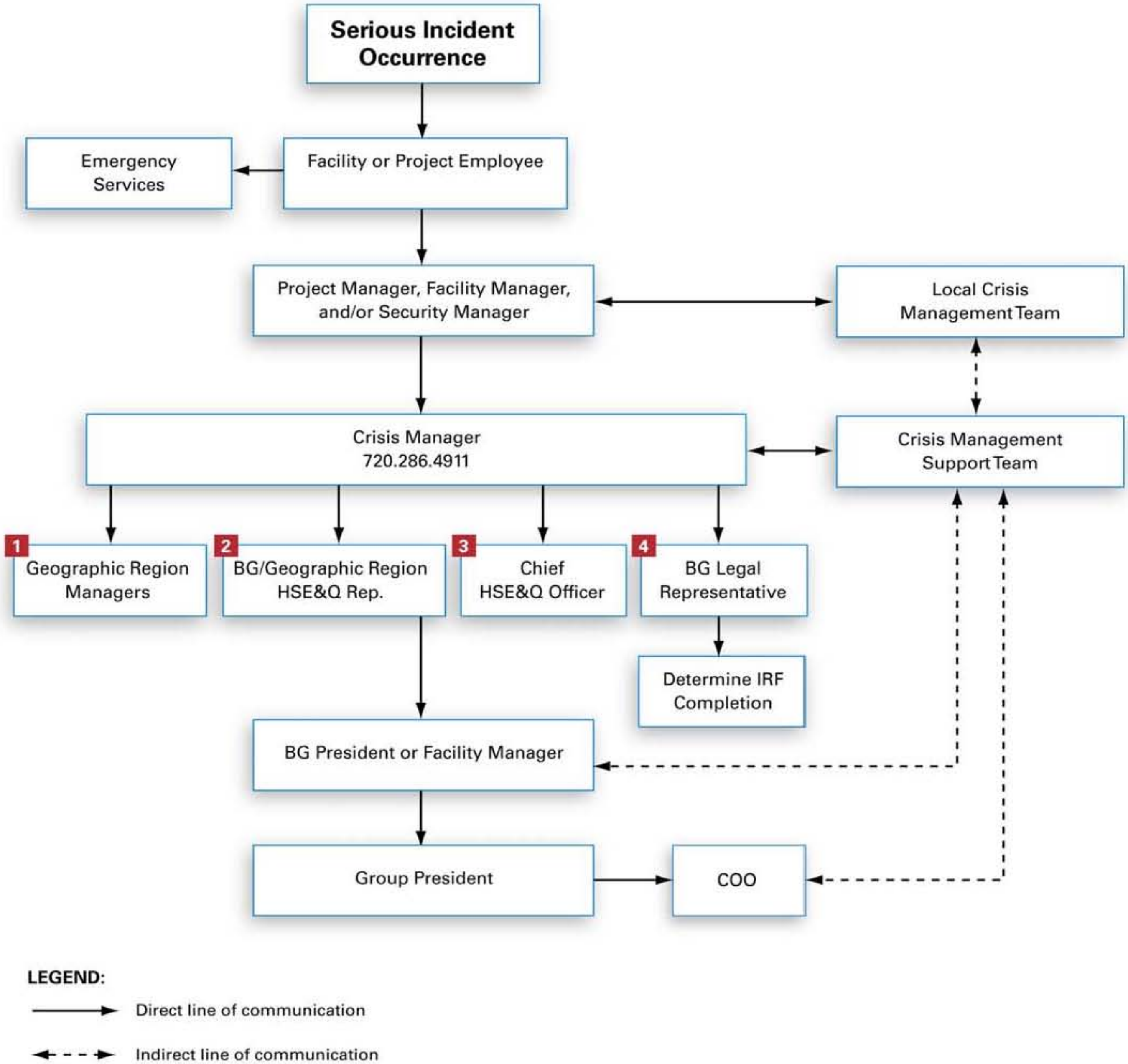
Attachment 1
CH2M HILL Immediate Incident Notification



ERC = Emergency Response Coordinator (designated in Emergency Response Plan)
ERP = Emergency Response Plan
FOM = Facility Office Manager
FWSO = Firm Wide Security Operations
HRR = Human Resources Representative
IMRTW = Injury Management/Return-to-Work
PM = Project Manager
REM = Responsible Environmental Manager
RHSM = Responsible Health & Safety Manager
SC = Safety Coordinator

HS052007002MKT

Attachment 2
CH2M HILL Serious Incident Notification



DEFINITIONS:

Local Crisis Management Team: Team comprised of key facility, project and/or business group personnel. Team is assembled as necessary and as appropriate to effectively manage and respond to a crisis situation (serious incident) at/on scene.

Crisis Management Support Team: Team comprised of key corporate personnel. Team is assembled as necessary and as appropriate to effectively support, direct, and /or supplement a Local Crisis Management Team.

Crisis Manager: Corporate based Crisis Manager, contactable by pager 24/7.

HS052007002MKT

10 Behavior Based Loss Prevention System

(Reference CH2M HILL SOP HSE-103, *Behavior Based Loss Prevention System*)

A Behavior Based Loss Prevention System (BBLPS) is a system to prevent or reduce losses using behavior-based tools and proven management techniques to focus on behaviors or acts that could lead to losses.

The four basic Loss Prevention tools that will be used by CH2M HILL projects to implement the BBLPS include:

- Activity Hazard Analysis (AHA)
- Pre-Task Safety Plans (PTSP)
- Safe Behavior Observations (SBO)
- Loss and Near Loss Investigations (NLI)

The SC or designated CH2M HILL representative onsite is responsible for implementing the BBLPS on the project site. The Project Manager remains accountable for its implementation. The SC or designee shall only oversee the subcontractor's implementation of their AHAs and PTSPs processes on the project.

10.1 Activity Hazard Analysis

An Activity Hazard Analysis (AHA) defines the activity being performed, the hazards posed and control measures required to perform the work safely. Workers are briefed on the AHA before doing the work and their input is solicited prior, during and after the performance of work to further identify the hazards posed and control measures required.

Activity Hazard Analysis will be prepared before beginning each project activity posing H&S hazards to project personnel using the AHA form provided in Attachment 5. The AHA shall identify the work tasks required to perform each activity, along with potential H&S hazards and recommended control measures for each work task. In addition, a listing of the equipment to be used to perform the activity, inspection requirements and training requirements for the safe operation of the equipment listed must be identified.

An AHA shall be prepared for all field activities performed by CH2M HILL and subcontractor activities during the course of the project. Hazard Controls (found in Sections 2.0 and its subsections of the HSP), the Hazard Analysis Table (Table 1), and applicable CH2M HILL CSs and SOPs should be used as a basis for preparing AHAs.

CH2M HILL subcontractors are required to provide AHAs specific to their scope of work on the project for acceptance by CH2M HILL. Each subcontractor shall submit AHAs for their field activities, as defined in their work plan/scope of work, along with their project-specific safety plan/accident prevention plan. Additions or changes in CH2M HILL or subcontractor field activities, equipment, tools or material to perform work or additional/different hazard encountered that require additional/different hazard control measures requires either a new AHA to be prepared or an existing AHA to be revised.

10.2 Pre-Task Safety Plans

Daily safety meetings are held with all project personnel in attendance to review the hazards posed and required H&S procedures/AHAs, which apply for each day's project activities. The PTSPs serve the same purpose as these general assembly safety meetings, but the PTSPs are held between the crew supervisor and their work crews to focus on those hazards posed to individual work crews. At the start of each day's activities, the crew supervisor completes the PTSP, provided in Attachment 5, with input from the work crew, during their daily safety meeting. The day's tasks, personnel, tools and equipment that will be used to perform these tasks are listed, along with the hazards posed and required H&S procedures, as identified in the AHA. The use of PTSPs, better promotes worker participation in the hazard recognition and control process, while reinforcing the task-specific hazard and required H&S procedures with the crew each day. The use of PTSPs is a common safety practice in the construction industry.

10.3 Safe Behavior Observations

Safe Behavior Observations (SBOs) shall be conducted by SC or designee for specific work tasks or operations comparing the actual work process against established safe work procedures identified in the project-specific HSP and AHAs. SBOs are a tool to be used by supervisors to provide positive reinforcement for work practices performed correctly, while also identifying and eliminating deviations from safe work procedures that could result in a loss. The SC or designee shall perform at least one SBO each week for tasks/operations addressed in the project-specific HSP or AHA. The SC or designee shall complete the SBO form in **Attachment 5** for the task/operation being observed and submit the SBO form weekly to Margaret Dombrowski/MKE.

10.4 Loss/Near Loss Investigations

Loss/Near Loss Investigations shall be performed for CH2M HILL and subcontractor incidents involving:

- Person injuries/illnesses and near miss injuries,
- Equipment/property damage,
- Spills, leaks, regulatory violations,
- Motor vehicle accidents.

The cause of loss and near loss incidents are similar, so by identifying and correcting the causes of near loss causes, future loss incidents may be prevented. The following is the Loss/Near Loss Investigation Process:

- Gather all relevant facts, focusing on fact-finding, not fault-finding, while answering the who, what, when, where and how questions.
- Draw conclusions, pitting facts together into a probable scenario.
- Determine incident root cause(s), which are basic causes on why an unsafe act/condition existed.
- Develop and implement solutions, matching all identified root causes with solutions.
- Communicate incident as a Lesson Learned to all project personnel.

- Filed follow-up on implemented corrective active action to confirm solution is appropriate.

The SC or designee shall perform an incident investigation, as soon as practical after incident occurrence during the day of the incident, for all Loss and Near Loss Incidents that occur on the project. Loss and Near Loss incident investigations shall be performed using the following incident investigation forms provided in **Attachment 5.**

- Incident Report Form (IRF)
- Root Cause Analysis Form

All Loss and Near Loss incident involving personal injury, property damage in excess of $1,000 or near loss incidents that could have resulted in serious consequences shall be investigated by completing the incident investigation forms and submitting them to the PM and RHSM within 24 hours of incident occurrence. A preliminary Incident Investigation and Root Cause Analysis shall be submitted to the Project Manager and RHSM within 24 hours of incident occurs. The final Incident Investigation and Root Cause Analysis shall be submitted after completing a comprehensive investigation of the incident.

11 Approval

This site-specific HSP has been written for use by CH2M HILL only. CH2M HILL claims no responsibility for its use by others unless that use has been specified and defined in project or contract documents. The plan is written for the specific site conditions, purposes, dates, and personnel specified and must be amended if those conditions change.

