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FINAL SAMPLING AND ANALYSIS PLAN FOR THE REMEDIAL INVESTIGATION FOR HARBOR DREDGE SPOIL AREA SITE 12 NSTC GREAT LAKES IL

1/1/2011

TETRA TECH NUS

Sampling and Analysis Plan
for the
Remedial Investigation for Site 12 Harbor Dredge Spoil Area

Naval Station Great Lakes
Great Lakes, Illinois

Naval Facilities Engineering Command Midwest

Contract Number N62460-08-D-1001

Contract Task Order F27A

January 2011

DRAFT
SAMPLING AND ANALYSIS PLAN
(Field Sampling Plan and Quality Assurance Project Plan)

January 2011

Remedial Investigation for Site 12 - Harbor Dredge Spoil Area
Naval Station Great Lakes
Great Lakes, Illinois

Prepared for:
Naval Facilities Engineering Command Midwest
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Prepared under:
Comprehensive Long-Term Environmental Action Navy (CLEAN)
Contract Number N62470-08-D-1001
Contract Task Order F27A

SAP Worksheet #1 – Title and Approval Page
(UFP-QAPP Manual Section 2.1)

Document Title: Sampling and Analysis Plan, (Field Sampling Plan and Quality Assurance Project Plan), March 2010, Remedial Investigation for Site 12 – Harbor Dredge Spoil Area, Naval Station Great Lakes, Illinois

Lead Organization: Naval Facilities Engineering Command Midwest

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Signature/Date
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Approval Signatures: 28 April 2011
Signature/Date
Brian Conrath, RPM, Illinois EPA

Signature/Date
Les Morrow, Risk Assessor, Illinois EPA

EXECUTIVE SUMMARY

This Uniform Federal Policy-Sampling and Analysis Plan (UFP-SAP) was prepared according to United States Environmental Protection Agency (USEPA) Quality Assurance Project Plan (QAPP) requirements for a Remedial Investigation (RI) of Site 12, Harbor Dredge Spoil Area, located at Naval Station (NS) Great Lakes, Great Lakes, Illinois. This UFP-SAP was prepared by Tetra Tech NUS, Inc. (Tetra Tech) on behalf of Naval Facilities Engineering Command (NAVFAC) Midwest under Contract Number N62470-08-D-1001, Contract Task Order (CTO) F27A. This SAP was generated in accordance with applicable United States Navy, Illinois Environmental Protection Agency (Illinois EPA), and USEPA requirements, regulations, guidance, and technical standards.

Site 12 is located in a flat area on the shore of the NS Great Lakes Outer Harbor, and is approximately 3.5 acres. Site 12 is currently a grass-covered field that is used as a picnic and recreational area. A gravel road transects the site from north to south and terminates in a gravel parking lot on the south against a concrete pier. The only structure on the site is a picnic pavilion overlooking the lake. The only other notable feature is a drainage ditch which emerges from the bluff on the west and extends eastwards across the site to Lake Michigan. During harbor dredge activities in 1952 and in the 1970s, dredge spoils were reportedly disposed of in this area. The sediment dredged from the harbor may have high organic content, and potentially contain heavy metals, oils, pesticides, and polychlorinated biphenyls (PCBs). The primary sources of the environmental contaminants in the sediments are from upstream industrial sources (historical discharges and contamination) and storm water discharges within the Pettibone Creek Watershed. Overland runoff and storm water discharges from Naval Station Great Lakes to Pettibone Creek may have contributed pollutants to the watershed, but analytical results do not suggest that a significant point source(s) is(are) impacting the sediment quality of Pettibone Creek.

A Remedial Investigation (RI) Verification Step was conducted by Dames & Moore (1991) at the site. Fill materials, encountered during the investigation of soil borings appeared to have the physical composition of lake dredge spoils. Surface and subsurface soil samples were collected and analyzed for volatile organic compounds (VOCs), heavy metals, pesticides, and PCBs. Several metals, including antimony, cadmium, copper, lead, mercury, selenium, silver, and zinc were detected at concentrations above representative background values throughout the areal extent of the site and at depth down to at least 8 feet below ground surface (bgs). Pesticides DDD, DDE, and DDT were also detected in near surface soils throughout the areal extent of the site.

Data collected during the field investigation for the Site 12 RI will used to determine if chemical concentrations are present at greater than acceptable risk-based human health levels. Risks to macroinvertabrates from erosion into the harbor will be evaluated. The possible outcomes of this RI are

No Further Action (NFA) if chemical concentrations are less than acceptable human health or ecological risk levels, or a Feasibility Study (FS) to evaluate alternatives address the site risks.

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Appendix D Laboratory Standard Operating Procedures
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ACRONYMS AND ABBREVIATIONS

AES	Atomic Emissions Spectrometry
ARARs	Applicable or Relevant and Appropriate Requirements
bgs	Below ground surface
BTU	British Termal UnitCA
CAS	Chemical Abstract Service
CCV	Continuing Calibration Verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
COPC	Constituent of potential concern
CSM	Conceptual Site Model
CTO	Contract Task Order
DI	Deionized
DFTPP	Decafluorotriphenylphosphine
DL	Detection Limits
DoD	Department of Defense
DOT	Department of Transportation
DPT	Direct-push technology
DQI	Data Quality Indicator
DQO	Data Quality Objective
DVM	Data Validation Manager
ECD	Electron Capture Detector
EDD	Electronic Data Deliverable
EE/CA	Engineering Estimate/Cost Analysis
Empirical	Empirical Laboratories, LLC
EPA	Environmental Protection Agency
EU	Exposure Unit
FOL	Field Operations Leader
FS	Feasibility Study
FTMR	Field Task Modification Request
GC	Gas Chromatograph
GC/MS	Gas chromatograph/mass spectrometer
GPS	Global Positioning System
HASP	Health and Safety Plan

HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
HSA	Hollow-stemmed Auger
HSM	Health and Safety Manager
IAC	Illinois Administrative Code
IAS	Initial Assessment Study
ICAL	Initial Calibration
ICP	Inductively Coupled Plasma
IDW	Investigation-derived waste
ILCR	Incremental Lifetime Cancer Risk
JULIE	Joint Utility Locating Information for Excavators
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LOQ	Limits of Quantitation
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MSL	Mean Sea Level
NA	Not Applicable
NAD	North American Datum
NAVD	North American Vertical Datum
NAVFAC	Naval Facilities Engineering Command
NFA	No Further Action
NIRIS	Naval Installation Restoration Information Solution
NS	Naval Station
NV	No Value
OPNAV	Office of the Chief of Naval Operations
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
PAL	Project Action Limit
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated biphenyl
PDF	Portable Document Format
PLC	Product Line Coordinator
PM	Project Manager
PPE	Personal protective equipment

PQL	Project Quantitation Limit
PQLG	Project Quantitation Limit Goal
QA	Quality Assurance
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
QL	Quantitation limit
QSM	Quality Systems Manual
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RPD	Relative Percent Difference
RPM	Remedial Project Manager
RSD	Relative Standard Deviation
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SDG	Sample Delivery Group
SOP	Standard Operating Procedure
SPCS	State Plane Coordinate System
SQL	Structured Query Language
SSO	Site Safety Officer
SVOC	Semivolatile organic compound
TACO	Tiered Approach to Corrective Action Objective
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
Tetra Tech	Tetra Tech, Inc.
UCL	Upper Confidence Level
UFP-SAP	Uniform Federal Policy-Sampling and Analysis Plan
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound

SAP Worksheet #2 -- SAP Identifying Information

(UFP-QAPP Manual Section 2.2.4)

Site Name/Number:	**Site 12, Harbor Dredge Spoil Area**
Operable Unit:	**NA**
Contractor Name:	**Tetra Tech NUS, Inc. (Tetra Tech)**
Contract Number:	**N62470-08-D-1001**
Contract Title:	**Comprehensive Long-Term Environmental Action Navy (CLEAN)**
Work Assignment Number:	**Contract Task Order (CTO) F27A**

1. This Uniform Federal Policy-Sampling and Analysis Plan (UFP-SAP or SAP) was prepared in accordance with the requirements of the United States Environmental Protection Agency (USEPA) Uniform Federal Policy for Quality Assurance Plans (UFP-QAPP) (2005) and USEPA Guidance for Quality Assurance Project Plans, EPA QA/G-5, (2002).

2. Identify regulatory program:

   Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

3. This document is a project-specific SAP.

4. List dates of scoping sessions that were held:

   Data Quality Objective (DQO) Scoping Session – December 2, 2009

5. List dates and titles of any SAP documents written for previous site work that are relevant to the current investigation.

Title	***Date***
Initial Assessment Study (IAS), Great Lakes Naval Complex (Rogers, Golden & Halpern, 1986)	1986
Technical Memorandum on the Remedial Investigation Verification Step for the Naval Training Center, Great Lakes, Illinois (Dames & Moore, 1991)	1991
Remedial Investigation Work Plan, Site 4 – Fire Fighting Training Unit, Site 12 – Harbor Dredging Spoil Area, Naval Training Center, Great Lakes, Illinois (Halliburton NUS, 1993)	1993

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

   Illinois Environmental Protection Agency (EPA) – regulatory oversight
   NAVFAC Midwest – property owner

7. Lead organization

   Department of the Navy, Naval Facilities Engineering Command (NAVFAC) Midwest

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

   All required elements are included in this SAP.

SAP Worksheet #3 – Distribution List

(UFP-QAPP Manual Section 2.3.1)

Name of SAP Recipient	Title/Role	Organization	Telephone Number	E-Mail Address
Howard Hickey	Product Line Coordinator (PLC)/ Program Manager	NAVFAC Midwest	(847) 688-2600 X 243	Howard.Hickey@navy.mil
Terese Van Donsel	Remedial Project Manager (RPM)	NAVFAC Midwest	(847) 688-2600 X 136	Terese.VanDonsel@navy.mil
Brian Conrath	Illinois Remedial Project Manager (RPM)	Illinois EPA	(217) 557-8155	Brian.Conrath@illinois.gov
Biff Cummings	Project Manager (PM)	Tetra Tech	(412) 920-7021	biff.cummings@tetratech.com
Tom Johnston	Atlantic Quality Assurance Manager (QAM)	Tetra Tech	(412) 921-8615	tom.johnston@tetratech.com
Matt Soltis	Health and Safety Manager (HSM)	Tetra Tech	(412)921-8912	Matt.Soltis@tetratech.com
Ann Cognetti	Project Chemist	Tetra Tech	(412) 921-8862	ann.cognetti@tetratech.com
Kim Kostzer	Laboratory P M	Empirical Laboratories, LLC (Empirical)	(615) 345-1115 X 240	kkostzer@empirlabs.com
TBD	Field Operations Leader (FOL)/Site Safety Officer (SSO)	Tetra Tech	TBD	TBD
Lee Leck	Database Manager	Tetra Tech	(412) 921-8856	lee.leck@@tetratech.com
Joseph Samchuck	Data Validation Manager (DVM)	Tetra Tech	(412) 921-8510	joseph.samchuck@tetratech.com
Glenn Wagner	Administrative Record Assistant	Tetra Tech	(412) 220-2211	Glenn.wagner@tetratech.com

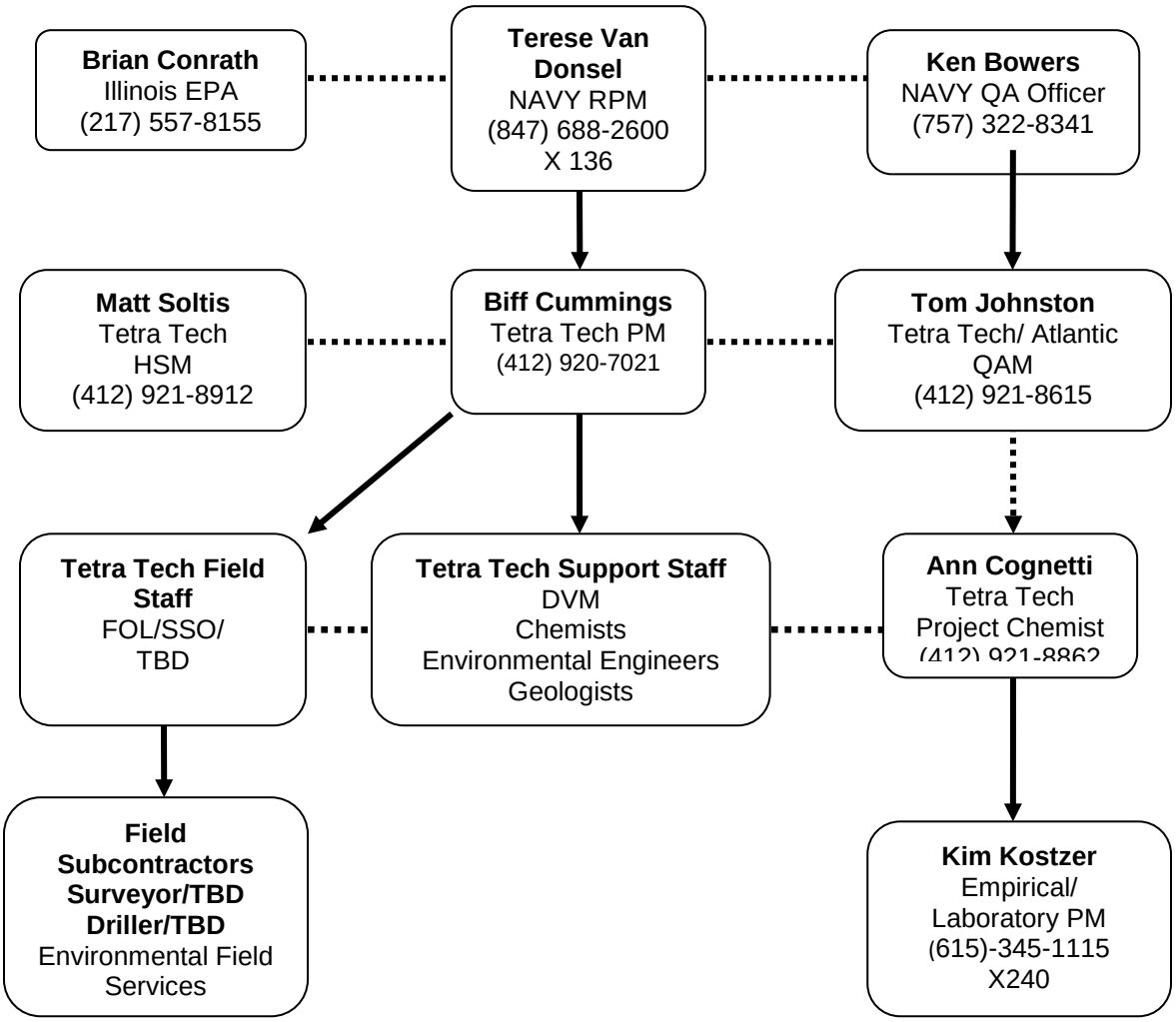
SAP Worksheet #4 – Project Personnel Sign-Off Sheet
(UFP-QAPP Manual Section 2.3.2)

Name	Organization/Title/Role	Telephone Number	Signature/Email Receipt	SAP Section Reviewed	Date SAP Read
Navy and Regulator Project Team Personnel					
Terese Van Donsel	NAVFAC Midwest/RPM	(847) 688-2600 X 136	See Worksheet #1	All	
Brian Conrath	Illinois RPM	(217) 557-8155	See Worksheet #1	All	
Tetra Tech Project Team Personnel					
Biff Cummings	Tetra Tech/PM	(412) 920-7021	See Worksheet #1	All	
Chuck Metz	Tetra Tech/FOL/SSO	(412) 921-8214	[illegible]	All	12-20-10
Ann Cognetti	Tetra Tech/Project Chemist	(412) 921-8862	Ann Cognetti	All	12-20-10
Matt Soltis	Tetra Tech/Health and Safety Manager	(412) 921-8912	See HASP	Health and Safety Plan (HASP)	
Joe Samchuck	Tetra Tech/Data Validation Manager	(412) 921-8510	[illegible]	All	12-20-10
Subcontractor Personnel					
Kim Kostzer	Empirical/Laboratory PM	(615) 345-1115 X 240	[illegible]	Worksheets #6, #12, #14, #15, #19, #23-28, #30, #34-#36	6-22-11

SAP Worksheet #5 -- Project Organizational Chart

(UFP-QAPP Manual Section 2.4.1)

Lines of Authority ——— ····· Lines of Communication



SAP Worksheet #6 -- Communication Pathways

(UFP-QAPP Manual Section 2.4.2)

Communication Driver	Responsible Affiliation	Name	Phone Number and/or E-Mail	Procedure (timing, pathway to & from, etc.)
Issues in the field that result in changes in scope of field work	Tetra Tech FOL Tetra Tech PM	TBD Biff Cummings	TBD (412) 920-7021	FOL will inform PM within one business day; PM will inform Navy RPM by close of next working day. Document the changes on a field task modification request (FTMR) form and obtain required approvals within 5 days of initiating the form
Identification of the need for a change in schedule	Tetra Tech PM	Biff Cummings	(412) 920-7021	Inform Navy via schedule impact letter within 1 business day
Recommendation to stop work and initiate work upon corrective action	Tetra Tech FOL/SSO Tetra Tech PM Tetra Tech QAM Tetra Tech HSM Navy RPM	TBD Biff Cummings Tom Johnston Matt Soltis Terese Van Donsel	TBD (412) 920-7021 (412) 921-8615 (412) 921-8912 (847) 688-2600 X 136	Responsible party informs subcontractors, the Navy, Illinois EPA, and Project Team (see Worksheet #9) within one business day.
Analytical data quality issues	Empirical Laboratory PM Tetra Tech Project Chemist	Kim Kostzer Ann Cognetti	(615) 345-1115 X 240 (412) 921-8862	Notify Tetra Tech Project Chemist within one business day. Tetra Tech Notify data validation staff and Tetra Tech PM within one business day.

Notes:
TBD – To be determined.

SAP Worksheet #7 – Personnel Responsibilities and Qualifications Table

(UFP-QAPP Manual Section 2.4.3)

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications
Brian Conrath	RPM	Illinois EPA	Makes sure that investigation work and documentation is in compliance with applicable regulations.	Available upon request
Terese Van Donsel	Navy RPM	Navy	Manages project and coordinates Project Team (see Worksheet #9).	Available upon request
Kim Kostzer	Laboratory PM	Empirical	Primary laboratory contact; ensures analyses are performed in accordance with SAP protocols.	Available upon request
Biff Cummings	PM	Tetra Tech	Oversees project, financial, scheduling and technical day-to-day management of the project. Overall coordination of the project and document review.	B.S. Civil Engineering, 31 years environmental engineering experience
Lee Leck	Data Manager	Tetra Tech	Assists in SAP preparation, makes sure that data management activities are performed in accordance with SAP procedures.	17 years of data management experience
Joseph Samchuck	DVM	Tetra Tech	Manages data validation deliverables.	B.S. Chemistry, M.S., Finance, 24 years of environmental experience
TBD	FOL, SSO	Tetra Tech	Supervises, coordinates, and performs field sampling activities.	Information will be provided in the Final SAP.
Tom Johnston	QAM	Tetra Tech	Assists in SAP preparation. Makes certain of implementation of quality aspects of the CLEAN program.	B.S. Chemistry, Ph.D. Chemistry; 30 years environmental experience
Ann Cognetti	Project Chemist	Tetra Tech	Prepares laboratory scope, coordinates with laboratory, and performs data quality review. Coordinates analyses with laboratory chemists, makes sure the scope is followed, reviews Quality Assurance (QA) data packages, and communicates with Tetra Tech staff.	M.S. Chemistry,1 years environmental experience
Matt Soltis	HSM	Tetra Tech	Oversees CLEAN Program Health and Safety Program.	B.S. Industrial Safety Sciences, 24 years environmental experience

In some cases, one person may be designated responsibilities for more than one position. For work conducted under this UFP-SAP, the FOL will also be responsible for SSO and Site QA/QC responsibilities. This action will be performed only as credentials, experience, and availability permits.

SAP Worksheet #8 -- Special Personnel Training Requirements Table

(UFP-QAPP Manual Section 2.4.4)

Each site worker will be required to have completed a 40-hour course (and 8-hour refresher, if applicable) in health and safety training as described under Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) 1910.120(b)(4). Safety requirements are addressed in greater detail in the site-specific Tetra Tech HASP included in Appendix A.

SAP Worksheet #9 -- Project Scoping Session Participants Sheet

(UFP-QAPP Manual Section 2.5.1)

Project Name: Site 12 RI Projected Date(s) of Sampling: Summer 2010 Project Manager: Biff Cummings	Site Name: Site 12 – Harbor Dredge Spoil Area Site Location: NS Great Lakes, Great Lakes, Illinois

Date of Session: December 2-4, 2009
Scoping Session Purpose: DQO Scoping Session

Project Team Member	Title, Affiliation	Phone #	E-Mail Address	Project Role
Biff Cummings	PM, Tetra Tech	(412)920-7021	biff. cummings@tetratech.com	Project Manager
Robert Davis	Technical Consultant, Tetra Tech	(412) 921-7251	robert.davis@tetratech.com	Technical Consultant
Tom Johnston	QAM, Tetra Tech	(412)921-8615	tom.johnston@tetratech.com	DQO Facilitator
Li Wang	Environmental Scientist, Tetra Tech	(412) 920-7015	li.wang@tetratech.com	Technical Support
David Morgan	Risk Assessor, Tetra Tech	(412) 921-8509	david.morgan@tetratech.com	Risk Assessment
Shannon Hill	Geologist, Tetra Tech	(412) 921-8876	shannon.hill@tetratech.com	Geologist

Comments/Decisions: None.

Action Items:

- Dave Morgan and Li Wang: Identify Soil and Groundwater Criteria (TACO and RSLs)
- Kelly Carper: Select Chemical Analysis Methods to ensure sensitivity is low enough that limits of quantitation (LOQs) and detection limits (DLs) will be less than the screening criteria.
- Shannon Hill and Li Wang: Review past reports to determine past soil sampling technique(s) - Note that solid stem auger was used in *1991 Tech Memo RI Verification Step*.
- Dave Morgan: Verify criterion for Pb evaluations.
- Bob Davis: Clarify potential exposure unit (EU) size based on land use and zoning regulations (completed during meeting).
- Biff Cummings and Bob Davis: Verify receptors list and related CSMs.

- Tom Johnston: Do statistical calculations with help of statistician if necessary.

- Biff Cummings: Confer with the Navy RPM regarding the proposed approach and develop a consensus with Illinois EPA RPM and the Navy Chemist.

Subsequent Discussions and Decisions:

Following the initial scoping meeting, conferences were held with the Tetra Tech PM and the Navy RPM, (Terese Van Donsel). Additionally, related discussions were held between the Navy RPM and the Illinois EPA RPM (Brian Conrath) and the Navy Chemist (Ken Bowers). The subsequent discussions concluded that:

- Due to the sizable amount of past sampling data at both the Site and within Pettibone Creek, which is considered to be the source area of sediment removed from the harbor and placed at Site 5, the number of sampling locations should be limited to the amount that can statistically support an assessment of risk (10 sampling locations).

- Sampling should be limited to soil only. Groundwater is not to be sampled since its condition is more likely related to surface water (Lake Michigan) influences rather than site contaminants and on-site flow. However, groundwater samples may be collected if review of the soil data by the project team warrants further investigation.

- Sample locations were selected based on a judgmental approach and with consensus and confidence of the Project Team that sampling will detect and provide a representation of any contamination occurring at the Site.

- Two soil samples should be collected from each sampling location for testing; one from each of the surface and subsurface soil stratas.

- The collected samples should be tested for semivolatile organic compounds (SVOCs), polynuclear aromatic hydrocarbons (PAHs), metals, and pesticides (20 total). Half of the samples collected from the subsurface soil strata should be tested for polychlorinated biphenyls PCBs (5 total). Samples shall be selected based on visual observations.

SAP Worksheet #10 – Conceptual Site Model

(UFP-QAPP Manual Section 2.5.2)

10.1 SITE BACKGROUND

NS Great Lakes covers 1,632 acres within Lake County, Illinois (See Figure 10-1). Lake County is located in northeastern Illinois, and is composed of 24 miles of Lake Michigan shoreline. Lake County is divided into 18 townships, 52 incorporated cities and villages, and 18 unincorporated cities and villages.

NS Great Lakes provides facilities and related support to training activities, including the Navy's only boot camp, as well as a variety of other military commands located on base. Land uses vary in the areas surrounding NS Great Lakes. Along the northern boundary of the base are mostly highly urbanized and industrialized areas. Much of the land beyond the northwestern site boundary comprises unincorporated lands of Lake County, and is vacant except for scattered commercial and residential properties. Adjacent to the western boundary are primarily industrial properties, and along the southern boundary is a mixture of public open space and residential land.

Site 12 is located in a flat area on the shore of the NS Great Lakes Outer Harbor, south of a stormwater retention basin (see Figure 10-2), and is approximately 3.5 acres in size. The stormwater retention basin was constructed between 1991 and 2002 over the former location of the tanks that were part of the installation's sewage treatment plant (shown on the inset 1974 aerial photo on Figure 10-2). (The installation's sewage is now treated offsite by the local municipal wastewater treatment plant.) Figure 10-2. Site 12 is a grass-covered field rising westward from the shore of Lake Michigan, and is bounded on the western edge by a wooded bluff that is 50 to 60-feet high (see Figure 10-2). The site is currently used as a picnic and recreational area and the only structure on the site is a picnic pavilion overlooking the lake. An archery range was reportedly situated on the northern portion of the site, immediately south of the stormwater retention basin; however, its presence at the site could not be verified from the aerial photo. A gravel road transects the site from north to south and terminates in a gravel parking lot on the south, against a concrete pier. The only other notable feature is a drainage ditch which emerges from the bluff and extends eastward across the site to Lake Michigan.

During harbor dredging activities in 1952 and the 1970s, dredge spoils from the boat slip area in the harbor were reportedly disposed in Site 12 (Rogers, Golden & Halpern, 1986). The harbor area receives flow from Pettibone Creek, which drains stormwater from the base and a number of off-base industries upstream of NS Great Lakes. The primary sources of the environmental contaminants in the sediments are from upstream industrial sources (historical discharges and contamination) and storm water discharges within the Pettibone Creek Watershed. Overland runoff and storm water discharges from Naval Station Great Lakes to Pettibone Creek may have contributed pollutants to the watershed, but

analytical results do not suggest that a significant point source(s) is(are) impacting the sediment quality of Pettibone Creek. Chemicals in the runoff may have settled in the sediments (Rogers, Golden & Halpern, 1986). An Initial Assessment Study (IAS) was performed at NS Great Lakes in 1986. The IAS identified seven sites, including Site 12, as requiring further study within NS Great Lakes. The area of Site 12 that may have received fill between 1950 and 1990 is shown on Figure 10-2.in Figure 10-2. Dames & Moore (1991) reviewed aerial photographs taken between 1946 and 1985 which indicated evidence of some filling and other modifications to Site 12 over this period. However, these filling activities do not coincide with or closely follow the reported dates of harbor dredging; therefore, the filling activities may not be related to the disposition of dredge spoils, as originally reported by the IAS (Dames & Moore, 1991). Dames & Moore (1991) reported that discussions with personnel at the base regarding the 1970s dredging operations indicated that spoils from this period were placed in the lake approximately 5 miles from shore. Installation personnel were not able to provide personal knowledge of the 1952 dredging operations. After the Dames & Moore (1991) report was issued, the stormwater retention pond was installed and an additional portion of Site 12 along Lake Michigan was filled in (Figure 10-2). Past development activities at the Site are documented on historic maps and aerial photographs. These maps and photographs are presented in Appendix B and are summarized in Section 10.2 of this document. The Dames and Moore report (1991) also notes that in the late 1980s, there were piles of soil and plant debris on Site 12. The soil and debris presumably came from other locations at NS Great Lakes. The sediment reportedly dredged from the harbor and deposited on Site 12 could have high organic content, and may contain heavy metals, oils (i.e., SVOCs and PAHs), pesticides, and PCBs from industries upstream of the NS Great Lakes.

Based on the recommendations of the IAS, Dames & Moore (1991) conducted the RI Verification Step on five of the seven sites identified in the IAS, including Site 12. Surface and subsurface soil samples were collected from various locations at Site 12 during in two sampling events in December 1988 and in March 1989 and were analyzed for volatile organic compounds (VOCs), metals, pesticides and PCBs. The samples from March 1989 exceeded laboratory holding times and were considered invalid. The site was resampled in August 1989. See Figure 10-3 for sample locations. Thirty-three surface and subsurface soil samples were collected from 11 soil borings. The pesticide and PCB data were validated and considered to be usable. The laboratory data for VOCs and metals could not be validated using USEPA Level III protocol for several technical and administrative reasons. Because the VOC and metals data were not validated they were presented in the Dames & Moore (1991) Technical Memorandum but not used in that report's conclusions and recommendations.

The following summarizes the results of the previous investigation as presented in the RI Verification Step):

- VOCs were analyzed in 14 surface and 28 subsurface soil samples collected in 1988 from 14 boring locations. Only four VOCs (acetone, 2-butanone, methylene chloride, and toluene) were detected. All of these compounds are common laboratory contaminants; therefore, they made be present in the laboratory results as a laboratory artifact. Based on the unvalidated VOC data and the fact that no VOCs were reported in excess of applicable criteria in the Site 17 RI and in the Harbor sampling data, VOCs are not considered potential contaminants of concern (COPCs) at Site 12. With that said, it is still possible that VOCs could be present in the Site 12 soil. Therefore, laboratory VOC analysis (using encore sample kits) will be performed on up to 4 samples depending on PID readings that are collected at the 10 proposed soil sample locations.