11.1 Original Plan

Written By: Carl Woods/BCN **Date: 7/16/09**

Approved By: Carl Woods/BCN **Date: 7/16/09**

Carl Woods

11.2 Revisions

Revisions Made By: **Date:**

Revisions to Plan:

Revisions Approved By: **Date:**

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12 Attachments

Attachment 1:	Employee Signoff Form – Health and Safety Plan
Attachment 2:	Chemical Inventory/Register Form
Attachment 3:	Chemical-Specific Training Form
Attachment 4:	Project Activity Self-Assessment Checklists/Permits
Attachment 5:	Behavior Based Loss Prevention Forms
Attachment 6:	Material Safety Data Sheets/Fact Sheets
Attachment 7:	Working Alone Standard
Attachment 8:	Tick Fact Sheet
Attachment 9:	Notice of Safety Violation Form
Attachment 10:	Stop Work Order Form

Health and Safety Plan Employee Sign-off Form

EMPLOYEE SIGNOFF FORM
Health and Safety Plan

The CH2M HILL project employees and subcontractors listed below have been provided with a copy of this HSP, have read and understood it, and agree to abide by its provisions.

Project Name: Indian Head – Site 66 **Project Number:** 386329

EMPLOYEE NAME (Please print)	**EMPLOYEE SIGNATURE**	**COMPANY**	**DATE**

CH2M HILL Health and Safety Plan

Attachment 2

Chemical Inventory/Register Form

CH2MHILL

CHEMICAL INVENTORY/REGISTER FORM

Refer to SOP HSE-107, Attachment 1, for instructions on completing this form.

Location: ______________________________

HCC: ______________________________

☐ Office ☐ Warehouse ☐ Laboratory ☐ Project: Indian Head – Site 66
Project No.: 386329

Regulated Product	Location	Container labeled (✓if yes)	MSDS available (✓if yes)

MSDS for the listed products will be maintained at: ______________________________

Chemical-Specific Training Form

CH2MHILL

CHEMICAL-SPECIFIC TRAINING FORM

Refer to SOP HSE-107 Attachment 1 for instructions on completing this form.

Location: Indian Head – Site 66	Project #: 386329
HCC:	Trainer:

TRAINING PARTICIPANTS:

NAME	SIGNATURE	NAME	SIGNATURE

REGULATED PRODUCTS/TASKS COVERED BY THIS TRAINING:

The HCC shall use the product MSDS to provide the following information concerning each of the products listed above.

☐ Physical and health hazards

☐ Control measures that can be used to provide protection (including appropriate work practices, emergency procedures, and personal protective equipment to be used)

☐ Methods and observations used to detect the presence or release of the regulated product in the workplace (including periodic monitoring, continuous monitoring devices, visual appearance or odor of regulated product when being released, etc.)

Training participants shall have the opportunity to ask questions concerning these products and, upon completion of this training, will understand the product hazards and appropriate control measures available for their protection.

Copies of MSDSs, chemical inventories, and CH2M HILL's written hazard communication program shall be made available for employee review in the facility/project hazard communication file.

CH2M HILL Health and Safety Plan

Attachment 4

Project Activity Self-Assessment Checklists/Permits/Forms

- **Arsenic**
- **Drilling**
- **Hazardous Materials Handling**
- **Lead**
- **Lockout/Tagout**

CH2MHILL

HSE Self-Assessment Checklist—Arsenic

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's HSP/FSI. This checklist is to be used at locations where CH2M HILL employees are exposed to arsenic, or are required to perform oversight of a subcontractor whose personnel are exposed to arsenic.

CH2M HILL staff shall not direct the means and methods of subcontractor arsenic activities nor direct the details of appropriate corrective actions. The subcontractor must determine how to correct deficiencies and CH2M HILL staff must carefully rely on their expertise. Conditions considered to be imminently dangerous (possibility of serious injury or death) must be corrected immediately or all exposed personnel must be removed from the hazard until corrected.

Project Name: ______________________ Project No.: ______________

Location: ______________________ PM: ______________________

Auditor: ______________________ Title: ______________________ Date: __________

This specific checklist has been completed to:

☐ Evaluate CH2M HILL compliance with its Arsenic program (SOP HSE-501)
☐ Evaluate a CH2M HILL subcontractor's compliance with its Arsenic program
Subcontractors Name: ______________________________

- Check "Yes" if an assessment item is complete/correct.
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

SECTION 1

PERSONNEL SAFE WORK PRACTICES (5.1)
COMPLIANCE PROGRAM (5.1.1)

		Yes	No	N/A	N/O
1.	Where EL ≥ PEL, a written compliance program is implemented before commencing work	☐	☐	☐	☐
2.	The compliance program is based on the most recent air monitoring/sampling results.	☐	☐	☐	☐
3.	The compliance program is updated for new exposure monitoring data or every six months.	☐	☐	☐	☐
4.	Written compliance program is available to all affected employees.	☐	☐	☐	☐
5.	Waste generated must be determined if considered hazardous waste.	☐	☐	☐	☐

EMPLOYEE INFORMATION (5.1.2)

		Yes	No	N/A	N/O
6.	Training on the Hazard Communication Standard has been met.	☐	☐	☐	☐
7.	CH2M HILL personnel have completed the Arsenic Training Module.	☐	☐	☐	☐
8.	Training on the Fact Sheet, HSP/FSI, and OSHA standard has been met.	☐	☐	☐	☐

CH2MHILL

HS&E Self-Assessment Checklist—Arsenic

	Yes	No	N/A	N/O
9. The selection of the appropriate respirator is based on the airborne arsenic concentration.	☐	☐	☐	☐
10. Personnel working near arsenic-contaminated soil or material shall use wet methods and work practices to control dust; wear disposable coveralls, and exercise personal hygiene practices.	☐	☐	☐	☐
11. Contact lenses are not to be worn when working with arsenic.	☐	☐	☐	☐
12. Written or verbal notification is given to owners, contractors, or other personnel working in the area of arsenic work activities.	☐	☐	☐	☐
13. Storage or shipping containers are properly labeled.	☐	☐	☐	☐
HOUSEKEEPING (5.1.3)				
14. All surfaces are free of accumulation of arsenic.	☐	☐	☐	☐
15. Cleaning methods minimize airborne arsenic activity.	☐	☐	☐	☐
16. Where vacuuming is used, vacuums are used and emptied to minimize airborne arsenic.	☐	☐	☐	☐
17. A written housekeeping and maintenance plan is in place and maintained.	☐	☐	☐	☐
18. Compressed air is not used to remove arsenic from surfaces.	☐	☐	☐	☐
REGULATED AREAS (5.1.4)				
19. Areas that exceed the PEL have been designated as regulated areas.	☐	☐	☐	☐
20. Personnel meet medical and training requirements.	☐	☐	☐	☐
21 No eating, drinking, and/or smoking is allowed in the regulated areas.	☐	☐	☐	☐
22 Warning signs have been posted at all entrances to the regulated areas.	☐	☐	☐	☐
23. Shower facilities are installed and used with cleaning agents and towels, where feasible.	☐	☐	☐	☐
24. Hand washing facilities are provided for use by employees before eating, drinking, smoking, etc.	☐	☐	☐	☐
25. Eating facilities free of arsenic are provided for employees working in regulated areas.	☐	☐	☐	☐
26. Change areas are provided where EL ≥ PEL or where employees are subject to eye or skin irritation.	☐	☐	☐	☐
EXPOSURE ASSESSMENTS (5.2)				
27. Initial air monitoring is conducted over full shift for each job classification.	☐	☐	☐	☐
28. Air sampling is conducted every 6 months when exposure limit (EL) ≥ AL but < PEL.	☐	☐	☐	☐
29. Air sampling of employees is conducted quarterly when EL ≥ PEL.	☐	☐	☐	☐
30. Additional air monitoring has been collected when there are any changes in operation.	☐	☐	☐	☐
31. Employees have been informed of air monitoring results within 5 days after receipt of results.	☐	☐	☐	☐
32. Where PEL is exceeded, affected employees have been notified of results and control measures to be used to reduce exposure below the PEL.	☐	☐	☐	☐
CONTROL METHODS (5.3)				
ENGINEERING AND WORK PRACTICE CONTROLS (5.3.1)				
33. Engineering controls and work practices have been used to reduce exposures below the PEL.	☐	☐	☐	☐
34. When controls are unable to reduce exposures below the PEL, respiratory protection is used.	☐	☐	☐	☐
35. Employees do not eat, drink, smoke, chew tobacco/gum, or apply cosmetics in regulated areas.	☐	☐	☐	☐
RESPIRATORY PROTECTION (5.3.2)				
36. Respirators are used in areas where EL ≥ PEL.	☐	☐	☐	☐
37. Respirator cartridges are replaced at the end of shift or service life indicator, where available.	☐	☐	☐	☐
38. PAPRs are provided to employees who request such a respirator.	☐	☐	☐	☐

PERSONAL PROTECTIVE EQUIPMENT (5.3.3)

39. PPE is supplied at no cost to employees.
40. Employee exposed to arsenic tri-chloride wear impervious clothing.
41 Clean and dry protective clothing is provided weekly. Daily if EL $\geq$ 100 $\mu g/m^3$.
42. Protective clothing is repaired or replaced if found to be ineffective.
43. Contaminated protective clothing is removed from change areas at the end of the shift.
44. All clothing requiring laundering is packaged in sealed, labeled containers.
45. Personnel or vendors who launder contaminated clothing are formally informed of the hazards.
46. Employee are not allowed to leave workplace wearing clothing worn during work shift.

CH2MHILL

HS&E Self-Assessment Checklist—Arsenic

SECTION 3

Complete this section for all items checked “No” in Section 1. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

Auditor: ________________________________ Project Manager: ____________________________

CH2MHILL

HSE Self-Assessment Checklist - Drilling

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's written safety plan.

This checklist is to be used at locations where: 1) CH2M HILL employees are potentially exposed to drilling hazards, 2) CH2M HILL staff are providing support function related to drilling activities, and/or 3) CH2M HILL oversight of a drilling subcontractor is required.

Safety Coordinator may consult with drilling subcontractors when completing this checklist, but shall not direct the means and methods of drilling operations nor direct the details of corrective actions. Drilling subcontractors shall determine how to correct deficiencies and we must carefully rely on their expertise. Items considered to be imminently dangerous (possibility of serious injury or death) shall be corrected immediately, or all exposed personnel shall be removed from the hazard until corrected.

Project Name: ______________________________ Project No.: ______________

Location: ______________________________ PM: ______________________

Auditor: ______________________ Title: ______________________ Date: __________

This specific checklist has been completed to:

☐ Evaluate CH2M HILL employee exposures to drilling hazards (complete Section 1).
☐ Evaluate CH2M HILL support functions related to drilling activities (complete Section 2)
☐ Evaluate a CH2M HILL subcontractor's compliance with drilling safety requirements (complete entire checklist).
Subcontractors Name: ______________________________________

- Check "Yes" if an assessment item is complete/correct.
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the drilling subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in SOP HSE-204.