- Heavy metals were analyzed in 14 surface and 28 subsurface soil samples collected in 1988 from 14 boring locations. Several metals were detected at the site in concentrations exceeding background soil concentrations provided in TACO. Metals are considered COPCs at Site 12 and will be investigate further.

- Pesticides were analyzed in 11 surface and 22 subsurface soil samples collected in 1989 from 11 boring locations. Pesticides are considered COPCs at Site 12 and will be investigate further.

- PCBs were analyzed in 33 soil samples collected in 1989, but were not detected above the detection limits in any samples. However, PCBs are still considered COPCs at Site 12 and will be investigate further.

- SVOCs have not been analyzed in soil samples from Site 12. They are considered COPCs at Site 12 and will be investigate further.

- The areal extent of contaminants encompasses the entire site area identified in the IAS. The vertical extent of contamination was not determined; however, because metals were detected at the greatest depth sampled (i.e., 8 feet bgs), contamination probably extends below this depth. Boring should extend through the dredge spoil to the natural soil layer which is expected to be 10 to 15 feet bsg.

10.2 HISTORICAL MAPS AND AERIAL PHOTOGRAPHS AND SITE DOCUMENTATION

The following information was identified during a review of NS Great Lakes historical drawings and photographs, which are provided in Appendix B.

Drawing/Photo Date	Description
1907 Topographic Map	• Harbor had not been constructed. • No above ground structure is identifiable in the area of Site 12.
1909 General Plan	• Inner Harbor had been constructed.
1923 Boundary Survey	• Harbor had been constructed. • No above ground structures are shown in the drawing.
1929 Drawing	• No above ground structures are shown in the area of Site 12.
1930 Drawing	• No above ground structures are shown in the area of Site 12.
1936 Sounding Contour Lines	• No significant changes are identifiable at Site 12.
1939 Aerial Photo	• The whole naval station was depicted in the aerial map.
1941 Drawing	• No significant change is identifiable at Site 12.
1943 Drawing	• Shoreline changed in the area of Site 12, with land surface extended eastward slightly into Lake Michigan. Backfilling and leveling of the site may have occurred. • Shows several above ground treatment units were added to the sewage treatment plant to the north of Site 12. The shoreline in the southeast part of the sewage treatment plant also changed, and backfilling and leveling in this area may also have occurred.
1946 Drawing, 1949, 1950, and 1957 Plot Plans	• No significant change is identifiable at Site 12.
1958 and 1959 Base Map and 1961 Aerial Photo	• Shoreline slightly changed at Site 12.
1974 Aerial Photo	• Shows two gravel roads at Site 12.
1988 Aerial Photo	• The sewage treatment plant to the north of site 12 is still present.
2002 Aerial Photo	• The sewage treatment plant to the north of site 12 is no longer present. • Shoreline at Site 12 changed significantly and extended eastward into the lake. • Shows the above ground structure, gravel road and parking lot discussed in Section 10.1.
2006 Harbor Bathymetry Map	• The bottom contour in the harbor changed significantly compared to the 1936 sounding contour lines.

10.3 CONCEPTUAL SITE MODEL

This section presents the conceptual site model (CSM), including a discussion of potential contaminants, site hydrogeology, possible contaminant migration pathways and potential human health and ecological risks. This conceptual site model is depicted on Figure 10-4.

Potential Contaminants

Contaminants potentially affecting soil from past on-site activities include heavy metals, pesticides, PCBs, polyaromatic hydrocarbons (PAHs), and SVOCs that may be associated with contaminants from dredge spoils or other materials that may have been placed at the site.

Hydrogeology

Site 12 is located in a flat area on the lakeshore. Ground elevations at the site are approximately 585 feet above mean sea level (msl), and only a few feet above lake level. The surface consists of hard-packed gravel, sand, and silt covered with weeds and grasses, underlain by approximately 100 feet of glacial till over bedrock. The composition of the underlying till is believed to be primarily clay, but no data are available to confirm this. Various mixtures of primarily sand and gravel, with construction debris and lesser amounts of silt and clay were encountered when shallow borings were installed by Dames & Moore in 1988. This is indicative of filling and active sorting by wave action of the lake, as would be expected by lake dredging. Dames & Moore reported that during soil boring installation, additional debris was being deposited at this site, and that during the last sampling event in August 1989 the site was being developed for recreational purposes.

Shallow hydrogeology at NS Great Lakes is complex and includes several perched aquifers found mostly in discontinuous sand lenses within layers of clay and silty clay. The shallow aquifer located along the shoreline at the installation has a depth to groundwater between 2 and 5 feet bgs due to the proximity of the lake. The overall groundwater flow direction at Site 12 is expected to be strongly influenced by Lake Michigan water levels. This water is not potable and is not utilized at NSGL or the surrounding area. The remaining aquifer system is known as the deep aquifer system, with depths ranging from 900 to 1,900 feet bgs. The shallow aquifer system recharges from local rainfall infiltration, while the deep aquifer system receives sources from areas of central Wisconsin. Surface runoff drains directly into Lake Michigan. Groundwater quality at Site 12 has not been evaluated but is expected to have little influence on lake conditions due to an extensive amount of dilution and dispersion.

Contaminant Migration Pathways

The following contaminant migration routes and release mechanisms have been identified for potential contaminants at Site 12:

Soil: Site 12 is largely unpaved; therefore, surface and/or subsurface soil contamination in the spoils area may release contaminants through leaching, erosion/runoff and dust emission. Infiltration of surface precipitation could result in leaching of contaminants from the fill material (e.g. dredge spoils) and, thereby impact native soil underlying the fill and downgradient groundwater. Data from past investigations suggest that surface soils could be impacted. Surface soil could have eroded and migrated overland as a result of runoff, which enters Lake Michigan eventually as there is no storm water collection system at Site 12. Impacted soil can be emitted to the air through wind erosion and be transmitted to human or ecological receptors, such as macroinvertabrate, at the site or in the lake. However, wind and water erosion mechanisms are not expected to be significant because the ground cover serves to limit the

erosion of soils. Additionally, it is unknown whether clean fill has been placed over the dredge spoil. If clean fill is present it will limit the access to the spoils and potential discharges by mechanical means to the environment and receptors. The native soil is expected to be 10 to15 feet bgs.

Groundwater: Because of its proximity to Lake Michigan, groundwater levels and groundwater quality at the site are expected to fluctuate and be directly influenced by changes in lake level. Impacts of groundwater on the surface water as a result of the contaminants in the dredge spoils are expected to be slight due to an extensive amount of dilution and dispersion within the lake.

Surface Water: Stormwater runoff from the site is not collected; it is discharged to Lake Michigan directly. As discussed above, much of Site 12 is vegetated; therefore, stormwater runoff is not expected to be significant.

Potential Receptors

Human receptors potentially exposed to contaminants at Site 12 include people who use the site as a picnic and recreational area, workers who maintain the recreational area and construction workers. There are no plans to redevelop this site; however, if it were to be redeveloped in the future for residential purposes, then residents and trespassers would be possible receptors. These receptors could be exposed to chemicals in surface soil through direct contact exposure pathways (i.e., incidental ingestion of soil, dermal contact with soil, and inhalation of chemicals volatilized from soil or emitted with dust from the soil). The construction worker could be exposed to chemicals in subsurface soil through direct contact exposure pathways. If Site 12 is redeveloped in the future and subsurface soil is brought to the surface as part of the redevelopment, future residents, occupational workers, recreational users, or adolescent and adult trespassers could be exposed to chemicals in subsurface soil through direct contact exposure pathways. A further description of potential human receptors and exposure routes is provided in the human health risk assessment (HHRA) methodology in Appendix C.

Potential ecological receptors include aquatic macroinvertebrate in Lake Michigan. Ecological risks to macroinvertabrates from erosion of the contaminated soil into the harbor will be evaluated. No threatened or endangered species are known to occur on or near Site 12.

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

(UFP-QAPP Manual Section 2.6.1)

11.1 PROBLEM DEFINITION

Based on data collected during past investigations, it has been determined that soil at Site 12 may be contaminated with metals, PCBs, pesticides, PAHs, and SVOCs from the fill material (dredged sediments from the harbor or unkown fill sources). Human and ecological receptors (macroinvertabrates) could be at risk if they are exposed to contaminated soil. The nature and extent of contamination, if any, at Site 12, and the degree of risk to human and ecological receptors (macroinvertabrates) are unknown and must be characterized so that appropriate actions can be taken to mitigate unacceptable risks. If risks are acceptable, then no further action (NFA) will be recommended for the site.

11.2 INFORMATION INPUTS

To resolve the problem identified in Section 11.1, the following physical and chemical data will be collected at Site 12:

1) Surface soil and subsurface soil chemical data will be collected to determine the nature and extent of Target Compound List (TCL), PAHs, SVOCs, PCBs, pesticides, and Target Analyte List (TAL) metals (see Worksheet #15). The sampling methods are presented in Worksheet #18, and the chosen analytical methods are presented in Worksheet #19 and Appendix D. Analytical methods were selected to provide enough sensitivity to support the attainment of project objectives.

2) Visual screening of Direct Push Technology (DPT) cores will also be used to determine the presence of dredge spoils or other materials that may contribute to contamination. Tetra Tech SOP SA-1.3 (Appendix E) will be used to conduct the screening.

3) To estimate the limit of dredge spoils, it will only be necessary to use visual observation of samples collected from soil borings.

4) Illinois EPA background concentrations for metals and polynuclear aromatic hydrocarbons (PAHs) (35 IAC 742 Appendix A: Table G. Concentrations of Inorganic Chemicals in Background Soils) will be used to ensure that measured soil concentrations consistent with background concentrations are not inadvertently considered to be contaminated.

5) Locations of soil borings will be measured by a global positioning system (GPS) with sub-meter accuracy. All horizontal surface coordinates will be surveyed using the North American Datum (NAD)

83 SPCS Illinois East (feet) coordinate system. All ground surface elevations will be reported using the North American Vertical Datum (NAVD) 1988.

6) Lithology data for borings. These data will be collected during boring operations and sampling will be done in accordance with Tetra Tech SOPs (SOP GH-1.5 in Appendix E) and Illinois state regulations.

7) Water level readings will be performed in the test borings immediately upon completion to help with sample selection.

Project Action Limits

The Site 12 RI requires the collection of chemical data that can be used to characterize the site and conduct a screening level human health risk assessment. The soil Project Action Limits (PALs) are set at the lowest matrix-specific, risk-based or regulatory human health screening criteria appropriate for the site. The complete list of applicable screening values for the selected analytes is presented in Worksheet #15, and the derivation of PALs is provided in Appendix F. The PALs for this investigation are as follows:

- USEPA, 2009. Residential Regional Screening Levels for Chemical Contaminants in Soil at Superfund Sites developed by Oak Ridge National Laboratory (ORNL).

- Illinois Pollution Control Board, 2007. Title 35 of the Illinois Administrative Code (IAC) Section 742: TACO, Appendix C, Table A, B, C, Tier 1 Soil Remediation Objectives.

- Threshold Effects Concentration from MacDonald, D.D., C.G. Ingersoll, and T.A. Berger, 2000. "Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems." Archives of Environmental Contamination and Toxicology, Vol. 39, pp. 20-31.

- Ontario Ministry of Environment (OMOE), 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of Environment and Energy. August.

- Illinois EPA, 2000. Tiered Approach for Evaluation and Remediation of Petroleum Product Releases to Sediments. Draft, Update 2. Office of Chemical Safety. September 21.

To conduct the investigation of soil, the selected laboratory must be able to achieve limits of quantitation (LOQs) that are low enough to measure constituent concentrations below the PALs. Worksheet #15 is the first step used to select chemicals of potential concern (COPCs) as stated in Appendix C, Human Health Risk Assessment Work Plan based on the PALs. If the PAL falls below the MDL for a particular

analyte or analytes, this will require evaluation of these chemicals as stated in Appendix C, Human Health Risk Assessment Work Plan in the uncertainty section of the Risk Assessment Report.

11.3 TEMPORAL AND SPATIAL BOUNDARIES

Site 12 is spatially bounded by the former location of the sewage treatment plant on the north, an approximately 50-foot high wooded bluff on the west, a concrete pier on the south, and Lake Michigan on the east (Figure 10-2). For this evaluation, if a risk assessment is required, the site will be evaluated as one exposure unit.

Two major soil fill populations are of interest. For contaminant delineation, a population of soil fill (as opposed to native soil) with chemical concentrations exceeding the applicable screening criteria must be delineated to determine the extent of contamination. Bounding this population are chemical concentrations in soil fill that are less than or equal to the applicable screening criteria and considered uncontaminated. Because the project focus is to establish contamination related to dredge spoils within Site 12, it is important to stay within the established Site 12 boundary, and to avoid investigating contamination unrelated to dredge spoils. This means that areas located physically upgradient of dredge spoils, such as north of the bulkhead wall and west of the bluff, are not of interest. The depth to native soils beneath the dredge spoils is of interest in order to define the vertical extent of the spoil.

Within these two soil populations, the Project Team must distinguish between surface and subsurface soil because they are treated differently for risk assessment. Surface soil is defined for this project to be 0 to 6 inches bgs. Subsurface soil is defined to be soil from the bottom of the surface soil interval to the depth where native soil is encountered.

The Project Team plans to limit the data collection to a single field event, after which a decision will be made about whether to deem NFA for the site or, to proceed to a Feasibility Study (FS). Sampling in the warmer months is preferred to winter sampling because of problems that occur with ground freezing and discomfort to field crews. Site 12 RI field activities will be conducted late 2010 or early 2011.

11.4 ANALYTIC APPROACH

Decision rules are provided below for delineating contamination and for evaluating human health and ecological risks.

Rule for Delineating Contamination

The vertical extent of contamination will be determined by analyzing contaminant concentrations and making visual observations of samples obtained from the soil borings. Historical aerial photographs and physical limitations will primarily be used to establish the lateral boundaries of the dredge spoil deposition. If contamination is bounded during the initial sampling event, then no more data will be collected and delineation is complete. If delineation is not complete, then return to the site for additional data collection to complete delineation.

Rule for Human Health Assessment of Soil

For the human health risk assessment of soil, risks and hazard indices will be calculated for direct contact exposures to soil. The rules governing data use for the human health risk assessment for all chemicals except lead are as follows:

- If the Incremental Lifetime Cancer Risk (ILCR) is greater than 1 x 10-4 or if the HQ is between 0.1 and 1 for any receptor or the hazard quotient (HQ) is greater than 1, the Project Team will proceed to a FS in order to evaluate remedial alternatives.

- If the ILCR is within the target risk range of 1×10^{-6} to 1×10^{-4}, and if the HQ is between 0.1 and 1 for residential receptors, and chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs) are exceeded, the Project Team will meet to consider risk management options such as an engineering estimate/cost analysis (EE/CA) or a FS.

- If the risks are less than risk thresholds for residential receptors (ILCR less than 1×10^{-6}, and HQ less than 1.0), NFA will be recommended.

If lead is a COPC in soil, then the USEPA models for evaluating direct contact exposures to lead in soil (child lead model and adult lead model) will be used. In this case, if calculated blood lead levels in child or adult receptors exceed USEPA guidelines of less than 5 percent of the target populations (young children and adult females) having blood lead levels exceeding 10 micrograms per deciliter, then an FS will be recommended; otherwise, an NFA will be recommended (with respect to lead only).

Risk estimates for soil will be based on the 95 percent upper confidence level (UCL) for all chemicals except lead; lead risk estimates will be based on the mean concentration of lead. Human receptors for which risks will be evaluated are identified in the CSM in Worksheet #10. Even though residential risk is used as the basis for decisions, all receptor risks will be evaluated in accordance with the CSM and documented in the project report to support an FS or any other future work that is conducted.

11.5 PERFORMANCE OR ACCEPTANCE CRITERIA

Since substantial data had already been collected from the Site and from Pettibone Creek, which was the source area for the dredged sediments at Site 12, it was determined by the Project Team that 10 samples of each media would be collected during the RI. Ten samples are the minimum number of samples required to achieve the specified decision performance if the inputs are correct. The sampling design was based on a judgmental approach utilizing data from past sampling events and knowledge of historical construction activities.

11.6 DATA COLLECTION PLAN

The data collection design and rationale are presented in Worksheet #17.

SAP Worksheet #12 -- Measurement Performance Criteria Table Field Quality Control Sample

(UFP-QAPP Manual Section 2.6.2)

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Field Duplicate	All Fractions	One per 10 field samples collected.	Precision	Relative Percent Difference (RPD) ≤ 30%	S&A
Cooler Temperature Indicator	All Fractions	One per cooler.	Representativeness	Temperature between 2 and 6 degrees Celsius (4 ± 2 °C).	S

SAP Worksheet #13 -- Secondary Data Criteria and Limitations Table

(UFP-QAPP Manual Section 2.7)

Secondary Data	Data Source	Data Generator(s)	How Data Will Be Used	Limitations on Data Use
Historical Aerial Photographs	NS Great Lakes	NS Great Lakes Aerial Photographs taken from 1939 to 2002	Aerial photographs were used to identify possible sources of contamination and active dates of use.	No Limitations.
Previous Site Investigation	Dames & Moore	Technical Memorandum on the Remedial Investigation Verification Step for the Naval Training Center, Great Lakes, Illinois, 1991	Soil sampling locations and analysis data were used to help establish sampling locations and parameters for testing.	VOC and metal data could not be validated and cannot be used; pesticide and PCB data were validated and can be used.

SAP Worksheet #14 -- Summary of Project Tasks

(UFP-QAPP Manual Section 2.8.1)

Site 12 RI field tasks are summarized below. All data recording and management procedures are described in Worksheet #29.

- Mobilization/demobilization
- Site-specific health and safety training (see HASP)
- Utility clearance/digging permit acquisition
- DPT boring
- Investigation-derived waste (IDW) management
- Land surveying
- Field decontamination procedures
- Field documentation procedures
- Analytical tasks
- Data management tasks

14.1 MOBILIZATION/DEMOBILIZATION

Mobilization will consist of the delivery of all equipment, materials, and supplies to the site, the complete assembly in satisfactory working order of all equipment at the site, and the satisfactory storage at the site of all materials and supplies. Tetra Tech will coordinate with the base to identify locations for the storage of equipment and supplies.

Demobilization shall consist of the prompt and timely removal of all equipment, materials, and supplies from the site following the completion of work. Demobilization will also include the cleanup and removal of waste generated during the investigation.

14.2 UTILITY CLEARANCE/DIGGING PERMIT AQUISITION

Potential underground utilities will be located and marked after a review of property maps and surface indications of utilities. See SOP HS-1.0 in Appendix E for locating underground utilities. The utility clearance will include contacting the Illinois one call system Joint Utility Locating Information for Excavators (JULIE) and NS Great Lakes Public Works personnel. Digging permits will be obtained prior to conducting intrusive activities.

14.3 DPT BORING

Soil will be collected from two intervals: surface and subsurface soils. Surface soil will be collected 0 to 6 inches below the ground surface. Subsurface soil will be and 6 inches below the ground surface to the depth where native soil is encountered. Soil sampling will occur at 10 locations using DPT. Therefore, a total of 20 soil samples will be collected. Each soil interval will be visually inspected and any signs of potential contamination (such as odor or staining) will be noted. These data will be used to select the soil sample to be tested. For each interval, a sample will be collected from an area where odor or staining was located. The methodology for sample collection is described in SOP SA-2.5 in Appendix E. All borings will be logged in accordance with SOP GH-1.5. The sample numbering scheme will be in accordance with SOP CT-04. Methods for recording data are included in SOP SA-6.3.

14.4 WATER LEVEL MEASUREMENTS

Water level measurements will be collected in the open borings and included on the boring logs.

14.5 INVESTIGATION-DERIVED WASTE MANAGEMENT

IDW will consist of decontamination water from cleaning field equipment and soil cuttings. Personal Protective Equipment (PPE), such as nitrile gloves or groundwater sampling tubing, will be disposed of as municipal waste and placed in a nearby dumpster. All other IDW will be containerized by Tetra Tech in Department of Transportation (DOT) -approved (DOT specification 17C) 55-gallon drums, labeled as IDW, and stored in a centralized location. Tetra Tech SOP SA-7.1 (Decontamination of Field Equipment) is provided in Appendix E and details general procedures for management and labeling of IDW.

Under oversight by Tetra Tech, the drilling subcontractor(s) will be responsible for providing, filling, sealing, and moving the drums to a centralized area specified by the base point of contact during mobilization. The drums must be generally clean prior to moving to the centralized storage area, and will be labeled by Tetra Tech with an IDW label (see Attachment A of Tetra Tech SOP SA-7.1 in Appendix E) as soon as possible after they are filled. The drums will be arranged into rows (no more than two drums deep) by the drilling subcontractor(s), with liquids and solids segregated, for easy access.

One composite IDW sample will be collected by Tetra Tech to characterize the solid waste for proper disposal. The IDW solid sample will be submitted to Empirical for toxicity characteristic leaching procedure (TCLP) VOCs, SVOCs, pesticides, herbicides, and metals and NS Great Lakes required analyses [BTU; flash point; pH; reactive with acid, base, and water; reactive with cyanide and sulfide; PCBs; water content (karl fisher); and paint filter test]. One aqueous IDW sample of decontamination water will be submitted to Empirical for TCL SVOCs, Pesticides, PCBs, and TAL Metals. The samples will

be submitted to the laboratory with a 7-day turnaround time. Analytical data for the two IDW samples will then be provided to NS Great Lakes for characterization of the solid and aqueous wastes and determination of proper disposal methods. NS Great Lakes will be responsible for contracting an approved IDW vendor to properly dispose of the IDW drums. Manifests for the IDW disposal will be maintained by NS Great Lakes. Copies of the manifest will be included in the RI report.

14.6 LAND SURVEYING

A GPS with sub-meter accuracy survey will be used to locate the soil sampling locations. Horizontal locations shall be referenced to the Illinois State Plane Coordinate System (SPCS), North American Datum of 1983 (NAD 83). Vertical locations (elevations) shall be referenced to Mean Sea Level, North American Vertical Datum 1988 (NAVD 88).

14.7 FIELD DECONTAMINATION PROCEDURES

Sample containers that are certified clean will be provided by Empirical. Decontamination of sampling equipment will be conducted prior to and between sampling at each location. At each site, an abbreviated decontamination procedure consisting of a soapy water (laboratory-grade detergent) rinse followed by a deionized (DI) water rinse will be performed. However, if free product is encountered, a more elaborate decontamination of equipment will be conducted in accordance with Tetra Tech SOP SA-7.1.

14.8 FIELD DOCUMENTATION PROCEDURES

Field documentation will be performed in accordance with SOP SA-6.3 presented in Appendix E.

A summary of all field activities will be properly recorded in a bound logbook with consecutively numbered pages that cannot be removed. Logbooks will be assigned to field personnel and will be stored in a secured area on base when not in use.

At a minimum, the following information will be recorded in the site logbook:

- Name of the person to whom the logbook is assigned.
- Project name.
- Project start date.
- Names and responsibilities of on-site project personnel including subcontractor personnel.
- Names, affiliations, and arrival/departure times of site visitors.
- Descriptions and arrival/departure times of on-site equipment.

- Sampling activity information and sample log sheet references.
- Descriptions of subcontractor activities.
- Sample information including chain-of-custody form numbers and air bill numbers, carrier, time, and date.
- Descriptions of borehole and monitoring well installation activities and operations.
- Health and safety issues.
- Descriptions of photographs including date, time, photographer, picture number, location, and compass direction of photograph, and what the photo is intending to show.

All entries will be written in ink, and no erasures will be made. If an incorrect entry is made, the person making the correction will strike a single line through the incorrect information, write in the correct information and initial and date the change.

14.9 ANALYTICAL TASKS

Chemical analysis will be performed by Empirical. Empirical is a current Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) approved laboratory. A copy of the laboratory certification for can be found in Appendix D. Analyses will be performed in accordance with the analytical methods identified in Worksheet #19. Empirical is expected to meet the PALs to the extent identified in Worksheet #15. Empirical will perform chemical analysis following laboratory-specific SOPs (Worksheets #19 and #23) developed based on the analytical methods listed in Worksheets #19 and #30. Copies of the Laboratory SOPs are included in Appendix D.

14.10 DATA MANAGEMENT TASKS

This section describes how the project information will be managed, organized, and maintained for efficient use by project personnel. The information management process is outlined from the point of data generation to ultimate storage.

Sample Collection and Field Measurements Data Package Deliverables

Sample collection data will be collected in accordance with the sample collection SOPs in Appendix E. In addition, calibration data will also be provided in accordance with the SOPs in Appendix E.

Off-site Laboratory Data Package Deliverables

Data package deliverable requirements are detailed in SAP Worksheet #30 (Analytical Services).

Data packages will be provided as both hardcopy and portable document format (.PDF). Empirical Laboratories will provide a Naval Installation Restoration Information Solution (NIRIS)-compatible electronic data deliverable (EDD). Data packages will be contract laboratory program (CLP)-equivalent (i.e., they will contain CLP-equivalent summary forms and raw data). The standard turnaround time for analytical services is 28 calendar days. Turnaround time will be measured from the laboratory receipt of the last samples in a sample delivery group (SDG). SDGs must contain 20 samples (no more than 20 and only less if the entire sampling event had less than 20 samples). Data will be stored by the analytical laboratory for 5 years.

Data Reporting Formats

Field data will be recorded in the field. Examples of the forms to be used in the field are presented in Appendix E of this SAP.

Data Handling and Management

The data-handling procedures to be followed by the laboratory will meet the standard Tetra Tech requirements in the laboratory subcontracts. The analytical and field data will be maintained in the project files. The project files will contain hard copies of the chain-of-custody forms, sample log forms, sample location maps, and documentation of QA of data manipulation. These forms are included in the applicable SOPs in Appendix E of this SAP.

Data Tracking and Control

A “cradle-to-grave” sample tracking system will be used from the beginning to the end of the investigation. Before field mobilization, the Tetra Tech FOL will coordinate/initiate the sample tracking process. If using e-DATA, the Tetra Tech FOL will print the sample jar labels at the time of sampling. The Tetra Tech FOL will review the labels for completeness of information and adherence to sampling plan requirements, as well as for accuracy. The Tetra Tech FOL and/or Tetra Tech PM will make sure that the analytical laboratory is aware of the number and type of samples and analyses that are about to be requested.

When field sampling is underway, the Tetra Tech FOL will forward the chain-of-custody forms to the Tetra Tech PM or designee via facsimile at the end of each day. The Tetra Tech PM or designee will compare the entries on the chain-of-custody forms with the sample tracking database, and enter the sample date and other sample information as appropriate. The Tetra Tech PM or designee will also confirm that the chain-of-custody forms provide the information required by the sampling plan. This will allow for early detection of errors made in the field so that adjustments can be made while the crew is mobilized. After successful completion of the requested analyses, the laboratory will submit an EDD for every SDG.

When the EDDs have been received from the laboratory, the Tetra Tech PM will make sure that the laboratory performed the requested analyses. Ideally, discrepancies will be noted early enough so that the samples can be analyzed within the prescribed holding times.