SECTION 1 - SAFE WORK PRACTICES (5.1)

	Yes	No	N/A	N/O
1. Personnel cleared during rig startup	☐	☐	☐	☐
2. Personnel clear while mast is being raised	☐	☐	☐	☐
3. Personnel clear of rotating parts	☐	☐	☐	☐
4. Personnel not positioned under hoisted loads	☐	☐	☐	☐
5. Loose clothing and jewelry removed	☐	☐	☐	☐
6. Smoking is prohibited around drilling operation	☐	☐	☐	☐
7. Personnel wearing appropriate personal protective equipment (PPE), per written plan	☐	☐	☐	☐
8. Personnel instructed not to approach equipment that has become electrically energized	☐	☐	☐	☐

SECTION 2 - SUPPORT FUNCTIONS (5.2)

AQUIFER DESIGNATIONS (5.2.1)

	Yes	No	N/A	N/O
9. Aquifer designations determined and BGEM consulted when required.	☐	☐	☐	☐

LOCATION OF UTILITIES (5.2.2)

	Yes	No	N/A	N/O
10. Location of underground utilities and structures identified	☐	☐	☐	☐
11. Power lines de-energized and grounded when safe distances cannot be maintained	☐	☐	☐	☐

SECTION 2 (Continued)

WASTE MANAGEMENT (5.2.3)	Yes	No	N/A	N/O
12. Drill cuttings and purge water managed and disposed properly	☐	☐	☐	☐
13. Wastes generated evaluated for proper disposal	☐	☐	☐	☐
14. Appropriate decontamination procedures being followed, per project's written safety plan	☐	☐	☐	☐
DRILLING AT ORDNANCE EXPLOSIVES OR UNEXPLODED ORDNANCE SITES (5.2.4)				
15. MEC plan prepared and approved	☐	☐	☐	☐
16. MEC avoidance provided, routes and boundaries cleared and marked	☐	☐	☐	☐
17. Initial pilot hole established by UXO technician with hand auger	☐	☐	☐	☐
18. Personnel remain inside cleared areas	☐	☐	☐	☐
SECTION 3 - DRILLING SAFETY REQUIREMENTS (5.3)				
GENERAL (5.3.1)				
19. Only authorized personnel operating drill rigs	☐	☐	☐	☐
20. Daily safety briefing/meeting conducted with crew	☐	☐	☐	☐
21. Daily inspection of drill rig and equipment conducted before use	☐	☐	☐	☐
22. Good housekeeping maintained on and around rig	☐	☐	☐	☐
SAFETY EQUIPMENT (5.3.2)				
23. Safety-toed shoes/boots, hardhats, safety glasses, gloves and hearing protection are worn	☐	☐	☐	☐
24. Drill rig equipped with fire extinguisher	☐	☐	☐	☐
25. Air monitoring instruments provided when required	☐	☐	☐	☐
26. PPE for protection from chemical hazards is worn if required				
DRILL RIG PLACEMENT (5.3.3)				
27. Location of underground utilities and structures identified	☐	☐	☐	☐
28. Safe clearance distance maintained from overhead power lines	☐	☐	☐	☐
29. Drilling pad established, when necessary	☐	☐	☐	☐
30. Drill rig leveled and stabilized	☐	☐	☐	☐
31. Additional precautions taken when drilling in confined areas	☐	☐	☐	☐
DRILL RIG TRAVEL (5.3.4)				
28. Rig shut down and mast lowered and secured prior to rig movement	☐	☐	☐	☐
29. Tools and equipment secured prior to rig movement	☐	☐	☐	☐
30. Only personnel seated in cab are riding on rig during movement	☐	☐	☐	☐
31. Backup alarm or spotter used when backing rig	☐	☐	☐	☐
32. Spotter used when backing rig in tight or confined areas or when low clearances exist	☐	☐	☐	☐
33. Safe clearance distance maintained while traveling under overhead power lines	☐	☐	☐	☐
EMERGENCY – CONTACT WITH OVERHEAD OR UNDERGROUND ELECTRICAL LINES (5.3.5)				
34. Personnel understand emergency procedures in the event of contact with overhead or underground electrical lines	☐	☐	☐	☐
DRILL RIG OPERATION (5.3.6)				
35. Kill switch clearly identified and operational	☐	☐	☐	☐
36. All machine guards are in place	☐	☐	☐	☐
37. Rig ropes never wrapped around any part of the body	☐	☐	☐	☐
38. Pressurized lines and hoses secured to prevent whipping hazards	☐	☐	☐	☐
39. Drilling operation stopped during inclement weather	☐	☐	☐	☐
40. Air monitoring conducted per written safety plan for hazardous atmospheres	☐	☐	☐	☐
41. Rig gear boxes placed in neutral when operator not at controls	☐	☐	☐	☐
42. Operator shuts rig engine down prior to leaving the drill rig vicinity	☐	☐	☐	☐

CH2MHILL

DRILL RIG SITE CLOSURE (5.3.7)

43. Ground openings/holes filled or barricaded ☐ ☐ ☐ ☐
44. Equipment and tools properly stored ☐ ☐ ☐ ☐
45. All vehicles locked and keys removed ☐ ☐ ☐ ☐

DRILL RIG MAINTENANCE (5.3.8)

46. Rig properly maintained per drilling company's maintenance program ☐ ☐ ☐ ☐
47. Defective components repaired immediately ☐ ☐ ☐ ☐
48. Lockout/tagout procedures used prior to maintenance ☐ ☐ ☐ ☐
49. Cathead in clean, sound condition ☐ ☐ ☐ ☐
50. Drill rig ropes in clean, sound condition ☐ ☐ ☐ ☐
51. Fall protection used for fall exposures of 6 feet (U.S.) 1.5 meters (Australia) or greater ☐ ☐ ☐ ☐
52. Rig in neutral and augers stopped rotating before cleaning ☐ ☐ ☐ ☐
53. Good housekeeping maintained on and around rig ☐ ☐ ☐ ☐

FORMS/PERMITS AND CHECKLISTS (7.0)

54. Driller license/certification obtained ☐ ☐ ☐ ☐
55. Well development/abandonment notifications and logs submitted and in project files ☐ ☐ ☐ ☐
56. Groundwater withdrawal permit obtained where required ☐ ☐ ☐ ☐
57. Dig permit obtained where required ☐ ☐ ☐ ☐

SECTION 4

Complete this section for all items checked “No” in previous sections. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

Auditor: ______________________________ Project Manager: ________________________________

CH2MHILL

HS&E Self-Assessment Checklist: HAZARDOUS MATERIALS

This checklist is provided as a method of verifying compliance with regulations pertaining to the handling of hazardous materials. It shall be used at locations where CH2M HILL employees handle hazardous materials, or are required to perform oversight of subcontractor personnel handling hazardous materials, or both.

CH2M HILL staff shall not direct the means and methods of subcontractor operations nor direct the details of corrective actions. The subcontractor must determine how to correct deficiencies, and CH2M HILL staff must carefully rely on the subcontractor's expertise. Items considered imminently dangerous (possibility of serious injury or death) must be corrected immediately, or all exposed personnel must be removed from the hazard until it is corrected.

Completed checklists must be sent to the appropriate regional health and safety program manager for review.

Project Name: ____________________ Project No.: ____________
Location: ____________________ PM: ____________
Auditor: ____________ Title: ____________ Date: ________

This specific checklist has been completed to (check only one of the boxes below):

☐ Evaluate CH2M HILL compliance with hazardous material handling requirements (SOP HSE-403)
☐ Evaluate a CH2M HILL subcontractor's compliance with hazardous material requirements
Subcontractor's Name: ____________________

- Check "Yes" if an assessment item is complete or correct.
- Check "No" if an item is incomplete or deficient. Section 2 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in Standard of Practice HSE-403.

SECTION 1	Yes	No	N/A	N/O

PROCEDURES FOR HAZARDOUS MATERIAL HANDLING (6.0)

GENERAL GUIDELINES (6.1)

	Yes	No	N/A	N/O
1. Acids are stored away from bases.	☐	☐	☐	☐
2. Oxidizers and organics are stored away from inorganic reducing agents.	☐	☐	☐	☐
3. Flammables and corrosives are stored in appropriate storage cabinets.	☐	☐	☐	☐
4. Paper and other combustibles are not stored near flammables.	☐	☐	☐	☐
5. Secondary containment and lipped shelving are in place in storage areas.	☐	☐	☐	☐
6. A fire suppression system is available.	☐	☐	☐	☐

SPILL CONTROL/CLEANUP (6.2)

	Yes	No	N/A	N/O
7. Spill control materials are located on the project site.	☐	☐	☐	☐

HAZARDOUS CHEMICAL INVENTORY REPORTING (6.3)

	Yes	No	N/A	N/O
8. Reporting is required if the project site handles and stores 10,000 lb or more of a hazardous chemical.	☐	☐	☐	☐
9. Or 500 lb or the threshold planning quantity (TPQ) of an extremely hazardous substance.	☐	☐	☐	☐
10. Regional ECC has been consulted for hazardous chemical inventory reporting.	☐	☐	☐	☐

TOXIC CHEMICAL RELEASE REPORTING

	Yes	No	N/A	N/O
11. Reporting requirements for toxic chemical release reporting have been followed.	☐	☐	☐	☐

SECTION 1 (continued)	Yes	No	N/A	N/O

FLAMMABLE AND COMBUSTIBLE LIQUIDS (6.5)

GENERAL STORAGE (6.5.1)

	Yes	No	N/A	N/O
12. Only approved containers/portable tanks used to store flammable and combustible liquids.	☐	☐	☐	☐
13. Approved safety cans used for handling flammable liquids in quantities 1-5 gallons.	☐	☐	☐	☐
14. For quantities of one gallon or less, the original container must be used for storage.	☐	☐	☐	☐
15. Flammable or combustible liquids are not stored in stairways or personnel passageways.	☐	☐	☐	☐
INDOOR STORAGE (6.5.2)				
16. Quantities of flammable or combustible liquids > 25 gallons stored in approved storage cabinet.	☐	☐	☐	☐
17. No more than 25 gallons of flamm. or comb. liquids can be stored outside an approved cabinet.	☐	☐	☐	☐
18. Cabinets are labeled with "'FLAMMABLE: KEEP FIRE AWAY."	☐	☐	☐	☐
19 No more than 60 gallons of flamm. or 120 gallons of comb. liquids stored in one storage cabinet.	☐	☐	☐	☐
20. Not more than three cabinets located in a single storage area.	☐	☐	☐	☐
OUTSIDE STORAGE (6.5.3)				
21. Storage of containers (not more than 60 gallons each) do not exceed 1,100 gallons in any area.	☐	☐	☐	☐
22. Storage areas are not within 20 feet of any building.	☐	☐	☐	☐
23. Storage areas graded to divert spills away from buildings and surrounded by an earth dike.	☐	☐	☐	☐
24. Storage areas are free from weeds, debris, and other combustible materials.	☐	☐	☐	☐
25. Outdoor portable tanks are provided with emergency vent devices.	☐	☐	☐	☐
26. Outdoor portable tanks are no closer than 20 feet from any building.	☐	☐	☐	☐
27. Signs indicating no smoking are posted around the storage area.	☐	☐	☐	☐
DISPENSING (6.5.4)				
28. Areas where liquids are dispensed in >5-gal quantities are separated from other operations by 25'.	☐	☐	☐	☐
29. Drainage or other means provided to control spills.	☐	☐	☐	☐
30. Adequate natural or mechanical ventilation provided to maintain concentration of flammable vapor < 10% of the lower flammable limit.	☐	☐	☐	☐
31. Dispensing of flammable liquids from one container to another is done only when containers are electrically interconnected (bonded).	☐	☐	☐	☐
32. Dispensing flammable or combustible liquids by means of air pressure on the container or portable tanks prohibited.	☐	☐	☐	☐
33. Dispensing devices and nozzles for flammable liquids are of an approved type.	☐	☐	☐	☐
USE (6.5.5)				
34. Flammable liquids are kept in closed containers when not in actual use.	☐	☐	☐	☐
35. Leakage or spillage of flammable or combustible liquids is disposed of promptly and safely.	☐	☐	☐	☐
36. Sources of ignition are kept at least 50 feet from flammable liquids.	☐	☐	☐	☐
LIQUID PETROLEUM GAS (6.6)				
37. LPG containers meet DOT requirements.	☐	☐	☐	☐
38. Each container or system has a safety relief device or valve in good working order.	☐	☐	☐	☐
39. Portable heaters using LPG have an automatic shutoff device in the event of flame failure.	☐	☐	☐	☐
40. Storage of LPG within buildings is prohibited.	☐	☐	☐	☐
41. LPG storage location has at least one portable fire extinguisher rated not less than 20-B:C.	☐	☐	☐	☐