SAP Worksheet #15 -- Reference Limits and Evaluation Table

(UFP-QAPP Manual Section 2.8.1)

Matrix: Soil
Analytical Group: TAL Metals

Analyte	CAS Number	Project Action Limit (PAL)(1)	Project Action Limit Reference(2)	Project Quantitation Limit Goal (3)	Empirical		
					Limit of Quantitation	Limit of Detection	Method Detection Limit
METALS SW-846 6010C (mg/kg)							
ALUMINUM	7429-90-5	55000	EPA	18000	20	10	5
ANTIMONY	**7440-36-0**	**0.66**	**EPA**	**0.22**	**1.0**	**0.50**	**0.25**
ARSENIC	**7440-38-2**	**0.0013**	**EPA**	**0.00043**	**0.25**	**0.20**	**0.15**
BARIUM	7440-39-3	300	EPA	100	2.0	1.0	0.50
BERYLLIUM	7440-41-7	58	EPA	19	0.25	0.125	0.05
CADMIUM	7440-43-9	1.4	EPA	0.47	0.25	0.125	0.05
CALCIUM	7440-70-2	NC	NC	NC	1000	500	250
CHROMIUM	7440-47-3	230	IL TACO	77	0.50	0.25	0.10
COBALT	**7440-48-4**	**0.49**	**EPA**	**0.16**	**0.60**	**0.40**	**0.20**
COPPER	7440-50-8	51	EPA	17	1.0	0.50	0.25
IRON	7439-89-6	640	EPA	210	10	5.0	2.5
LEAD	7439-92-1	107	IL TACO	36	0.50	0.25	0.10
MAGNESIUM	7439-95-4	NC	NC	NC	1000	500	200
MANGANESE	7439-96-5	57	EPA	19	1.0	0.50	0.25
MERCURY	7439-97-6	0.03	EPA	0.01	0.03	0.02	0.01
NICKEL	7440-02-0	48	EPA	16	1.0	0.50	0.25
POTASSIUM	7440-09-7	NC	NC	NC	1000	500	200
SELENIUM	7782-49-2	0.95	EPA	0.32	0.50	0.25	0.15
SILVER	7440-22-4	1.6	EPA	0.53	0.50	0.25	0.15
SODIUM	7440-23-5	NC	NC	NC	1000	500	200
THALLIUM	7440-28-0	NC	NC	NC	0.50	0.25	0.15
VANADIUM	7440-62-2	180	EPA	60	1.0	0.50	0.25
ZINA	7440-66-6	680	EPA	230	2.0	1.0	0.50

Matrix: Soil
Analytical Group: TCL Semivolatiles (including low level PAHs)

Analyte	CAS Number	Project Action Limit (PAL)(1)	Project Action Limit Reference(2)	Project Quantitation Limit Goal (3)	Empirical		
					Limit of Quantitation	Limit of Detection	Method Detection Limit
SVOCs including low level PAHs SW-846 8270C (µg/kg)							
BIS(2-CHLOROETHYL)ETHER	**111-44-4**	**0.031**	**EPA**	**0.01**	**333**	**133**	**30**
2-CHLOROPHENOL	**95-57-8**	**150**	**EPA**	**50**	**333**	**133**	**30**
PHENOL	108-95-2	6300	EPA	2100	333	133	30
HEXACHLOROETHANE	**67-72-1**	**2.9**	**EPA**	**0.97**	**333**	**133**	**30**
N-NITROSO-DI-N-PROPYLAMINE	**621-64-7**	**0.0072**	**EPA**	**0.0024**	**333**	**133**	**30**
NITROBENZENE	**98-95-3**	**0.079**	**EPA**	**0.026**	**333**	**133**	**30**
2-METHYLPHENOL	95-48-7	1500	EPA	500	333	133	30
ISOPHORONE	**78-59-1**	**23**	**EPA**	**7.7**	**333**	**133**	**30**
4-METHYLPHENOL	**106-44-5**	**150**	**EPA**	**50**	**333**	**133**	**30**
1,1-BIPHENYL	92-52-4	19000	EPA	6300	333	133	30
2,2'-OXYBIS(1-CHLOROPROPANE)	**108-60-1**	**0.12**	**EPA**	**0.04**	**333**	**133**	**30**
2,4,5-TRICHLOROPHENOL	95-95-4	14000	EPA	4700	333	133	30
2,4,6-TRICHLOROPHENOL	**88-06-2**	**23**	**EPA**	**7.7**	**333**	**133**	**30**
2,4-DICHLOROPHENOL	**120-83-2**	**130**	**EPA**	**43**	**333**	**133**	**30**
2,4-DIMETHYLPHENOL	105-67-9	860	EPA	290	333	133	30
2,4-DINITROPHENOL	**51-28-5**	**82**	**EPA**	**27**	**333**	**133**	**30**
2,4-DINITROTOLUENE	**121-14-2**	**0.29**	**EPA**	**0.097**	**333**	**133**	**30**
2,6-DINITROTOLUENE	**606-20-2**	**0.7**	**IL TACO**	**0.23**	**333**	**133**	**30**
2-CHLORONAPHTHALENE	91-58-7	15000	EPA	5000	333	133	30
2-NITROANILINE	**88-74-4**	**140**	**IL NON-TACO**	**47**	**333**	**133**	**30**

Analyte	CAS Number	Project Action Limit (PAL)(1)	Project Action Limit Reference(2)	Project Quantitation Limit Goal (3)	Empirical		
					Limit of Quantitation	Limit of Detection	Method Detection Limit
2-NITROPHENOL	88-75-5	NC	NC	NC	333	133	30
3,3'-DICHLOROBENZIDINE	**91-94-1**	**0.98**	**EPA**	**0.33**	**333**	**133**	**30**
3-NITROANILINE	**99-09-2**	**10**	**IL NON-TACO**	**3.3**	**333**	**133**	**30**
4,6-DINITRO-2-METHYLPHENOL	**534-52-1**	**3.1**	**IL NON-TACO**	**1**	**333**	**133**	**30**
4-BROMOPHENYL PHENYL ETHER	101-55-3	NC	NC	NC	333	133	30
4-CHLORO-3-METHYLPHENOL	59-50-7	4300	EPA	1400	333	133	30
4-CHLOROANILINE	**106-47-8**	**0.14**	**EPA**	**0.047**	**333**	**133**	**30**
4-CHLOROPHENYL PHENYL ETHER	7005-72-3	NC	NC	NC	333	133	30
4-NITROANILINE	**100-01-6**	**1.4**	**EPA**	**0.47**	**333**	**133**	**30**
4-NITROPHENOL	100-02-7	NC	NC	NC	333	133	30
ACETOPHENONE	98-86-2	1100	EPA	370	333	133	40
ATRAZINE	**1912-24-9**	**0.19**	**EPA**	**0.063**	**333**	**133**	**30**
BENZALDEHYDE	100-52-7	810	EPA	270	333	133	55
BIS(2-CHLOROETHOXY)METHANE	**111-91-1**	**25**	**EPA**	**8.3**	**333**	**133**	**30**
BIS(2-ETHYLHEXYL)PHTHALATE	117-81-7	1100	EPA	370	333	133	30
BUTYL BENZYL PHTHALATE	85-68-7	510	EPA	170	333	133	30
CAPROLACTAM	105-60-2	4500	EPA	1500	333	133	67
CARBAZOLE	86-74-8	600	IL TACO	200	333	133	30
DIBENZOFURAN	132-64-9	820000	IL NON-TACO	270000	333	133	30
DIETHYL PHTHALATE	84-66-2	12000	EPA	4000	333	133	30
DIMETHYL PHTHALATE	131-11-3	NC	NC	NC	333	133	30
DI-N-BUTYL PHTHALATE	84-74-2	9200	EPA	3100	333	133	30
DI-N-OCTYL PHTHALATE	117-84-0	1600000	IL TACO	530000	333	133	30
HEXACHLOROBENZENE	**118-74-1**	**0.53**	**EPA**	**0.18**	**333**	**133**	**30**
HEXACHLOROBUTADIENE	**87-68-3**	**1.7**	**EPA**	**0.57**	**333**	**133**	**30**
HEXACHLOROCYCLOPENTADIENE	77-47-4	680	EPA	53	333	133	30
N-NITROSODIPHENYLAMINE	**86-30-6**	**75**	**EPA**	**25**	**333**	**133**	**30**
PENTACHLOROPHENOL	**87-86-5**	**5.7**	**EPA**	**1.9**	**333**	**133**	**30**

Analyte	CAS Number	Project Action Limit (PAL)(1)	Project Action Limit Reference(2)	Project Quantitation Limit Goal (3)	Empirical		
					Limit of Quantitation	Limit of Detection	Method Detection Limit
Low Level PAHs							
2-METHYLNAPHTHALENE	91-57-6	0.75	EPA	0.25	0.00667	0.00333	0.00167
ACENAPHTHENE	83-32-9	22	EPA	7.3	0.00667	0.00333	0.00167
ACENAPHTHYLENE	208-96-8	85	IL NON-TACO	28.3	0.00667	0.00333	0.00167
ANTHRACENE	120-12-7	360	EPA	120	0.00667	0.00333	0.00167
BENZO(A)ANTHRACENE	56-55-3	0.01	EPA	0.0033	0.00667	0.00333	0.00167
BENZO(A)PYRENE	**50-32-8**	**0.0035**	**EPA**	**0.00117**	**0.00667**	**0.00333**	**0.00167**
BENZO(B)FLUORANTHENE	205-99-2	0.035	EPA	0.0117	0.00667	0.00333	0.00167
BENZO(G,H,I)PERYLENE	191-24-2	2300	IL NON-TACO	770	0.00667	0.00333	0.00167
BENZO(K)FLUORANTHENE	207-08-9	0.35	EPA	0.117	0.00667	0.00333	0.00167
CHRYSENE	218-01-9	1.1	EPA	0.37	0.00667	0.00333	0.00167
DIBENZO(A,H)ANTHRACENE	53-70-3	0.011	EPA	0.0037	0.00667	0.00333	0.00167
FLUORANTHENE	206-44-0	160	EPA	53.3	0.00667	0.00333	0.00167
FLUORENE	86-73-7	27	EPA	9	0.00667	0.00333	0.00167
INDENO(1,2,3-CD)PYRENE	193-39-5	0.12	EPA	0.04	0.00667	0.00333	0.00167
NAPHTHALENE	**91-20-3**	**0.00047**	**EPA**	**0.00016**	**0.00667**	**0.00333**	**0.00167**
PHENANTHRENE	85-01-8	200	IL NON-TACO	66.7	0.00667	0.00333	0.00167
PYRENE	129-00-0	120	EPA	40	0.00667	0.00333	0.00167

Matrix: Soil
Analytical Group: PCBs

Analyte	CAS Number	Project Action Limit (PAL)(1)	Project Action Limit Reference(2)	Project Quantitation Limit Goal (3)	Empirical		
					Limit of Quantitation	Limit of Detection	Method Detection Limit
PCBs SW-846 8082A (µg/kg)							
AROCLOR-1016	12674-11-2	92	EPA	31	33	17	8
AROCLOR-1221	**11104-28-2**	**0.12**	**EPA**	**0.04**	**33**	**17**	**8**
AROCLOR-1232	**11141-16-5**	**0.12**	**EPA**	**0.04**	**33**	**17**	**8**
AROCLOR-1242	**53469-21-9**	**5.3**	**EPA**	**1.8**	**33**	**17**	**8**
AROCLOR-1248	**12672-29-6**	**5.2**	**EPA**	**1.7**	**33**	**17**	**8**
AROCLOR-1254	**11097-69-1**	**8**	**EPA**	**2.9**	**33**	**17**	**8**
AROCLOR-1260	**11096-82-5**	**24**	**EPA**	**8**	**33**	**17**	**8**
TOTAL AROCLOR	1336-36-3	220	EPA	73	33	17	8

Matrix: Soil
Analytical Group: Pesticides

Analyte	CAS Number	Project Action Limit (PAL)(1)	Project Action Limit Reference(2)	Project Quantitation Limit Goal (3)	Empirical		
					Limit of Quantitation	Limit of Detection	Method Detection Limit
PESTICIDES SW-846 8081B (µg/kg)							
4,4' DDD	72-54-8	86	USEPA	28	0.66	0.33	0.16
4,4'-DDE	72-55-9	60	USEPA	20	0.66	0.33	0.16
4,4'-DDT	50-29-3	87	USEPA	29	0.66	0.33	0.16
ALDRIN	309-00-2	0.84	USEPA	0.28	0.66	0.33	0.16
ALPHA-BHC	**319-84-6**	**0.074**	**USEPA**	**0.025**	**0.66**	**0.33**	**0.16**
ALPHA-CHLORDANE	5103-71-9	NC	NC	NC	0.66	0.33	0.16
BETA-BHC	**319-85-7**	**0.26**	**USEPA**	**0.087**	**0.66**	**0.33**	**0.16**
DELTA-BHC	319-86-8	NC	NC	NC	0.66	0.33	0.16
DIELDRIN	**60-57-1**	**0.09**	**USEPA**	**0.03**	**0.66**	**0.33**	**0.16**
ENDOSULFAN I	959-98-8	9,700	USEPA	3200	0.66	0.33	0.16
ENDOSULFAN II	33213-65-9	9,700	USEPA	3200	0.66	0.33	0.16
ENDOSULFAN SULFATE	1031-07-8	9,700	USEPA	3200	0.66	0.33	0.16
ENDRIN	72-20-8	230	USEPA	77	0.66	0.33	0.16
ENDRIN ALDEHYDE	7421-93-4	230	USEPA	77	0.66	0.33	0.16
ENDRIN KETONE	53494-70-5	230	USEPA	77	0.66	0.33	0.16
GAMMA-BHC (LINDANE)	**58-89-9**	**0.43**	**USEPA**	**0.14**	**0.66**	**0.33**	**0.16**
GAMMA-CHLORDANE	5103-74-2	NC	NC	NC	0.66	0.33	0.16
HEPTACHLOR	76-44-8	1.6	USEPA	0.53	0.66	0.33	0.16
HEPTACHLOR EPOXIDE	**1024-57-3**	**0.079**	**USEPA**	**0.026**	**0.66**	**0.33**	**0.16**
METHOXYCHLOR	72-43-5	3400	USEPA	1100	0.66	0.33	0.16
TOXAPHENE	**8001-35-2**	**12**	**USEPA**	**4**	**66**	**33**	**11**

Matrix: IDW Solids
Analytical Group: Toxicity Characteristic Leaching Procedure (TCLP) Metals

Analyte	CAS Number	PAL[4] (ug/L)	PAL Reference	PQLG (ug/L)	Empirical	
					LOQ (ug/L)	MDL (ug/L)
ARSENIC	7440-38-2	5	RCRA 40 CFR 261.24	1.7	0.1	0.03
BARIUM	7440-39-3	100	RCRA 40 CFR 261.24	33	2	0.05
CADMIUM	7440-43-9	1	RCRA 40 CFR 261.24	0.33	0.05	0.01
CHROMIUM	7440-47-3	5	RCRA 40 CFR 261.24	1.7	0.1	0.02
LEAD	7439-92-1	5	RCRA 40 CFR 261.24	1.7	0.03	0.015
MERCURY	7439-97-6	0.2	RCRA 40 CFR 261.24	0.067	0.002	0.0008
SELENIUM	7782-49-2	1	RCRA 40 CFR 261.24	0.33	0.05	0.03
SILVER	7440-22-4	5	RCRA 40 CFR 261.24	1.7	0.1	0.01

Matrix: IDW Solids
Analytical Group: TCLP VOCs

Analyte	CAS Number	PAL[4] (ug/L)	PAL Reference	PQLG (ug/L)	Empirical	
					LOQ (ug/L)	MDL (ug/L)
BENZENE	71-43-2	0.5	RCRA 40 CFR 261.24	0.17	0.01	0.0033
CARBON TETRACHLORIDE	56-23-5	0.5	RCRA 40 CFR 261.24	0.17	0.01	0.0033
CHLOROBENZENE	108-90-7	100	RCRA 40 CFR 261.24	33	0.01	0.0033
CHLOROFORM	67-66-3	6	RCRA 40 CFR 261.24	2.0	0.01	0.0033
1,2-DICHLOROETHANE	107-06-2	0.5	RCRA 40 CFR 261.24	0.17	0.01	0.0033
1,1-DICHLOROETHENE	75-35-4	0.7	RCRA 40 CFR 261.24	0.23	0.01	0.0033
2-BUTANONE	78-93-3	200	RCRA 40 CFR 261.24	67	0.1	0.033
TETRACHLOROETHENE	127-18-4	0.7	RCRA 40 CFR 261.24	0.23	0.01	0.0033
TRICHLOROETHENE	79-01-6	0.5	RCRA 40 CFR 261.24	0.17	0.01	0.0033
VINYL CHLORIDE	75-01-4	0.2	RCRA 40 CFR 261.24	0.067	0.02	0.0033