SECTION 1 (continued)	Yes	No	N/A	N/O

COMPRESSED GAS CYLINDERS (6.7)

	Yes	No	N/A	N/O
GENERAL (6.7.1)				
42. Cylinders and apparatus inspected for defects and leakage prior to use. Damaged items not used.	☐	☐	☐	☐
43. Gas distributor notified and subsequent instructions followed for defective cylinders.	☐	☐	☐	☐
44. Leaking cylinders removed from the work area.	☐	☐	☐	☐
45. Cylinder users do not modify, tamper, or attempt repair on cylinders or apparatus.	☐	☐	☐	☐
46. Only cylinder owners or authorized agent refill cylinders or attempt to mix gases in a cylinder.	☐	☐	☐	☐
47. Cylinders labeled with the identity of the contents.	☐	☐	☐	☐
TRANSPORTING (6.7.2)				
48. Cylinders not rolled in the horizontal position or dragged; suitable material-handling device used.	☐	☐	☐	☐
49. Cylinders being transported have valve protection caps installed.	☐	☐	☐	☐
50. Cylinders in vertical position when transported by motor vehicle, hoisted, or carried.	☐	☐	☐	☐
51. Cylinders hoisted by a cradle or pallet designed for such use, and not by magnets, slings, or their valve protection caps.	☐	☐	☐	☐
STORAGE (6.7.3)				
52. Cylinders are stored in the vertical position with valve protection caps installed.	☐	☐	☐	☐
53. Cylinders are secured from being knocked over by a chain or other stabilizing device.	☐	☐	☐	☐
54. Cylinders are stored away from readily ignitable substances.	☐	☐	☐	☐
55. Cylinders are protected from exposure to temperature extremes.	☐	☐	☐	☐
56. Oxygen cylinders in storage are separated from fuel gas cylinders or combustible materials > 20’	☐	☐	☐	☐
or by a ½-hour fire-resistant barrier at least 5’ high.	☐	☐	☐	☐
57. Cylinders inside buildings are stored in dry, well-ventilated locations > 20’ from comb. materials.	☐	☐	☐	☐
58. Cylinders are stored in definitely assigned places away from elevators, stairs, or gangways.	☐	☐	☐	☐
59. Signs indicating no smoking are provided for storage areas containing flammable gas cylinders.	☐	☐	☐	☐
PLACEMENT FOR USAGE (6.7.4)				
60. Cylinders are located where they will not be knocked over or damaged.	☐	☐	☐	☐
61. Cylinders are secured in the vertical position.	☐	☐	☐	☐
62. Cylinders are not placed where they can become part of an electrical circuit.	☐	☐	☐	☐
63. Cylinders are kept far enough away from welding and cutting operations to prevent sparks, hot slag, or flames from reaching them. When impractical, fire resistant shields are provided.	☐	☐	☐	☐
64. Cylinders are not taken into confined spaces.	☐	☐	☐	☐
CYLINDER CONNECTIONS (6.7.5)				
65. Pressure-controlling apparatus is compatible with the particular gas used.	☐	☐	☐	☐
66. Cylinders and pressure-controlling apparatus are kept free of oil and grease.	☐	☐	☐	☐
67. Pressure-controlling apparatus is kept gastight to prevent leakage.	☐	☐	☐	☐
68. Cylinders not attached to process where backflow could occur unless check valves or traps used.	☐	☐	☐	☐
69. Manifolds designed for product used at the appropriate temperatures, pressures, and flow rates.	☐	☐	☐	☐
70. Manifolds are labeled and placed in well-ventilated and accessible locations.	☐	☐	☐	☐
71. Cylinders are not cross-connected with plant air lines.	☐	☐	☐	☐
72. Flash arrestors or reverse flow check valves are installed on all flammable gas cylinders.	☐	☐	☐	☐
USAGE (6.7.6)				
73. Eye protection (safety glasses or goggles) is worn when using cylinders.	☐	☐	☐	☐
74. Cylinder valve and regulator are inspected for foreign material before connecting.	☐	☐	☐	☐
75. If cylinders are frozen, warm (not boiling) water is used to thaw cylinders.	☐	☐	☐	☐
76. Cylinder valve remains closed except when the cylinder is in use.	☐	☐	☐	☐
77. Fuel gas cylinder valves are not opened more than 1½ turns, for quick closing.	☐	☐	☐	☐
78. If a special wrench is used to open a cylinder valve, it is left in position on the valve.	☐	☐	☐	☐

SECTION 1 (continued)	Yes	No	N/A	N/O
USAGE (continued) (6.7.6)				
79. Acetylene cylinders are used in the vertical position.	☐	☐	☐	☐
80. Acetylene cylinders are not used > 15 psig or > 30 psia.	☐	☐	☐	☐
81. Copper pipe or fittings are not used with acetylene systems.	☐	☐	☐	☐
82. Compressed gas is not used to dust off clothing.	☐	☐	☐	☐
83. Cylinder valve closed and regulator relieved of internal pressure before regulators are removed.	☐	☐	☐	☐
EXPLOSIVES (6.8)				
84. Written authorization provided by Munitions Market Segment Leader designating individuals who can store or use high explosives under the authority of the CH2M HILL BATF Type 33 User of High Explosives License/permit.	☐	☐	☐	☐
85. Written authorization provided by Munitions Market Segment Leader designating individuals who can manufacture high explosives under the authority of the CH2M HILL BATF Type 20 Manufacturer of High Explosives License/permit.	☐	☐	☐	☐
86. Approved Explosive Siting Plan (ESP).	☐	☐	☐	☐
87. Approved Explosive Management Plan (EMP).	☐	☐	☐	☐
88. Sources of ignition are not brought in or near storage magazines, or within 50’ of an area where explosives are being handled, transported, or used.	☐	☐	☐	☐
89. Radio transmitting or receiving equipment is not brought within 1,000’ of blasting activities.	☐	☐	☐	☐
90. Transportation and storage of explosives comply with local, state, and federal regulations.	☐	☐	☐	☐
91. Vehicles transporting explosives are placarded and displayed according to DOT regulations.	☐	☐	☐	☐
92. Detonators or blasting caps are not stored with explosive charges.	☐	☐	☐	☐
93. Explosives are stored in storage magazines as required by local, state, and federal regulations.	☐	☐	☐	☐
94. Contact the Munitions Response market Segment Leader for additional instructions	☐	☐	☐	☐
	☐	☐	☐	☐

PROCEDURES FOR HAZARDOUS MATERIALS SHIPPING (7.0)

1. Only dangerous goods shippers are permitted to ship dangerous goods (CH2M HILL only).	☐	☐	☐	☐
2. Dangerous goods are shipped or transported in accordance with CH2M HILL’s procedures.	☐	☐	☐	☐
3. All personnel shipping dangerous goods have completed the computer-based training (CH2M HILL only)	☐	☐	☐	☐
4. Dangerous goods are stored only in the equipment warehouse prior to shipping.	☐	☐	☐	☐
5. Written authorization provided by Munitions Market Segment Leader designating individuals who can "offer explosives for shipment" under the authority of the CH2M HILL Department of Transportation Hazardous Materials Certificate of Registration				

SHIPPING BY AIR (7.1)

5. Shipments for Federal Express meet IATA requirements for dangerous goods.	☐	☐	☐	☐
6. Before shipping, packages are clearly identified, packed, marked, labeled, and documented.	☐	☐	☐	☐
7. The quantity does not exceed IATA regulations.	☐	☐	☐	☐
8. Packaging meets IATA requirements and withstand transport by air.	☐	☐	☐	☐
9. Shipper classifies each item into one of the 9 hazard classes.	☐	☐	☐	☐
10. Inner packages are packed to prevent breaking or leaking during shipping.	☐	☐	☐	☐
11. Absorbent or cushioning material does not react with the contents of the inner package.	☐	☐	☐	☐
12. Outer packages in fiberboard, a plastic case, or other sturdy container.	☐	☐	☐	☐
13. Package is capable of withstanding 4’ drop test with no damage.	☐	☐	☐	☐
14. Package is marked with: proper shipping name of contents, technical name, UN number, total net. quantity, and the name and address of the shipper and recipient.	☐	☐	☐	☐
15. Irrelevant labels have been removed from package.				
16. Hazard label and handling label are secured in correct locations.	☐	☐	☐	☐
17. Dangerous goods airbill has been completed.	☐	☐	☐	☐
18. Dangerous goods are not shipped via UPS.	☐	☐	☐	☐

SECTION 1 (continued)

SHIPPING BY HIGHWAY (7.2)

	Yes	No	N/A	N/O
19. Use Federal Express packaging and paperwork requirements that comply with DOT regs for ground transportation of dangerous goods.	☐	☐	☐	☐
20. Consult with local state highway police if route includes vehicular tunnels.	☐	☐	☐	☐
21. Inner packaging prevents breakage or leakage under normal conditions of transport.	☐	☐	☐	☐
22. Absorbent/cushioning material does not react with contents of the package.	☐	☐	☐	☐
23. Labels for highway transportation are the same as those for air transportation.	☐	☐	☐	☐
24. Engine turned off, brake set during loading and unloading.	☐	☐	☐	☐

EMERGENCY RESPONSE (7.3)

25. Appropriate emergency response information available not on the package, within reach of driver.	☐	☐	☐	☐
26. Information includes copy of pages from *Emergency Response Guidebook* for each item.	☐	☐	☐	☐
27. An MSDS for each item must also be included.	☐	☐	☐	☐
28. Emergency response information must also include the information found on the shipping papers.	☐	☐	☐	☐
29. CH2M HILL's 24-hour EMERGENCY RESPONSE TELEPHONE NUMBER, (800) 255-3954, is included, as required.	☐	☐	☐	☐
30. In the event of an accident, keep other individuals, except response workers, from the vicinity.	☐	☐	☐	☐
31. In case of breakage, spillage, or leakage, use means to prevent spreading and contain the spill.	☐	☐	☐	☐
32. Care taken during the handling of cargo to minimize hazards.	☐	☐	☐	☐
33. MSDS is consulted for safe handling procedures.	☐	☐	☐	☐
34. Wash the area of the vehicle where the dangerous goods may have spilled.	☐	☐	☐	☐
35. Consult your supervisor in the event of a spill.	☐	☐	☐	☐
36. Ask your supervisor to call CHEM-TEL of the local HAZMAT unit if the spill poses a danger.	☐	☐	☐	☐

SECTION 2

Complete this section for all items checked “No” in Section 1. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned or Taken	Date Corrected

Auditor: ______________________________ Project Manager: ________________________________

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's HSP/FSI. This checklist is to be used at locations where CH2M HILL employees are exposed to lead, or are required to perform oversight of a subcontractor whose personnel are exposed to lead.

CH2M HILL staff shall not direct the means and methods of subcontractor lead activities nor direct the details of appropriate corrective actions. The subcontractor must determine how to correct deficiencies and CH2M HILL staff must carefully rely on their expertise. Conditions considered to be imminently dangerous (possibility of serious injury or death) must be corrected immediately or all exposed personnel must be removed from the hazard until corrected.

Project Name: ______________________________ Project No.: ______________

Location: ______________________________ PM:

Auditor: ____________________ Title: __________________ Date: __________

This specific checklist has been completed to:

☐ Evaluate CH2M HILL compliance with its Lead program (SOP HSE-508)

☐ Evaluate a CH2M HILL subcontractor's compliance with its Lead program

Subcontractors Name: ____

- Check "Yes" if an assessment item is complete/correct
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable
- Check "N/O" if an item is applicable but was not observed during the assessment

SECTION 1

	Yes	No	N/A	N/O
PERSONNEL SAFE WORK PRACTICES (5.1)				
COMPLIANCE PROGRAM (5.3)				
1. Where EL ≥ PEL, a written compliance program is implemented prior to commencing work.	☐	☐	☐	☐
2. The compliance program is based on the most recent air monitoring/sampling results.	☐	☐	☐	☐
3. The compliance program is updated for new exposure monitoring data or annually.	☐	☐	☐	☐
4. Written compliance program is available to all affected employees.	☐	☐	☐	☐
5. Waste generated must be determined if considered hazardous waste.	☐	☐	☐	☐
EMPLOYEE INFORMATION (5.2.1)				
6. CH2M HILL personnel have completed the Lead Training Module	☐	☐	☐	☐
7. Training on the Fact Sheet, HSP/FSI and OSHA standard has been met.	☐	☐	☐	☐
8. The selection of the appropriate respirator is based on the airborne lead concentration	☐	☐	☐	☐
9. Personnel working near lead-contaminated soil or material shall use wet methods and work practices to control dust; wear disposable coveralls and exercise personal hygiene practices	☐	☐	☐	☐
10. Contact lenses are not worn when working with lead	☐	☐	☐	☐

		Yes	No	N/A	N/O
REGULATED AREAS (5.4)					
11.	Written or verbal notification to owners, contractors or other personnel working in the area of lead work activities	☐	☐	☐	☐
12.	Areas that exceed the PEL have been designated as regulated areas.	☐	☐	☐	☐
13.	Personnel meet medical and training requirements.	☐	☐	☐	☐
14.	No eating, drink, and/or smoking are allowed in the regulated areas.	☐	☐	☐	☐
15.	Warning signs have been posted at all entrances to the regulated areas.	☐	☐	☐	☐
16.	Shower facilities installed and used with cleaning agents and towels, where feasible.	☐	☐	☐	☐
17.	Hand washing facilities provided for use by employees prior to eating, drinking, smoking, etc.	☐	☐	☐	☐
18.	Eating facilities free of lead provided for employees working in regulated areas.	☐	☐	☐	☐
19.	Change areas provided where EL ≥ PEL or where employees are subject to eye or skin irritation.	☐	☐	☐	☐
HOUSEKEEPING (5.5)					
20.	All surfaces are free of accumulation of lead.	☐	☐	☐	☐
21	Cleaning methods minimize airborne lead activity.	☐	☐	☐	☐
22.	Where vacuuming is used, vacuums are used and emptied as to minimize airborne lead.	☐	☐	☐	☐
23	Compressed air not used to remove lead from surfaces.	☐	☐	☐	☐
EXPOSURE ASSESSMENTS (5.1)					
24.	Initial air monitoring conducted over full shift for each job classification.	☐	☐	☐	☐
25.	Air sampling conducted every six months when exposure limit (EL) ≥ AL but < PEL.	☐	☐	☐	☐
26.	Air sampling of employees conducted quarterly when EL ≥ PEL.	☐	☐	☐	☐
27.	Additional air monitoring has been collected when there are any changes in operation.	☐	☐	☐	☐
28.	Employees have been informed of air monitoring results within 5 days after receipt of results.	☐	☐	☐	☐
29.	Where PEL is exceeded, affected employees have been notified of results and control measures to be utilized to reduce exposure below the PEL.	☐	☐	☐	☐
CONTROL METHODS (5.2)					
ENGINEERING AND WORK PRACTICE CONTROLS (5.2.1)					
30.	Engineering controls and work practices have been utilized to reduce exposures below the PEL.	☐	☐	☐	☐
31.	Mechanical ventilation performance evaluated when used to control exposure.	☐	☐	☐	☐
32.	Job rotation schedule established, when using administrative controls.	☐	☐	☐	☐
33.	When controls are unable to reduce exposures below the PEL, respiratory protection is utilized	☐	☐	☐	☐

RESPIRATORY PROTECTION (5.2.2)	Yes	No	N/A	N/O
34. Respirators are used in areas where EL ≥ PEL.	☐	☐	☐	☐
35. Respirator filters are replaced at the beginning of shift.	☐	☐	☐	☐
36. PAPRs are provided to employees who request such a respirator.	☐	☐	☐	☐

PERSONAL PROTECTIVE EQUIPMENT (5.2.3)	**Yes**	**No**	**N/A**	**N/O**
37. PPE is supplied at no cost to employees	☐	☐	☐	☐
38. Clean and dry protective clothing is provided weekly, daily if EL ≥ 200 $\mu g/m^3$	☐	☐	☐	☐
39. Protective clothing is repair or replaced if found to be ineffective	☐	☐	☐	☐
40. PPE is not blown, shook or other methods used to clean...	☐	☐	☐	☐
41. Employee not allowed to leave workplace wearing clothing worn during work shift.	☐	☐	☐	☐
42. Contaminated protective clothing is removed from change areas at the end of the shift.	☐	☐	☐	☐
43. All clothing requiring laundering is packaged in sealed, labeled containers.	☐	☐	☐	☐
44. Personnel or vendors who launder contaminated clothing are formally informed of the hazards.	☐	☐	☐	☐

SECTION 2

Complete this section for all items checked "No" in Section 1. Deficient items be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

Auditor: ________________________________ Project Manager: ___________________________

CH2MHILL

HS&E Self-Assessment Checklist – LOCKOUT/TAGOUT

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's written safety plan.

This checklist is to be used when: 1) CH2M HILL staff are exposed to lockout/tagout hazards (complete Section 1), 2) CH2M HILL staff are self-performing lockout/tagout activities (completed Section 2), or 3) CH2M HILL provides oversight of subcontractor personnel who are performing lockout/tagout activities (complete Sections 1 and 2).

Safety Coordinator may consult with subcontractors when completing this checklist, but shall not direct the means and methods of lockout/tagout operations nor direct the details of corrective actions. Subcontractors shall determine how to correct deficiencies and we must carefully rely on their expertise. Items considered to be imminently dangerous (possibility of serious injury or death) shall be corrected immediately, or all exposed personnel shall be removed from the hazard until corrected.

Project Name: ______________________________ Project No.: ______________

Location: ______________________________ PM: ______________

Auditor: ______________________ Title: ______________ Date: ________

This specific checklist has been completed to:

☐ Evaluate CH2M HILL affected employee exposure to equipment during lockout/tagout
☐ Evaluate CH2M HILL authorized employee exposure to equipment requiring lockout/tagout
☐ Evaluate a CH2M HILL subcontractor's compliance with lockout/tagout requirements
Subcontractors Name: ______________________________

- Check "Yes" if an assessment item is complete/correct.
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in Standard of Practice HSE-33.

SECTION 1

SAFE WORK PRACTICES (4.1)

		Yes	No	N/A	N/O
1.	Only trained and authorized personnel are performing lockout/tagout activities	☐	☐	☐	☐
2.	All affected employees notified prior to lockout/tagout activities	☐	☐	☐	☐
3.	Equipment has been shutdown using normal operating controls	☐	☐	☐	☐
4.	Employees do not attempt to start, energize or use equipment that is locked out or tagged	☐	☐	☐	☐
5.	Employees do not remove locks or tags placed on equipment by other personnel	☐	☐	☐	☐
6.	Affected employees are notified after lockout/tagout is completed	☐	☐	☐	☐
7.	Employees verify that all safe guards have been replaced prior to equipment start-up	☐	☐	☐	☐