Matrix: IDW Solids
Analytical Group: TCLP SVOCs

Analyte	CAS Number	PAL[4] (ug/L)	PAL Reference	PQLG (ug/L)	Empirical	
					LOQ (ug/L)	MDL (ug/L)
O-CRESOL	95-48-7	200	RCRA 40 CFR 261.24	67	0.05	0.01
M-CRESOL	95-48-7	200	RCRA 40 CFR 261.24	67	0.05	0.01
P-CRESOL	106-44-5	200	RCRA 40 CFR 261.24	67	0.05	0.01
1,4-DICHLOROBENZENE	106-46-7	7.5	RCRA 40 CFR 261.24	2.5	0.05	0.01
2,4-DINITROTOLUENE	121-14-2	0.13	RCRA 40 CFR 261.24	0.043	0.05	0.01
HEXACHLOROBENZENE	118-74-1	0.13	RCRA 40 CFR 261.24	0.043	0.05	0.01
HEXACHLORO-1,3-BUTADIENE	87-68-3	0.5	RCRA 40 CFR 261.24	0.17	0.05	0.01
HEXACHLOROETHANE	67-72-1	3	RCRA 40 CFR 261.24	1.0	0.05	0.01
NITROBENZENE	98-95-3	2	RCRA 40 CFR 261.24	0.67	0.05	0.01
PENTACHLOROPHENOL	87-86-5	100	RCRA 40 CFR 261.24	33	0.2	0.02
PYRIDINE	110-86-1	5	RCRA 40 CFR 261.24	1.7	0.2	0.02
2,4,5-TRICHLOROPHENOL	95-95-4	400	RCRA 40 CFR 261.24	130	0.05	0.01
2,4,6-TRICHLOROPHENOL	88-06-2	2	RCRA 40 CFR 261.24	0.67	0.05	0.01

Matrix: IDW
Analytical Group: TCLP Pesticides

Analyte	CAS Number	PAL[4] (ug/L)	PAL Reference	PQLG (ug/L)	Empirical	
					LOQ (ug/L)	MDL (ug/L)
CHLORDANE	57-74-9	0.03	RCRA 40 CFR 261.24	0.010	0.0005	0.0001
ENDRIN	72-20-8	0.02	RCRA 40 CFR 261.24	0.0067	0.0001	0.00003
HEPTACHLOR	76-44-8	0.008	RCRA 40 CFR 261.24	0.0027	0.0001	0.00003
HEPTACHLOR EPOXIDE	1024-57-3	0.008	RCRA 40 CFR 261.24	0.0027	0.0001	0.00003

Analyte	CAS Number	PAL[4] (ug/L)	PAL Reference	PQLG (ug/L)	Empirical	
					LOQ (ug/L)	MDL (ug/L)
LINDANE	58-89-9	0.4	RCRA 40 CFR 261.24	0.13	0.0001	0.00003
METHOXYCHLOR	72-43-5	10	RCRA 40 CFR 261.24	3.3	0.0001	0.00003
TOXAPHENE	8001-35-2	0.5	RCRA 40 CFR 261.24	0.17	0.01	0.002

Matrix: IDW
Analytical Group: TCLP Herbicides

Analyte	CAS Number	PAL[4] (ug/L)	PAL Reference	PQLG (ug/L)	Empirical	
					LOQ (ug/L)	MDL (ug/L)
2,4-D	94-75-7	10	RCRA 40 CFR 261.24	3.3	0.005	0.002
2,4,5-TP (SILVEX)	93-72-1	1	RCRA 40 CFR 261.24	0.33	0.001	0.0002

Notes:
CAS = Chemical Abstract Service
CFR = Code of Federal Regulations
IL = Illinois
MDL - Method Detection Limit
RCRA = Resource Conservation Recovery Act
TACO = Tiered Approach to Corrective Action Objectives
mg/kg = Milligram per kilogram
µg/kg = Microgram per kilogram
mg = Milligrams
NV = No Value.
NC = Not Criteria.
PAL = Project Action Limit
PQLG = Project Quantitation Limit Goal

1= The PAL is the lower screening value presented in either EPA or Illinois TACO criteria. Appendix F screens all applicable screening criteria for each analyte and lists the lowest value. Refer to Appendix F for the selection of each PAL.

2= The PAL reference is listed as either EPA for TACO (and NON – TACO) for each analyte based on the screening conducted in Appendix F for the lowest PAL value. Refer to Appendix F for the exposure scenario that the PAL is based on.

3= The Project Quantitation Limit Goal is one-third the value of the PAL.

4= PALs for IDW management are based on disposal requirements in RCRA 40 CFR 261.24.

Bolded cells indicate the PAL is less than the LOD but greater than the LOQ
Shaded and bolded cells indicate the PAL is less than the LOD and LOQ.

If the PAL falls below the MDL for a particular analyte or analytes, this will require evaluation of these chemicals as stated in Appendix B, Human Health Assessment Work Plan in the uncertainty section of the Risk Assessment Report.

SAP Worksheet #16 -- Project Schedule/Timeline Table

(UFP-QAPP Manual Section 2.8.2)

Activity	Organization	Dates		Deliverable	Deliverable Due Date
		Anticipated Date of Initiation	Anticipated Date of Completion		
Draft UFP-SAP/Field Sampling Plan/HASP	Tetra Tech	10/3/09	3/23/10	Draft UFP-SAP	3/15/10
Navy Review	NAVFAC Midwest	3/16/10	4/16/10	Navy Comments	4/16/10
Resolve Comments	Tetra Tech	4/19/10	4/23/10	Response to Comments	4/23/10
Regulatory Review	Illinois EPA	4/26/10	5/21/10	Illinois EPA Comments	5//21/10
Resolve Comments	Tetra Tech	5/22/10	12/17/10	Response to Comments	5/28/10
Final UFP- SAP/Field Sampling Plan/HASP	Tetra Tech	6/1/10	12/31/10	Final UFP-SAP	12/31/10
Field Work and Chemical analysis	Tetra Tech and Empirical	12/14/10	2/14/11	None	None
Field Data Review	Tetra Tech	2/14/11	2/28/11	None	None
Data Validation	Tetra Tech	2/28/11	3/28/11	None	3/28/11
Data Analysis and Interpretation/Draft RI Report	Tetra Tech	2/28/11	5/28/11	Draft RI Report	5/28/11
Navy and Regulatory Review	Navy and Illinois EPA	5/28/11	6/28/11	None	None
Resolve Comments	Tetra Tech	7/211	8/2/11	Response to Comments	8/2/11
Final RI	Tetra Tech	8/3/11	10/1/11	Final RI Report	10/1/11

SAP Worksheet #17 -- Sampling Design and Rationale

(UFP-QAPP Manual Section 3.1.1)

Site 12 is an area where spoils from harbor dredging activities were suspected to be placed. The area is now vegetated and serves as recreational area with a picnic pavilion, picnic tables, and access to approximately 500 feet of Lake Michigan shoreline. Previous sampling activities were performed which partially characterized the nature and the extent (to a limited degree) of the spoil. Surface conditions have changed at the Site since the previous sampling event. Additionally, some of the data collected were not reproducible and therefore not usable to adequately and confidently characterize the site.

The sampling objective is to determine if past dredge disposal activities have contributed to unacceptable contaminant concentrations in soil at the site. A judgmental sampling approach will be used to evaluate contamination in the suspected source area, as discussed below. Figure 17-1 shows the locations of the proposed soil boring samples. Worksheet #18 provides a detailed description of the sampling methods to be used at Site 12. Field QC samples, including field duplicates, and matrix spike/matrix spike duplicates (MS/MSD) will be collected as outlined in Worksheet #20. Samples will be analyzed for a select list of chemicals, as presented in Worksheet #15.

Ten sampling locations were identified based on consensus of the Project Team. The selected soil data collection design is based on a judgmental approach which utilized past sampling data and knowledge of the Site including historical construction activities to identify sampling locations. This approach will provide good spatial coverage, and will therefore be useful for estimating the extent of contamination in soil and for evaluating risks. Ten samples is general considered the minimum number required to support risk based evaluations. A DPT rig will be used to obtain surface and subsurface soil samples at 10 locations. Each soil boring will be extended until the boring encounters native soil, which is expected to be 10 to 15 feet bgs. Borings will be stopped once they encounter native soil. The characteristics of the soil in the boring will be noted in the field logs, including the texture of the soil at each depth. The surface soil sample will be collected in the top 6 inches of the soil boring. The subsurface soil sample will be collected from the interval between 6 inches to the top of the native soil zone. Discrete subsurface soil sample will be collected based on visual determination by the FOL upon visual observations (staining, odor, ect.) or PID measurements. Provided groundwater is encountered, approximately two-thirds of the subsurface soil samples will be collected from the unsaturated zone, and one-third of the samples will be taken from below the water table as determined by the FOL. Subsurface soil samples will be collected from dredge spoils or in locations where staining or odors are observed. If dredge spoils are not evident or if there is no staining or odors are observed, the subsurface soil sample depth intervals will be determined by the FOL. All test samples will be collected from fill (not native soil). Ten surface soil and ten subsurface soil samples will be analyzed for SVOCs, PAHs, metals, and pesticides. Half (five) of the subsurface soil samples will be analyzed for PCBs. Samples selected for PCB analysis will be based on

visual observations by the FOL. VOC samples will be collected in up to 4 locations but only if warranted by high PID measurements.

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

(UFP-QAPP Manual Section 3.1.1)

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
NTC12-SB21-01 to NTC12-SB30-01	Surface Soil	0 to 0.5	SVOCs (including PAHs)	10 plus 1 duplicate	HS-1.0, CT-04, CT-05, SA-1.3, SA-2.5, SA-6.1, SA-6.3, SA-7.1, GH-1.5
			Metals		
			Pesticides		
NTC12-SB21-02 to NTC12-SB30-02	Subsurface Soil	0.5 to natural soil	SVOCs (including PAHs)	10 plus 1 duplicate	HS-1.0, CT-04, CT-05, SA-1.3, SA-2.5, SA-6.1, SA-6.3, SA-7.1, GH-1.5
			VOCs (if warranted by PID readings)	4 plus 1 duplicate	
			PCBs	5 plus 1 duplicate	
			Pesticides	10 plus 1 duplicate	
			Metals	10 plus 1 duplicate	
IDW	Solid	Not applicable	TCLP VOCs	1 plus 0 duplicate	SA-7.1
			TCLP SVOCs		
			TCLP Pesticides		
			TCLP Herbicides		
			TCLP Metals		
			Reactivity		
			Ignitibility		
			pH (Corrosivity)		

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
NS Great Lakes Waste Tests	Solid	Not applicable	BTU, flash point, pH, reactive with acid, base, and water, reactive with cyanide and sulfide, phenolics, PCBs, water content (karl fisher), and paint filter test	1 plus 0 duplicate	SA-7.1
IDW	Aqueous	Not applicable	SVOCs Pesticides PCBs Metals	1 plus 0 duplicate	SA-7.1

SAP Worksheet #19 -- Analytical SOP Requirements Table

(UFP-QAPP Manual Section 3.1.1)

Matrix	**Analytical Group**	**Analytical and Preparation Method / SOP Reference**	**Containers** (number, size, and type)	**Sample volume** (units)	**Preservation Requirements** (chemical, temperature, light protected)	**Maximum Holding Time**[1] (preparation / analysis)
Aqueous IDW	SVOCs (including low level Polynuclear Aromatic Hydrocarbons)	SW-846 3510C/8270C SOPs:300/201	2 – 1000ml Amber Glass	1000 milliliters	Cool to 4 °C ± 2°C	7 days to extraction/40 days from extract to analysis
Soil	SVOCs (including low level Polynuclear Aromatic Hydrocarbons)	SW-846 3546/8270C SOPs:343/201	1 – 4 ounce Glass Jar	30 grams	Cool to 4 °C ± 2°C	14 days to extraction/40 days from extract to analysis
Soil	VOCs	SW-846 5035/8260B SOP:202/225	3 - Encore or samplers or equivalent (If warranted by PID readings)	5 grams	Sodium bisulfate;Cool to 4 °C ± 2°C	48 hours to extraction/14 days to analysis
Aqueous IDW	PCBs	SW-846 3510C/8082A SOPs: 302/211	2 – 1000ml Amber Glass	1000 milliliters	Cool to 4 °C ± 2°C	7 days to extraction/40 days from extract to analysis

Matrix	**Analytical Group**	**Analytical and Preparation Method / SOP Reference**	**Containers** (number, size, and type)	**Sample volume** (units)	**Preservation Requirements** (chemical, temperature, light protected)	**Maximum Holding Time**[1] (preparation / analysis)
Soil	PCBs	SW-846 3546/8082A SOPs:343/211	1 –4oz Glass Jar	30 grams	Cool to 4 °C ± 2°C	14 days to extraction/40 days from extract to analysis
Aqueous IDW	Pesticides	SW-846 3510C/8081B SOPs: 302/211	2 – 1000ml Amber Glass	1000 milliliters	Cool to 4 °C ± 2°C	7 days to extraction/40 days from extract to analysis
Soil	Pesticides	SW-846 3546/8081B SOPs: 343/211	1 – 4oz Glass Jar	30 grams	Cool to 4 °C ± 2°C	14 days to extraction/40 days from extract to analysis
Aqueous IDW	Metals	SW-846 3010A/3020A/ 6010C/7470A SOPs: 100/105/103	1 – 250ml Plastic	200 milliliters/50 milliliters mercury	Nitric acid to a pH<2; Cool to 4 °C ± 2°C	180 days to analysis except mercury which is 28 days to analysis
Soil	Metals	SW-846 3050B/6010C/ 7471A SOPs: 100/105/104	1 – 4oz Glass Jar	10 grams	Cool to 4 °C ± 2°C	180 days to analysis except mercury which is 28 days to analysis
Solid IDW	Flash point	SW-846 1010	1-4ounce jar	50 grams	Cool to 4 °C ± 2°C	7 days to analysis
Solid IDW	pH	SW-846 9045C	1 - 4oz. Glass Jar	20 grams	None	Analyze immediately
Solid IDW	Reactivity	SW-846 ch 7.7.3 (Reactive Sulfide and Cyanide)	1 – 4 oz. Glass Jar	20 grams	Cool to 4 °C± 2°C	14 days to analysis