SECTION 2	Yes	No	N/A	N/O
GENERAL (4.2.1)				
8. Only trained and authorized personnel are performing lockout/tagout activities	☐	☐	☐	☐
9. Daily safety briefing/meeting conducted with affected and authorized employees	☐	☐	☐	☐
10. Employees made aware of any equipment-specific lockout/tagout procedures	☐	☐	☐	☐
11. Authorized employees provided with lockout devices, locks, tags and other isolation devices	☐	☐	☐	☐
12. New or modified equipment designed to accept lockout devices	☐	☐	☐	☐
INITIATING LOCKOUT/TAGOUT (LOTO) CONTROL (4.2.2)				
13. LOTO procedures available when required to be documented	☐	☐	☐	☐
14. Equipment-specific LOTO procedures developed when not available from the facility	☐	☐	☐	☐
15. Affected employees notified that equipment will be shut down for LOTO	☐	☐	☐	☐
16. Energy sources, hazards, and control measures determined	☐	☐	☐	☐
17. Orderly shutdown of equipment is conducted that does not increase hazards	☐	☐	☐	☐
18. Energy isolating devices operated to isolate energy sources	☐	☐	☐	☐
19. Authorized employees apply personal lockout devices and tags to energy isolating device	☐	☐	☐	☐
20. Lockout devices are applied to secure equipment in the “off” position	☐	☐	☐	☐
21. Lockout tags applied to clearly indicate that operating the equipment is prohibited	☐	☐	☐	☐
22. Tags are located as close to or at the energy isolating device	☐	☐	☐	☐
23. All hazardous stored or residual energy is relieved, disconnected or restrained.	☐	☐	☐	☐
24. Isolation of energy sources has been verified (tested) prior to of work on equipment	☐	☐	☐	☐
25. Lockout tags are used alone only where lockout devices cannot be applied	☐	☐	☐	☐
LOCKOUT DEVICES AND TAGS (4.2.3)				
26. Lockout devices and tags only used to isolate energy sources	☐	☐	☐	☐
27. Lockout devices and tags are standardized by color, shape, size, print, and format	☐	☐	☐	☐
28. Lockout devices and tags indicate identity of employee applying the devices	☐	☐	☐	☐
29. Lockout devices and tags capable of withstanding anticipated environmental conditions of use	☐	☐	☐	☐
30. Lockout devices are substantial enough to prevent removal without the use of excessive force	☐	☐	☐	☐
31. Tags and their means of attachment are substantial enough to prevent inadvertent removal	☐	☐	☐	☐
32. Tags are legible and understandable by all employees	☐	☐	☐	☐
33. Tags warn against hazardous conditions if equipment is energized	☐	☐	☐	☐
RELEASING LOTO CONTROL (4.2.4)				
34. Work area inspected prior to removing LOTO devices and reenergization	☐	☐	☐	☐
35. LOTO devices only removed by authorized employees who applied the device	☐	☐	☐	☐
36. If employee not available to remove LOTO devices, steps in Section 4.2.4 of SOP followed	☐	☐	☐	☐
37. All affected employees notified prior to starting equipment previously locked or tagged out	☐	☐	☐	☐
GROUP LOTO (4.2.5)				
38. Group LOTO procedures followed when more than one employees is to work on equipment	☐	☐	☐	☐
39. Primary authorized person assigned to coordinate LOTO process	☐	☐	☐	☐
40. Normal steps for initiating LOTO control completed as above	☐	☐	☐	☐
41. Primary authorized person applies own lockout device and tag	☐	☐	☐	☐
42. Each authorized person applies own lockout device and tag	☐	☐	☐	☐
43. Primary authorized person removes LOTO devices after all other LOTO devices are removed	☐	☐	☐	☐
SPECIAL CONDITIONS (4.2.6)				
44. Shift or personnel changes coordinated to ensure LOTO protection is always provided	☐	☐	☐	☐
45. Procedures followed when LOTO devices are temporarily removed to test or reposition	☐	☐	☐	☐

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HS&E Self-Assessment Checklist – LOCKOUT/TAGOUT

SECTION 3

Complete this section for all items checked “No” in Sections 1 or 2. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

Auditor: ________________________________ Project Manager: __________________________________

CH2M HILL Health and Safety Plan

Attachment 5

Behavior Based Loss Prevention System Forms

Activity Hazard Analysis Template

Pre-Task Safety Plans

Safe Behavior Observation

Incident Report and Investigation

(use electronic form when possible)

HITS

Activity:	**Date:**
	Project:
Description of the work:	**Site Supervisor:**
	Site Safety Officer:
	Review for latest use: **Before the job is performed.**

Work Activity Sequence (Identify the principal steps involved and the sequence of work activities)	Potential Health and Safety Hazards (Analyze each principal step for potential hazards)	Hazard Controls (Develop specific controls for each potential hazard)

Equipment to be used (List equipment to be used in the work activity)	Inspection Requirements (List inspection requirements for the work activity)	Training Requirements (List training requirements including hazard communication)

	PRINT NAME	SIGNATURE	
Supervisor Name:	____________________	____________________	Date/Time:____________________
Safety Officer Name:	____________________	____________________	Date/Time:____________________
Employee Name(s):	____________________	____________________	Date/Time:____________________
	____________________	____________________	Date/Time:____________________
	____________________	____________________	Date/Time:____________________
	____________________	____________________	Date/Time:____________________
	____________________	____________________	Date/Time:____________________
	____________________	____________________	Date/Time:____________________
	____________________	____________________	Date/Time:____________________
	____________________	____________________	Date/Time:____________________
	____________________	____________________	Date/Time:____________________

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Pre-Task Safety Plan (PTSP)

Project: ______________________ Location: _____________________ Date: _________________________

Supervisor: ______________________________ Job Activity: _____________________________________

____

Task Personnel:

____

____

____

____

List Tasks:

____

____

____

____

Tools/Equipment Required for Tasks (ladders, scaffolds, fall protection, cranes/rigging, heavy equipment, power tools):

____

____

____

Potential H&S Hazards, including chemical, physical, safety, biological and environmental (check all that apply):

__ Chemical burns/contact	__ Trench, excavations, cave-ins	__ Ergonomics
__ Pressurized lines/equipment	__ Overexertion	__ Chemical splash
__ Thermal burns	__ Pinch points	__ Poisonous plants/insects
__ Electrical	__ Cuts/abrasions	__ Eye hazards/flying projectile
__ Weather conditions	__ Spills	__ Inhalation hazard
__ Heights/fall > 6 feet	__ Overhead Electrical hazards	__ Heat/cold stress
__ Noise	__ Elevated loads	__ Water/drowning hazard
__ Explosion/fire	__ Slips, trip and falls	__ Heavy equipment
__ Radiation	__ Manual lifting	__ Aerial lifts/platforms
__ Confined space entry	__ Welding/cutting	__ Demolition

Other Potential Hazards (Describe):

____

____

____

Hazard Control Measures (Check All That Apply):

PPE __ Thermal/lined __ Eye __ Dermal/hand __ Hearing __ Respiratory __ Reflective vests __ Flotation device	Protective Systems __ Sloping __ Shoring __ Trench box __ Barricades __ Competent person __ Locate buried utilities __ Daily inspections	Fire Protection __ Fire extinguishers __ Fire watch __ Non-spark tools __ Grounding/bonding __ Intrinsically safe equipment	Electrical __ Lockout/tagout __ Grounded __ Panels covered __ GFCI/extension cords __ Power tools/cord inspected
Fall Protection __ Harness/lanyards __ Adequate anchorage __ Guardrail system __ Covered opening __ Fixed barricades __ Warning system	Air Monitoring __ PID/FID __ Detector tubes __ Radiation __ Personnel sampling __ LEL/O2 __ Other	Proper Equipment __ Aerial lift/ladders/scaffolds __ Forklift/heavy equipment __ Backup alarms __ Hand/power tools __ Crane with current inspection __ Proper rigging __ Operator qualified	Welding & Cutting __ Cylinders secured/capped __ Cylinders separated/upright __ Flash-back arrestors __ No cylinders in CSE __ Flame retardant clothing __ Appropriate goggles
Confined Space Entry __ Isolation __ Air monitoring __ Trained personnel __ Permit completed __ Rescue	Medical/ER __ First-aid kit __ Eye wash __ FA-CPR trained personnel __ Route to hospital	Heat/Cold Stress __ Work/rest regime __ Rest area __ Liquids available __ Monitoring __ Training	Vehicle/Traffic __ Traffic control __ Barricades __ Flags __ Signs
Permits __ Hot work __ Confined space __ Lockout/tagout __ Excavation __ Demolition __ Energized work	Demolition __ Pre-demolition survey __ Structure condition __ Isolate area/utilities __ Competent person __ Hazmat present	Inspections: __ Ladders/aerial lifts __ Lanyards/harness __ Scaffolds __ Heavy equipment __ Cranes and rigging	Training: __ Hazwaste __ Construction __ Competent person __ Task-specific (THA) __ Hazcom

Field Notes:____

____

____

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Name (Print): ________________________________

Signature:________________________________ Date:_________________

Safe Behavior Observation Form		
Project Name:	Observer:	Date:
Program / Client:	Project Mgr. & No.:	
Position/Title of worker observed:	Background Information/ comments:	
Task/Observation Observed:		

- ❖ Identify and reinforce safe work practices/behaviors
- ❖ Identify and improve on at-risk practices/acts
- ❖ Identify and improve on practices, conditions, controls, and compliance that eliminate or reduce hazards
- ❖ Proactive PM support facilitates eliminating/reducing hazards (do you have what you need?)
- ❖ Positive, corrective, cooperative, collaborative feedback/recommendations

Actions & Behaviors	Safe	At-Risk	Observations/Comments
Current & accurate Pre-Task Planning/Briefing (Project safety plan, STAC, AHA, PTSP, tailgate briefing, etc., as needed)			**Positive Observations/Safe Work Practices:**
Properly trained/ qualified/ experienced			
Tools/equipment available and adequate			
Proper use of tools			**Questionable Activity/Unsafe Condition Observed:**
Barricades/work zone control			
Housekeeping			
Communication			
Work Approach/Habits			
Attitude			
Focus/attentiveness			**Observer's Corrective Actions/Comments:**
Pace			
Uncomfortable/unsafe position			
Inconvenient/unsafe location			
Position/Line of fire			
Apparel (hair, loose clothing, jewelry)			
Repetitive motion			**Observed Worker's Corrective Actions/Comments:**
Other…			

CH2M HILL Health and Safety Plan

Attachment 6

Material Safety Data Sheets/Fact Sheets

CH2MHILL

Arsenic

Standard of Practice HSE-501

Arsenic Fact Sheet

Uses and Occurrences

The manufacture and transportation of arsenic compounds; used in the manufacture of herbicide, pesticide, fungicides, and defoliants; used in the manufacture and handling of calcium arsenate; used in the manufacture of electrical semiconductors, diodes, and solar batteries; used as an additive for food and drinking water for animals; used as a preharvest desiccant, sugarcane ripener, soil sterilant, or for timber thinning; used as a bronzing or decolorizing addition in glass manufacturing; used in the production of opal glass and enamels; used as an addition to alloys to increase hardening and heat resistance; used during smelting of ores; used during the cleanup of soil contaminated with arsenic; used military applications; and used in the general handling, storage, and use of arsenic.

Physical Characteristics

Appearance:	Gray metal or white powder
Odor:	Odorless solid, garlic-like when heated
Flammable:	None
Flash Point:	None
Flammable Range:	None
Specific Gravity:	5.73 for arsenic metal, 3.74 for arsenic trioxide
Stability:	Stable
Incompatibilities:	Heat, hydrogen gas, and oxidizing agents
Melting Point:	Sublimes at 613^{o}C (1135^{o}F); 315^{o}C (599 ^{o}F) for arsenic trioxide
Boiling Point:	Sublimes at 613^{o}C (1135^{o}F); 465^{o}C (869 ^{o}F) for arsenic trioxide

Signs and Symptoms of Exposure

Short-term (Acute):	Nausea, vomiting, diarrhea, weakness, loss of appetite, cough, chest pain, giddiness, headache, and breathing difficulty.
Long-term (Chronic):	Numbness and weakness in the legs and feet, skin and eye irritation, hyperpigmentation, thickening of palms and soles (hyperkeratosis), contact dermatitis, skin sensitization, warts, ulceration, perforation of the nasal septum, and lung and lymphatic cancer.

Modes of Exposure

Inhalation:	Dusts and Vapors
Absorption:	Liquid
Ingestion:	Dusts and Liquid

Exposure Limits

Action level (AL)	5 µg/m^3
PEL	10 µg/m^3
STEL	None
TLV	10 µg/m^3

Exposure Level vs. Regulatory Requirements

EXPOSURE LEVEL (EL)	**REGULATORY REQUIREMENTS**
EL < AL	Maintain exposure as low as reasonably achievable.
AL > EL, EL < PEL	Implement portions of the OSHA Arsenic Standard and training.
EL > PEL	Implement all portions of the OSHA Arsenic Standard, including training, medical surveillance, engineering controls, establishment of work areas, etc.

PPE

Eye:	Safety glasses; contact lenses should **not** be worn.
Skin:	Chemical protective gloves and body protection.
Respiratory:	Air purifying respirators and supplied air respirators, depending on the exposure.

First Aid

Inhalation:	Move to fresh air; seek medical attention promptly.
Skin:	Quick drenching with water; wash skin with soap and water; seek medical attention promptly.
Eyes:	Flush with water for 15 minutes, lifting the lower and upper lids occasionally; seek medical attention promptly.
Ingestion:	Seek medical attention promptly.

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Lead
Standard of Practice HSE-508

Lead Fact Sheet

Uses and Occurrences

Lead can be found in the following: construction materials for tank linings and piping; component of lead-acid storage batteries; lead solder; plastics; steel; and pigments for paints. Lead can also be found in waste rock associated with mining activities, wood debris or stock used for electrical co-generation activities, and soil and waste associated with manufacturing activities. Elevated levels of naturally occurring lead may also be found in the soil in certain parts of this country.

Physical Characteristics

Appearance:	Bluish-white, slivery, gray metal. Very soft and easily malleable
Odor:	None
Flammable:	Noncombustible
Flash Point:	Not Applicable
Flammable Range:	Not Applicable
Specific gravity:	11.35
Stability:	very stable
Incompatibilities:	hot nitric acid, boiling concentrated hydrochloric and sulfuric acids
Melting Point:	327^{o}C

Signs and Symptoms of Exposure

Skin and Eye: Irritation

Ingestion and Inhalation (Acute Overexposure): Lead is a potent, systemic poison that serves no known useful function once absorbed by your body. Taken in large enough doses, lead can kill you in a matter of days. A condition affecting the brain called acute encephalopathy may arise that develops quickly to seizures, coma, and death from cardio-respiratory arrest. A short term dose of lead can lead to acute encephalopathy. Short term occupational exposures of this magnitude are highly unusual, but not impossible. Similar forms of encephalopathy may, however, arise from extended, chronic exposure to lower doses of lead. There is no sharp dividing line between rapidly developing acute effects of lead, and chronic effects that take longer to acquire. Lead adversely affects numerous body systems, and causes forms of health impairment and disease that arise after periods of exposure as short as days or as long as several years.

Ingestion and Inhalation (Chronic Overexposure):Chronic overexposure to lead may result in severe damage to your blood-forming, nervous, urinary and reproductive systems. Some common symptoms of chronic overexposure include loss of appetite, metallic taste in the mouth, anxiety, constipation, nausea, pallor, excessive tiredness, weakness, insomnia, headache, nervous irritability, muscle and joint pain or soreness, fine tremors, numbness, dizziness, hyperactivity and colic. In lead colic, there may be severe abdominal pain.

Modes of Exposure

Inhalation:	Dusts and fumes
Skin Absorption:	None
Ingestion:	Dusts and solids

Exposure Limits

Action level	0.03 mg/m^3
PEL	0.05 mg/m^3
STEL	None
PEL-C	None
TLV	0.05 mg/m^3

Exposure Level vs. Regulatory Requirements

EXPOSURE LEVEL (EL)	REGULATORY REQUIREMENTS
EL less than Action Level (AL)	Maintain exposure as low as reasonably achievable
EL greater than AL and less than PEL	Implement portions of the OSHA Lead Standard (i.e., initial medical monitoring) and Training
EL greater than PEL	Implement all portions of the OSHA Lead Standard including training, medical surveillance, engineering controls, establishment of work areas, etc.

PPE

Eye:	Safety Glasses
Skin:	Coveralls or disposable coveralls to keep lead off clothing and to prevent the spread of lead contamination.
Respiratory:	Air purifying respirators and supplied air respirators, depending on the exposure.

First Aid

Inhalation:	Move to fresh air, contact a physician
Skin:	Wash with water
Eyes	Flush with water
Ingestion:	Contact a physician

CH2M HILL Health and Safety Plan

Attachment 7

Working Alone Standard

CALL – IN CONTACT FORM

Date of site work:_______________ Expected start time:______________

Name of CH2M HILL employee in the field:_____________________________________

Name of CH2M HILL employee responsible to receive contact:

Client Emergency Contact (if any):

CH2M HILL employee's contact numbers:

Radio #__________________________

Cell Phone #______________________

Address and Location of work:____

Directions/Map:

Planned Activity:____

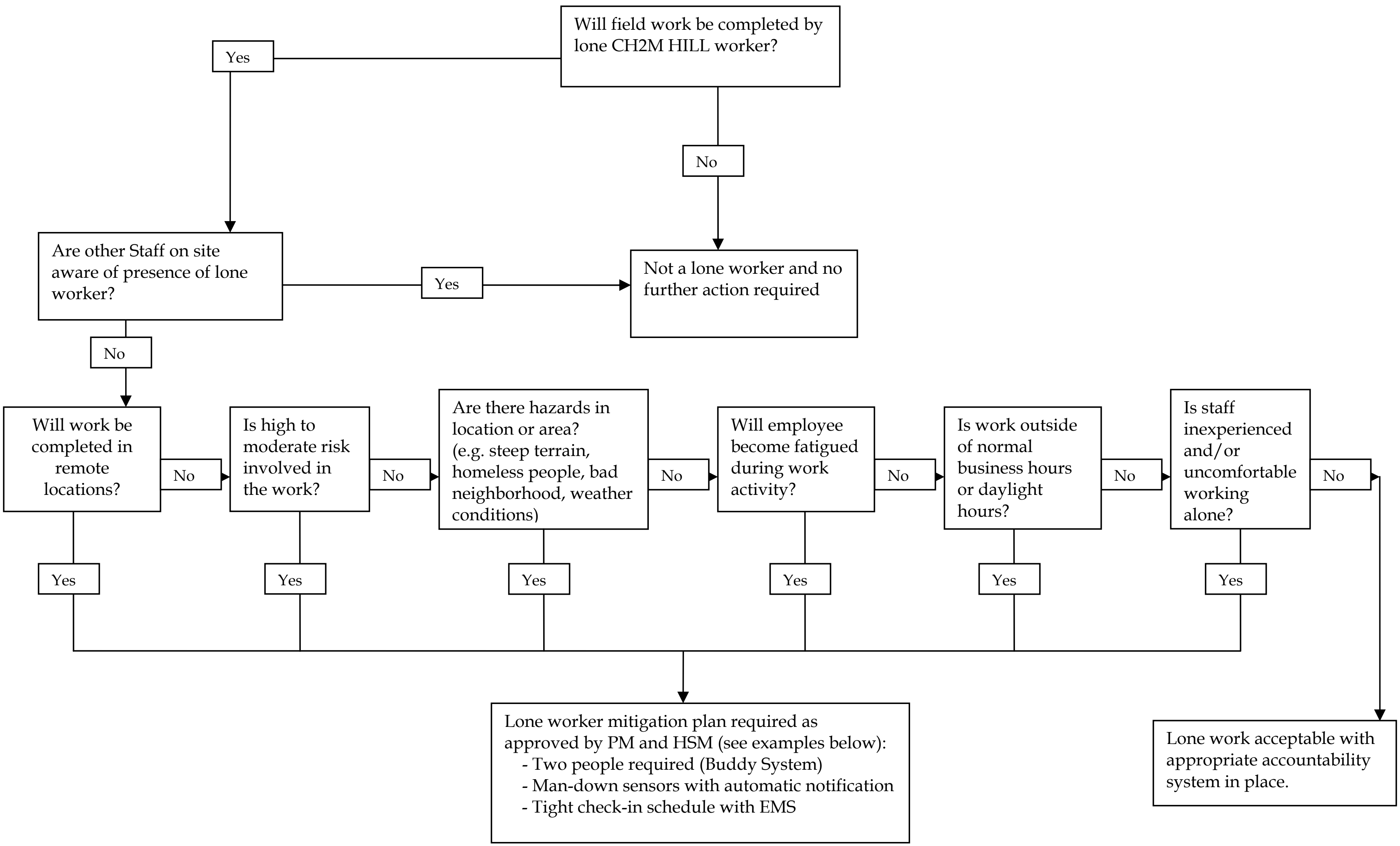
Specified Frequency and time for call in:____

Time	Verified	Location

If lone worker fails to call in at specified frequency/time:

1) Call worker's radio and cell to determine if an emergency exists.
2) If no reply, immediately call Client security/emergency service if there is one at the site.
3) If there is no client security call Emergency Services (911). Inform the dispatcher there is a lone worker that cannot be contacted and there may be an emergency on site. Provide the lone worker's name, their last known location, and your contact information.
4) After Emergency Services have been contacted, call the other emergency contacts, Project Manager, and Health and Safety Manager.

Lone Worker Protocol



CH2M HILL HEALTH AND SAFETY PLAN

Attachment 8

Tick Fact Sheet

Tick-Borne Pathogens — A Fact Sheet

Most of us have heard of Lyme disease or Rocky Mountain Spotted Fever (RMSF), but there are actually six notifiable tick-borne pathogens that present a significant field hazard. In some areas, these account for more than half of our serious field incidents. The following procedures should be applied during any field activity—even in places that are predominantly paved with bordering vegetation.

Hazard Recognition

An important step in controlling tick related hazards is understanding how to identify ticks, their habitats, their geographical locations, and signs and symptoms of tick-borne illnesses.

Tick Identification

There are five varieties of hard-bodied ticks that have been associated with tick-borne pathogens. These include:

- Deer (Black Legged) Tick (eastern and pacific varieties)
- Lone Star Tick
- Dog Tick
- Rocky Mountain Wood Tick

These varieties and their geographical locations are illustrated on the following page.

Tick Habitat

In eastern states, ticks are associated with deciduous forest and habitat containing leaf litter. Leaf litter provides a moist cover from wind, snow, and other elements. In the north-central states, is generally found in heavily wooded areas often surrounded by broad tracts of land cleared for agriculture.

On the Pacific Coast, the bacteria are transmitted to humans by the western black-legged (deer) tick and habitats are more diverse. For this region, ticks have been found in habitats with forest, north coastal scrub, high brush, and open grasslands. Coastal tick populations thrive in areas of high rainfall, but ticks are also found at inland locations.