Matrix	**Analytical Group**	**Analytical and Preparation Method / SOP Reference**	**Containers** (number, size, and type)	**Sample volume** (units)	**Preservation Requirements** (chemical, temperature, light protected)	**Maximum Holding Time**[1] (preparation / analysis)
Solid IDW	Phenolics	SW-846 3546/8270D	1 –4 ounce Glass Jar	30grams	Cool to 4 °C ± 2°C	14 days to extraction/40 days from extract to analysis
Solid IDW	BTU	ASTM D3286	1-4 ounce jar	30 grams	Cool to 4 °C ± 2°C	Not specified
Solid IDW	Total PCBs	SW-846 8082A	1 –4 ounce Glass jar	30 grams	Cool to 4 °C± 2°C	14 days to extraction/40 days from extract to analysis
Solid IDW	Water Content	SW-846 9000	1-4 ounce Jar	30 grams	Cool to 4 °C± 2°C	Not specified
Solid IDW	Paint Filter	SW-846 9095B	1 – 4 ounce Glass Jar	100 grams	Cool to 4 °C± 2°C	28 days to analysis
Solid IDW	TCLP Organics	SW-846 1311/8260B, 8270D,8081A, 8151A	1 – 4 ounce Glass Jar (1311/ 8260B) 1 – 4 ounce Glass Jar (1311/ 8270D/ 8081A/ 8151A)	5 grams (8260B) 100 grams (8270D/ 8081A/ 8151A)	Cool to 4 °C± 2°C, no headspace	14 days to TCLP extraction, Semi-volatiles has another 7 days until preparative extraction; 14 days to analysis for volatiles and 40 days to analysis for semi-volatiles

Matrix	**Analytical Group**	**Analytical and Preparation Method / SOP Reference**	**Containers** (number, size, and type)	**Sample volume** (units)	**Preservation Requirements** (chemical, temperature, light protected)	**Maximum Holding Time**[1] (preparation / analysis)
Solid IDW	TCLP Metals	SW-846 1311/6010B/7470A	1 – 4 ounce. Glass Jar	100 grams	Cool to 4 °C± 2°C	180 days to extraction, except mercury which is 28 days to extraction; 180 days until analysis, except mercury which is 28 days until analysis

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

SAP Worksheet #20 -- Field Quality Control Sample Summary Table

(UFP-QAPP Manual Section 3.1.1)

Matrix	Analytical Group	No. of Sampling Locations[1]	No. of Field Duplicates [2]	No. of MS/MSDs[3]	No. of Field Blanks	No. of Equip. Blanks	No. of Volatile Organic Analysis Trip Blanks	No. of Proficiency Test Samples	Total No. of Samples to Lab
Soil (Surface and Subsurface)	TCL Semivolatiles (including low level PAHs)	20	2	1/1	0	0	0	0	22
	TCL Pesticides	20	2	1/1	0	0	0	0	22
	TAL Metals	20	2	1/1	0	0	0	0	22
	PCBs	5	1	1/1	0	0	0	0	6

Notes:

1 There are 10 soil sampling locations, and two soil samples will be collected at each location.
2 Field duplicates will be collected at 10 percent of the number of sampling locations.
3 MS/MSDs will be collected at 5 percent of the number of sampling locations.
4 See SOP CT-04 in Appendix E for how field QA/QC samples are to be labeled.

SAP Worksheet #21 -- Project Sampling SOP References Table

(UFP-QAPP Manual Section 3.1.2)

Reference Number	Title, Revision Date, and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work?	Comments
CT-04	Sample Nomenclature, 03/09 Rev. 2	Tetra Tech	NA	Y	Refer to Appendix E for field SOPs
CT-05	Data Base Records and Quality Assurance, 01/01 Rev. 2	Tetra Tech	NA	N	
GH-1.3	Soil and Rock Drilling Methods, 06/99 Rev. 1	Tetra Tech	DPT and Hollow Stem Auger (HSA) combination drill rig	Y	
GH-1.5	Borehole and Sample Logging, 06/99 Rev. 1	Tetra Tech	DPT drill rig	N	
HS-1.0	Utility Locating and Excavation Clearance, 12/03 Rev. 2	Tetra Tech	Remote subsurface sensing, magnetometer, ground-penetrating radar, etc.	Y	
SA-1.3	Soil Sampling, 04/08 Rev. 9	Tetra Tech	DPT drill rig	Y	
SA-2.5	Direct Push Technology, 09/03 Rev. 3	Tetra Tech	DPT drill rig	Y	
SA-6.1	Non-Radiological Sample Handling, 02/04 Rev. 3	Tetra Tech	Sample bottleware, packaging material, shipping materials	N	
SA-6.3	Field Documentation, 03/09 Rev. 3	Tetra Tech	Field logbook, field sample forms, boring logs	Y	
SA-7.1	Decontamination of Field Equipment, 01/09 Rev. 6	Tetra Tech	Decontamination equipment, scrub brushes, phosphate-free detergent, DI water	Y	

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

(UFP-QAPP Manual Section 3.1.2.4)

Field Equipment	Activity	Frequency	Acceptance Criterion	Corrective Action	Resp. Person	SOP Reference	Comments
Water Level Indicator	Field Checks per Manufacturer	Once upon receiving from vendor	0.01-foot accuracy	Operating correction or replacement	FOL	GH-1.2	

SAP Worksheet #23 -- Analytical SOP References Table

(UFP-QAPP Manual Section 3.2.1)

Laboratory SOP Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
100	Metals Digestion/ Preparation Methods 3005A,3010A,3020A,3030,3040A,3050B USEPA CLPILMO 04.1 Aqueous and Soil/Sediment USEPA CLPILMO 05.2 Aqueous and Soil/Sediment, USEPA Method 200.7 (Standard Methods) 3030C Revision 19 4/20/2009	Definitive	Aqueous IDW and Soil/Metals preparation	NA	Empirical	N
103	Mercury Analysis in Water by Manual Cold Vapor Technique Methods USEPA SW846 7470A and 245.1 CLP-M 4.1 Revision 16 1/28/2009	Definitive	Aqueous IDW/Mercury	Mercury Analyzer	Empirical	N
104	Mercury Analysis in Soil/Sediment by Manual Cold Vapor Technique Methods SW846 7471A, 7471B,245.5 And CLPILM 04.1 Revision 17 1/29/2009	Definitive	Soil/Mercury	Mercury Analyzer	Empirical	N
105	Metals Analysis by ICP Technique Methods 200.7, SW846 6010B, SW846 6010C, Standard Methods 19th edition 2340B, USEPA CLP ILMO 4.1 Revision 15 5/8/2009	Definitive	Aqueous IDW and Soil/Metals	Inductively Coupled Plasma-Atomic Emissions Spectrometry (ICP-AES)	Empirical	N
149	Flashpoint Ignitibility Method SW-846 1010, Rev. 1	Definitive	Inorganic	Flashpoint Tester	Empirical	N
156	Reactive Sulfide Method SW-846, Chapter 7, Section 7.3.4, Rev. 4	Definitive	Inorganic	NA	Empirical	N

Laboratory SOP Number	**Title, Revision Date, and / or Number**	**Definitive or Screening Data**	**Matrix and Analytical Group**	**Instrument**	**Organization Performing Analysis**	**Modified for Project Work?** (Y/N)
164	Distillation of Aqueous/Solid Samples for Total and Non-Amenable Cyanide Analysis Methods 335.1/335.4, SW-846 9012A/USEPA CLP ILMO 4.1, Rev. 12	Definitive	Inorganic	Lachat	Empirical	N
168	Phenolics, Total Recoverable (USEPA) Method 420.1 and 420.4 (Spectrophotometric, Manual and Automated with Distillation), Rev. 6	Definitive	Wet Chemistry	NA	Empirical	N
170	Threshold Odor Test Method Standard Methods SM 2150B, Rev. 1	Definitive	Wet Chemistry	NA	Empirical	N
171	Color – Standards, Methods 19th Edition 2120B, Rev. 2	Definitive	Wet Chemistry	NA	Empirical	N
181	Phenol and Phenolic Materials Distilled Water Samples Method SW846 9066 Lachat 10-210-00-1-A, Rev. 6	Definitive	Wet Chemistry	Lachat	Empirical	N
	Electrometric Determination of pH, Methods 150.1, Standard Methods 4500H+B and 9040B for Waters, Liquids and Liquid Wastes, 9045C for Soils and Solid Wastes, Rev. 6	Definitive	Wet Chemistry	pH Meter	Empirical	N
198	Toxicity Character Leaching Procedure (Method 1311), Rev. 5	Definitive	Inorganic	NA	Empirical	N
201	GC/MS Semivolatiles and Low-Concentration PAHsby EPA Method 625 and SW846 Method 8270C and 8270D, Including Appendix IX Compounds (Revision 20, 04/26/10)	Definitive	Aqueous IDW and Soil/SVOCs and low level PAHs	Gas Chromatography/Mass spectrometry (GC/MS)	Empirical	N

Laboratory SOP Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
211	GC/ECD Organochlorine Pesticides/PCBs by EPA Method 608 and SW846 Method 8081A , 8081B/8082, 8082A Revision 20 4/27/2009	Definitive	Aqueous IDW and Soil/Pesticides and PCBs	Gas Chromatography/Electron Capture Detector (GC/ECD)	Empirical	N
300	GC/MS- Semivolatile BNA-Aqueous Matrix Extraction Using SW-846 Method 3510C for 8270/625 Analysis (Revision 18, 04/26/10)	Definitive	Aqueous IDW/SVOCs and low level PAHs	NA	Empirical	N
302	Pesticides/PCBs- Aqueous Matrix Extraction for EPA Method 608 and SW846 Method 8081A/8082 Using SW846 3510C Revision 16 9/23/2008	Definitive	Aqueous QC/Pesticides and PCBs	NA	Empirical	N
343	BNA, Pesticides/PCB, and TPH non-aqueous matrix microwave extraction Using SW-846 Method 3546 (Revision 0, 8/01/09)	Definitive	Soil	NA	Empirical	N
404	Laboratory Sample Receiving Log-In and Storage Standard Operating Procedures Revision 13 6/29/2009	NA	NA	NA	Empirical	N
405	Analytical Laboratory Waste Disposal Revision 5 6/23/2009	NA	NA	NA	Empirical	N
410	Standard Operating Procedures for Laboratory Sample Storage, Secure Areas and Sample Custody Revision 7 6/23/2009	NA	NA	NA	Empirical	N

1 Laboratory SOPs are provided in Appendix D.

SAP Worksheet #24 -- Analytical Instrument Calibration Table

(UFP-QAPP Manual Section 3.2.2)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
GC/MS SVOCs and low level PAHs	Initial Calibration (ICAL) - A minimum 5-point calibration is required.	Instrument receipt, instrument change (new column, source cleaning, etc.), when continuing calibration verification (CCV) is out of criteria.	Percent Relative Standard Deviation (%RSD) must be < 15% for all Target compounds. Relative Response Factor (RRF) must be ≥ 0.05. If not met: Option 1) Linear least squares regression (r) must be ≥ 0.995 Option 2) Non-linear regression: COD (r^2) must be ≥ 0.99 (6 points for second order).	Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data.	Analyst, Department Manager	Empirical SOP: 201
	Initial calibration verification (ICV) – Second Source	Once after each ICAL prior to beginning a sample run.	Percent Recovery (%R) of each analyte must be within 80-120%.	Identify source of problem, correct, repeat calibration, rerun samples.	Analyst, Department Manager	
	CCV	Analyze a standard at the beginning of each 12-hour shift after a decafluorotriphenylphosphine (DFTPP) tune.	All target compounds must be ≤ 20 Percent Difference or Percent Drift (%D); RRF for must be ≥0.050.	Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data.	Analyst, Department Manager	
	DFTPP Tune	Prior to ICAL and at the beginning of each 12 hour analytical sequence.	Criteria listed in SOP 201 section 7.2. Must meet the ion abundance criteria required by the method. No samples may be accepted without a valid tune.	Retune and/or clean source.	Analyst, Department Manager	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
GC/ECD Pesticides	ICAL - A 6 point calibration of individual pesticides with a mid-point calibration of toxaphene and chlordane.	Upon instrument receipt, major instrument change, or when the CCV does not meet criteria.	The %RSD for each analyte must be ≤ 20%, or Option 1) r must be ≥ 0.995 Option 2) r^2 must be ≥ 0.99 (6 points for second order).	Repeat ICAL If single point calibration for toxaphene, or chlordane is identified in analysis of sample; 6-point calibration run of identified compound with reanalysis of sample.	Analyst, Department Manager	Empirical SOP: 211
	ICV	Once after each ICAL.	%Rs of individual compounds must be within 80-120%.	Identify source of problem, correct, repeat calibration, rerun samples.	Analyst, Department Manager	
	CCV	Once after each initial calibration, at the beginning and end of each run sequence, after every 10 samples, and at the end of the analysis sequence.	%Rs of individual compounds must be within 80-120%.	Identify source of problem, correct, repeat calibration, rerun samples.	Analyst, Department Manager	
	Breakdown Check	At the beginning of each 12-hour period, prior to sample analysis.	The degradation must be ≤ 15% for both Endrin and DDT.	Column maintenance; injection port maintenance.	Analyst, Department Manager	
GC/ECD PCBs	ICAL - A 6-point calibration of Aroclor 1260 (1016/1260 mixture).	Instrument receipt, major instrument change, when CCV does not meet criteria.	r^2 must be ≥ 0.990. Mid-point calibration of other Aroclors.	Repeat ICAL and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst, Department Manager	Empirical SOP: 211
	ICV – Second Source	Once after each ICAL.	The %R of all analytes must be within 80-120%.	Identify source of problem, correct, repeat calibration, rerun samples.	Analyst, Department Manager	
	CCV	Once after each ICAL.	The %R of all analytes must be within 80-120%.	Identify source of problem, correct, repeat calibration, rerun samples.	Analyst, Department Manager	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
ICP-AES Metals	ICAL – one point calibration.	At the beginning of each day or if QC is out of criteria.	One point calibration per manufacturer's guidelines.	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards	Analyst, Department Manager	Empirical SOP: 105
	ICV (Second Source)	Before beginning a sample run.	%Rs must be within 90-110%.	Do not use results for failing elements unless the ICV > 110% and the sample < the LOQ. Investigate and correct problem.	Analyst, Department Manager	
	Calibration Blank	Before beginning a sample run, after every 10 samples, and at the end of the analysis sequence.	No analytes detected > LOD.	Correct the problem, then re-prepare and reanalyze calibration blank.	Analyst, Department Manager	
	CCV	At the beginning and end of each run sequence, after every 10 samples and at the end of the analysis sequence.	%Rs of true values must be within 90-110% of true values.	Check problem, recalibrate and reanalyze any samples not bracketed by passing CCVs.	Analyst, Department Manager	
	Low-level Calibration Check Standard (if using one-point ICAL)	At beginning and end of run.	%Rs must be within 80%-120% of the true value.	Do not use results for failing elements, unless LOQ recovery > upper limit and sample result < LOQ.	Analyst, Department Manager	
	Interference Check Standards (ICS - ICSA & ICSB)	At the beginning of an analytical run.	ICSA recoveries must be less than the absolute value of the LOD and ICSB %Rs must be within 80-120% of the true value.	Correct the problem, then re-prepare and reanalyze all affected samples.	Analyst, Department Manager	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
Mercury	ICAL – A 5-point calibration curve is prepared.	Perform daily prior to sample analysis.	Must be ≤20% RSD. r must be ≥ 0.995	Recalibrate.	Analyst, Department Manager	Empirical SOP: 103/104
	ICV (Second Source)	Each analytical sequence.	%Rs must be within 90-110%of true value.	Recalibrate.	Analyst, Department Manager	
	Calibration Blank	One is performed at the beginning of analytical sequence, after every 10 samples, at the end of the sequence.	No analytes detected > LOD.	Re-prepare and analyze all associated samples.	Analyst, Department Manager	
	CCV	Perform every 10 samples and at the end of the analytical sequence.	%Rs must be within 80-120% of the true value.	Recalibrate.	Analyst, Department Manager	
	CCV (undistilled)	CCV (undistilled)-at beginning and end of each run sequence and every 10 samples.	The %R must be within 90-110% of the true value.	If the CCV (undistilled) fails high, report samples that are <LOQ. Recalibrate and/or reanalyze samples back to last acceptable CCV.	Analyst, Department Manager	