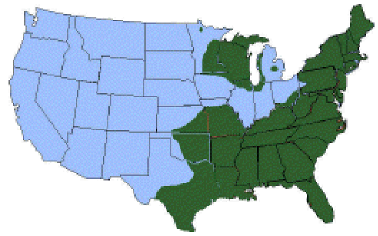
Illnesses and Signs & Symptoms

There are six notifiable tick-borne pathogens that cause human illness in the United States. These pathogens may be transmitted during a tick bite—normally hours after attachment. The illnesses, presented in approximate order of most common to least, include:

- Lyme (bacteria)
- RMSF (bacteria)
- Ehrlichiosis (bacteria)
- STARI (Southern Tick-Associated Rash Illness) (bacteria)
- Tularemia (Rabbit Fever) (bacteria)
- Babesia (protozoan parasite)

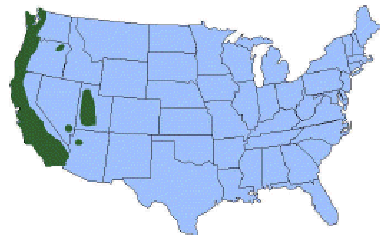
Symptoms will vary based on the illness, and may develop in infected individuals typically between 3 and 30 days after transmission. Some infected individuals will not become ill or may develop only mild symptoms. These illnesses present with some or all of the following signs & symptoms: fever, headache, muscle aches, stiff neck, joint aches, nausea, vomiting, abdominal pain, diarrhea, malaise, weakness, small solid, ring-like, or spotted rashes. The bite site may be red, swollen, or develop ulceration or lesions. For Lyme disease, the bite area will sometimes resemble a target pattern. A variety of long-term symptoms may result if the illness is left untreated, including debilitating effects and death.

Deer Tick



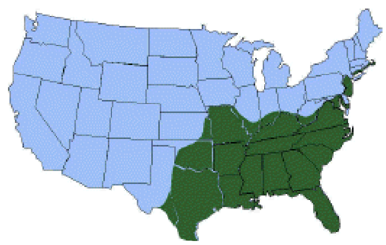
Distribution of Deer Tick (dark green)

From Left: adult female, adult male, nymph, and larvae Deer Tick (cm scale)



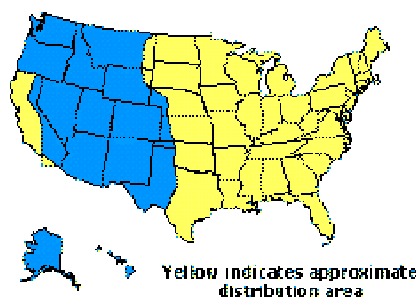
Distribution of Pacific Deer Tick (dark green)

Lone Star Tick

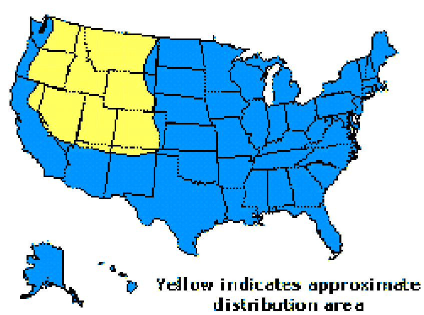


Distribution of Lone Star Tick (Green)

Dog Tick



Rocky Mountain Wood Tick



Hazard Control

The methods for controlling exposure to ticks include, in order of most- to least-preferred:

- Avoiding tick habitats and ceasing operations in heavily infested areas
- Reducing tick abundance through habitat disruption or application of acracide
- Personal protection through use of repellants and protective clothing
- Frequent tick inspections and proper hygiene

Vaccinations are not available and preventative antibiotic treatment after a bite is generally not recommended.

Avoidance and Reduction of Ticks

To the extent practical, tick habitats should be avoided. In areas with significant tick infestation, consider stopping work and withdrawing from area until adequate tick population control can be achieved. Stopping and withdrawing should be considered as seriously as entering an area without proper energy control or with elevated airborne contaminants—tick-borne pathogens present risk of serious illness!

In areas where significant population density or infestation exists, tick reduction should be considered. Tick reduction can be achieved by disrupting tick habitats and/or direct population reduction through the use of tick-toxic pesticides (Damminix, Dursban, Sevin, etc.).

Habitat disruption may include only simple vegetative maintenance such as removing leaf litter and trimming grass and brush. Tick populations can be reduced by between 72 and 100 percent when leaf litter alone is removed. In more heavily infested areas, habitat disruption may include grubbing, tree trimming or removal, and pesticide application (Damminix, Dursban, Sevin, etc.). This approach is practical in smaller, localized areas or perimeter areas that require occasional access. Habitat controls are to be implemented with appropriate health and safety controls, in compliance with applicable environmental requirements, and may be best left to the property owner or tenant or to a licensed pesticide vendor. Caution should be exercised when using chemical repellents or pesticides in or around areas where environmental or industrial media samples will be collected for analysis.

Personal Protection

After other prevention and controls are implemented, personal protection is still necessary to control exposure to ticks. Personal protection must include all of the following steps:

- Where site conditions warrant (vegetation above knee height, tick endemic area) or when tasks warrant (e.g., having to sit/kneel in vegetation) that diminish the effectiveness of the other controls mentioned above, bug-out suits (obtained from MKE warehouse)/Tyvek shall be used. Bug-out suits are more breathable than Tyvek.
- So that ticks may be easily seen, wear light-colored clothing. Full-body New Tyvek (paper-like disposable coveralls) may also be used
- To prevent ticks from getting underneath clothing tuck pant legs into socks or tape to boots
- Wear long-sleeved shirts, a hat, and high boots
- Apply DEET repellent to exposed skin or clothing per product label
- Apply permethrin repellent to the outside of boots and clothing before wearing, per product label
- Frequently check for ticks and remove from clothing
- At the end of the day, search your entire body for ticks (particularly groin, armpits, neck, and head) and shower
- To prevent pathogen transmission through mucous membranes or broken/cut skin, wash or disinfect hands and/or wear surgical-style nitrile gloves any time ticks are handled

Pregnant individuals and individuals using prescription medications should consult with their physician and/or pharmacists before using chemical repellents. Because human health effects may not be fully known, use of chemical repellents should be kept to a minimum frequency and quantity. Always follow manufacturers' use instructions and precautions. Wash hands after handling, applying, or removing protective gear and clothing. Avoid situations such as hand-to-face contact, eating, drinking, and smoking when applying or using repellents.

Remove and wash clothes per repellent product label. Chemical repellents should not be used on infants and children.

Vaccinations are generally not available for tick-borne pathogens. Although production of the LYMErix™ Lyme disease vaccination has been ceased, vaccination may still be considered under specific circumstances and with concurrence from the consulting physician.

Tick Check

A tick check should be performed after field survey before entering the field vehicle (you do not want to infest your field vehicle with ticks). Have your field partner check your back; the backs of your legs, arms, and neck; and your hairline. Shake off clothing as thorough as possible before entering the vehicle. Once the field day is complete, repeat this procedure and perform a thorough self check.

If a tick has embedded itself into the skin, remove the tick as described below.

Tick Removal

1. Use the tick removal kit obtained through the CH2M HILL Milwaukee warehouse, or a fine-tipped tweezers or shield your fingers with a tissue, paper towel, or nitrile gloves.

Tick Bites\Tick Remover.pdf

2. Grasp the tick as close to the skin surface as possible and pull upward with steady, even pressure. Do not twist or jerk the tick; this may cause the mouthparts to break off and remain in the skin. If this happens,

remove mouthparts with tweezers. Consult your healthcare provider if infection occurs.

3. Avoid squeezing, crushing or puncturing the body of the tick because its fluids (saliva, hemolymph, gut contents) may contain infectious organisms. Releasing these organisms to the outside of the tick's body or into the bite area may increase the chance of infectious organism transmission.

4. Do not handle the tick with bare hands because infectious agents may enter through mucous membranes or breaks in the skin. This precaution is particularly directed to individuals who remove ticks from domestic animals with unprotected fingers. Children, elderly persons, and immunocompromised persons may be at greater risk of infection and should avoid this procedure.

5. After removing the tick, thoroughly disinfect the bite site and wash your hands with soap and water.

6. You may wish to save the tick for identification in case you become ill. Your doctor can use the information to assist in making an accurate diagnosis. Place the tick in a plastic bag and put it in your freezer. Write the date of the bite on a piece of paper with a pencil and place it in the bag.

Note: Folklore remedies such as petroleum jelly or hot matches do little to encourage a tick to detach from skin. In fact, they may make matters worse by irritating the tick and stimulating it to release additional saliva, increasing the chances of transmitting the pathogen. These methods of tick removal should be avoided. In addition, a number of tick removal devices have been marketed, but none are better than a plain set of fine tipped tweezers.

First-Aid and Medical Treatment

Tick bites should always be treated with first-aid. Clean and wash hands and disinfect the bite site after removing embedded tick. Individuals previously infected with Lyme disease does not confer immunity—re-infection from future tick bites can occur even after a person has contracted a tick-borne disease.

CH2M Hill has a protocol in place for employees who have experienced a tick bite due to work-related activities, to test all ticks that have been removed from them for the presence of Borrelia burgdorferi.

The employee should contact the Injury Management/Return To Work provider (IMRTW), WorkCare using the toll-free number 866-893-2514 to report the tick bite. WorkCare will follow-up with each CH2M Hill employee who reports a tick bite and is at risk of developing Lyme disease by monitoring for symptoms up to 45 days, and will refer the employee to a medical provider for evaluation and treatment as necessary

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 9

Notice of Safety Violation Form

Notice of Safety Violation

REPORT PREPARED BY:

Name:	**Title:**	**Signature:**	**Date:**

VIOLATION:

Description:	Date:

SUBCONTRACTOR SIGNATURE OF NOTIFICATION:

Name:	**Title:**	**Signature:**	**Date:**

**** Corrective action is to be taken immediately. Note below the action taken, sign and return to CCI.****

SUBCONTRACTOR'S CORRECTIVE ACTION

Description:	Date of Nonperformance:

SUBCONTRACTOR SIGNATURE OF CORRECTION

Name:	**Title:**	**Signature:**	**Date:**

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 10

Stop Work Order Form

Stop Work Order

REPORT PREPARED BY:

Name:	**Title:**	**Signature:**	**Date:**

ISSUE OF NONPERFORMANCE:

Description:	Date of Nonperformance:

SUBCONTRACTOR SIGNATURE OF NOTIFICATION:

Name:	**Title:**	**Signature:**	**Date:**

**** Corrective action is to be taken immediately. Note below the action taken, sign and return to CCI.* Work may not resume until authorization is granted by CH2M HILL Constructors, Inc. Representative,***

SUBCONTRACTOR'S CORRECTIVE ACTION

Description:	Date of Nonperformance:

SUBCONTRACTOR SIGNATURE OF CORRECTION

Name:	**Title:**	**Signature:**	**Date:**

Appendix D
Laboratory Standard Operating Procedures

Laboratory SOPs are proprietary and confidential.
They are provided upon request at the discretion of the Project Manager.