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

(UFP-QAPP Manual Section 3.2.3)

INSTRUMENT/ EQUIPMENT	MAINTENANCE ACTIVITY	TESTING ACTIVITY	INSPECTION ACTIVITY	FREQUENCY	ACCEPTANCE CRITERIA	CORRECTIVE ACTION	RESPONSIBLE PERSON	SOP REFERENCE(1)
GC/MS	Check pressure and gas supply daily. Manual tune if DFTPP not in criteria, change septa as needed, change liner as needed and cut column as needed. Other maintenance specified in laboratory Equipment Maintenance SOP.	SVOCs and low level PAHs	Ion source, injector liner, column, column flow.	Prior to ICAL and/or as necessary.	Acceptable ICAL and CCV.	Correct the problem and repeat ICAL or CCV.	Analyst, Department Manager	Empirical SOP:201
GC/ECD	Check pressure and gas supply daily. Change septa and/or liner as needed, replace or cut column as needed. Other maintenance specified in laboratory Equipment Maintenance SOP.	Pesticides and PCBs	Injector liner, septa, column, column flow.	Prior to ICAL and/or as necessary.	Acceptable ICAL and CCV.	Correct the problem and repeat ICAL or CCV.	Analyst, Department Manager	Empirical SOP: 211
ICP-AES	Clean torch assembly and spray chamber when discolored or when degradation in data quality is observed. Clean nebulizer, check argon, and replace peristaltic pump tubing as needed. Other maintenance specified in laboratory Equipment Maintenance SOP.	Metals	Torch, nebulizer chamber, pump, pump tubing.	Prior to ICAL and/or as necessary.	Acceptable ICAL and CCV.	Correct the problem and repeat ICAL or CCV.	Analyst, Department Manager	Empirical SOP:105
Mercury Analyzer	Replace peristaltic pump tubing, replace mercury lamp, replace drying tube, clean optical cell and/or clean liquid/gas separator as needed. Other maintenance specified in laboratory Equipment Maintenance SOP.	Mercury	Tubing, sample probe, optical cell.	Prior to ICAL and/or as necessary.	Acceptable ICAL and CCV.	Correct the problem and repeat ICAL or CCV.	Analyst, Department Manager	Empirical SOP: 103/104

SAP Worksheet #26 -- Sample Handling System

(UFP-QAPP Manual Appendix A)

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): FOL or designee/Tetra Tech
Sample Packaging (Personnel/Organization): FOL or designee Tetra Tech
Coordination of Shipment (Personnel/Organization): FOL or designee /Tetra Tech
Type of Shipment/Carrier: Federal Express
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Custodians/Empirical
Sample Custody and Storage (Personnel/Organization): Sample Custodians/Empirical
Sample Preparation (Personnel/Organization): Extraction Lab, Metals Preparation Lab/Empirical
Sample Determinative Analysis (Personnel/Organization): Gas Chromatography Lab, Gas Chromatography/Mass Spectrometry Lab, Metals Lab/Empirical
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): 60 days from receipt
Sample Extract/Digestate Storage (No. of days from extraction/digestion): 3 months from sample digestion/extraction
Biological Sample Storage (No. of days from sample collection): NA
SAMPLE DISPOSAL
Personnel/Organization: Sample Custodians/Empirical
Number of Days from Analysis: 30 days from submittal of final report or 60 days from receipt, whichever is longer

SAP Worksheet #27 – Sample Custody Requirements Table

(UFP-QAPP Manual Section 3.3.3

27.1 SAMPLE NOMENCLATURE, SAMPLE COLLECTION DOCUMENTATION, HANDLING, TRACKING, AND CUSTODY PROCEDURES

The following sections outline the procedures that will be used to document project activities and sample collection, handling, tracking, and custody procedures during the investigation. All forms must be filled in as completely as possible.

27.1.1 Sample Identification

Refer to Worksheet #18 for how the samples will be labeled. Also, refer to SOP CT-04 in Appendix E for how the field QA/QC samples will be labeled.

27.1.2 Sample Collection Documentation

Documentation of field observations will be recorded in a field logbook and/or on field log sheets including sample collection logs, boring logs and monitoring well construction logs. Field logbooks utilized on this project will be bound, water-resistant logbooks. All pages of the logbook will be numbered sequentially, and observations will be recorded with indelible ink.

Field sample log sheets will be used to document sample collection details, and other observations and activities will be recorded in the field logbook. Instrument calibration logs will be used to record the daily instrument calibration. Example field forms are included in Appendix E.

For sampling and field activities, the following types of information will be recorded in the field log as appropriate:

- Site name and location.
- Date and time of logbook entries.
- Personnel and their affiliations.
- Weather conditions.
- Activities involved with the sampling.
- Subcontractor activity summary.
- Site observations including site entry and exit times.
- Site sketches made on site.
- Visitor names, affiliations, arrival and departure times.
- Health and safety issues including PPE.

27.1.3 Sample Handling and Tracking System

Following sample collection into the appropriate bottleware, all samples will be immediately placed on ice in a cooler. The glass sample containers will be enclosed in bubble-wrap in order to protect the bottleware during shipment. The cooler will be secured using strapping tape along with a signed custody seal. Sample coolers will be delivered to a local courier location for priority overnight delivery to the Empirical Laboratories for analysis. Samples will be preserved as appropriate based on the analytical method. The laboratory will provide pre-preserved sample containers for sample collection. Samples will be maintained at 4 (± 2) °C until delivery to the laboratory. Proper custody procedures will be followed throughout all phases of sample collection and handling.

After collection, each sample will be maintained in the sampler's custody until formally transferred to another party (e.g., Federal Express). For all samples collected, chain-of-custody forms will document the date and time of sample collection, the sampler's name, and the names of all others who subsequently held custody of the sample. Specifications for chemical analyses will also be documented on the chain-of-custody form. Tetra Tech SOP SA-6.3 (Field Documentation), included in Appendix E, provides further details on the chain-of-custody procedure.

These subsections outline the procedures that will be used by field and laboratory personnel to document project activities and sample collection procedures during this RI. All forms must be filled in as completely as possible.

27.1.4 Sample Handling

Sample handling requirements are described in Worksheet #26. Tetra Tech personnel will collect the samples. The samplers will take care not to contaminate samples through improper handling. Samples will be sealed in appropriate containers, packaged by Tetra Tech personnel and placed into sealed coolers under chain-of-custody in accordance with the applicable SOP (See Worksheet #21). All coolers will contain a temperature blank. Samples will be transferred under chain-of-custody to a courier as described below. Once received by the laboratory, receipt will be documented on the chain-of-custody form and the samples will be checked in. The samples will remain under chain-of-custody throughout the analysis period to ensure that their integrity is preserved. Details are provided below.

27.1.5 Sample Delivery

Samples to be delivered to the laboratory will be made by a public courier (i.e., Federal Express). After samples have been collected, they will be sent to the laboratory within 24 hours. Under no circumstances will sample holding times be exceeded.

27.1.6 Sample Custody

Chain-of-custody protocols will be used throughout sample handling to establish the evidentiary integrity of sample containers. These protocols will be used to demonstrate that the samples were handled and transferred in a manner that would eliminate possible tampering. Samples for the laboratory will be packaged and shipped in accordance with Tetra Tech SOP SA-6.1 (Appendix E).

A sample is under custody if:

- The sample is in the physical possession of an authorized person.
- The sample is in view of an authorized person after being in his/her possession.
- The sample is placed in a secure area by an authorized person after being in his/her possession.
- The sample is in a secure area, restricted to authorized personnel only.

Custody documentation is designed to provide documentation of preparation, handling, storage, and shipping of all samples collected. A multi-part form is used with each page of the form signed and dated by the recipient of a sample or portion of a sample. The person releasing the sample and the person receiving the sample each will retain a copy of the form each time a sample transfer occurs.

Integrity of the samples collected during the site investigation will be the responsibility of identified persons from the time the samples are collected until the samples, or their derived data, are incorporated into the final report

The FOL is responsible for the care and custody of the samples collected until they are delivered to the laboratory or are entrusted to a carrier. When transferring samples, the individuals relinquishing and receiving them will sign, date, and note the time on the chain-of-custody form. This record documents the sample custody transfer from the sampler to the laboratory, often through another person or agency (common carrier). Upon arrival at the laboratory, internal sample custody procedures will be followed as defined in the laboratory SOPs included in Appendix D.

27.1.7 Laboratory Custody (Empirical Laboratories)

Detailed descriptions of the practices referenced here are provided in the attached Empirical Laboratories' Laboratory Sample Receiving, Log In and Storage SOP (SOP404) and Empirical Laboratories' Laboratory Sample Storage, Secure Areas and Sample Custody SOP (SOP410). Copies of the related forms and labels are included in those SOPs which are provided in Appendix D.

SAP Worksheet #28 -- Laboratory QC Samples Table

(UFP-QAPP Manual Section 3.4)

Matrix	Soil, Solid IDW, and Aqueous IDW
Analytical Group	SVOCs and low level PAHs
Analytical Method/ SOP Reference	SW-846 8270C Empirical SOP-343/300/201

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 preparation batch of 20 or fewer samples of similar matrix.	Contaminants in the method blank must be < ½ LOQ, except common lab contaminants, which must be <LOQ.	(1) Investigate source of contamination (2) Re-prepare and analyze method blank and all samples processed with the contaminated blank.	Analyst, Laboratory Department Manager and Data Validator	Bias/ Contamin ation	Same as Method/SOP QC Acceptance Limits.

Matrix	Soil, Solid IDW, and Aqueous IDW
Analytical Group	SVOCs and low level PAHs
Analytical Method/ SOP Reference	SW-846 8270C Empirical SOP-343/300/201

QC SAMPLE	FREQUENCY/ NUMBER	METHOD/SOP QC ACCEPTANCE LIMITS	CORRECTIVE ACTION	PERSON(S) RESPONSIBLE FOR CORRECTIVE ACTION	DATA QUALITY INDICATOR (DQI)	MEASUREMENT PERFORMANCE CRITERIA
Surrogates	Six per sample: Nitrobenzene-d5 2-Fluorobiphenyl Terphenyl-d14 Phenol d-6 2-Fluorophenol 2,4,6-Tribromophenol	%Rs must meet the laboratory statistically-derived control limits. Current limits are provided in Appendix G. [1]	(1) Check chromatogram for interference; if found, then flag data. (2) If not found, then check instrument performance; if problem is found, then correct and reanalyze. (3) If still out, then re-extract and analyze sample. (4) If reanalysis is out, then flag data.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/ Bias	Same as Method/SOP QC Acceptance Limits.
LCS LCSD (not required)	One is performed for each batch of up to 20 samples.	%Rs must meet the laboratory statistically-derived control limits. Current limits are provided in Appendix G. [1] RPD must be ≤30% (for LCS/LCSD).	Evaluate and reanalyze if possible. If an MS/MSD was performed in the same 12 hour clock and is acceptable, then narrate. If the LCS recoveries are high but the sample results are <LOQ, then narrate. Otherwise, re-prepare and reanalyze.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy / Bias Precision also, if LCSD is analyzed	Same as Method/SOP QC Acceptance Limits.

Matrix	Soil, Solid IDW, and Aqueous IDW
Analytical Group	SVOCs and low level PAHs
Analytical Method/ SOP Reference	SW-846 8270C Empirical SOP-343/300/201

QC SAMPLE	FREQUENCY/ NUMBER	METHOD/SOP QC ACCEPTANCE LIMITS	CORRECTIVE ACTION	PERSON(S) RESPONSIBLE FOR CORRECTIVE ACTION	DATA QUALITY INDICATOR (DQI)	MEASUREMENT PERFORMANCE CRITERIA
Internal Standards (IS)	Six per sample – 1,4-Dichlorobenzene-d4 Naphthalene-d8 Acenaphthene-d10 Phenanthrene-d10 Chrysene-d12 Perylene-d12	Retention times for ISs must be + within +/-_30 seconds and the response areas must be within -50% to +100% of the midpoint ICAL standard for each IS.	Reanalyze affected samples.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/ Bias	Same as Method/SOP QC Acceptance Limits.
MS/MSD	One per SDG or every 20 samples.	%Rs should meet the laboratory statistically-derived control limits. Current limits are provided in Appendix G. [1] RPD should be ≤ 30%.	Corrective Action will not be taken for samples when %Rs are outside limits and surrogate and LCS criteria are met. If both the LCS and MS/MSD are unacceptable, then re-prepare the samples and QC.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/ Bias / Precision	Same as Method/SOP QC Acceptance Limits.

1 Please note that limits are updated periodically and may change from the issuance of the final SAP to the time data validation is performed. The limits used for validation will be the limits that are current at the time of analysis.

Matrix	Soil, Solid IDW, and Aqueous IDW
Analytical Group	Pesticides / PCBs
Analytical Method/ SOP Reference	SW-846 8081B/8082A Empirical SOP- 343/302/211

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 preparation batch of 20 or fewer samples of similar matrix.	Contaminants must be < ½ LOQ.	Investigate source of contamination. Evaluate the samples and associated QC: i.e., if the blank results are above the LOQ, then report sample results which are <LOQ or > 10X the blank concentration. Otherwise, re-prepare a blank and samples >LOQ and <10X LOQ.	Analyst, Laboratory Department Manager, and Data Validator	Bias/Contamination	Same as Method/SOP QC Acceptance Limits.

Matrix	Soil, Solid IDW, and Aqueous IDW
Analytical Group	Pesticides / PCBs
Analytical Method/ SOP Reference	SW-846 8081B/8082A Empirical SOP- 343/302/211

QC SAMPLE	FREQUENCY/ NUMBER	METHOD/SOP QC ACCEPTANCE LIMITS	CORRECTIVE ACTION	PERSON(S) RESPONSIBLE FOR CORRECTIVE ACTION	DATA QUALITY INDICATOR (DQI)	MEASUREMENT PERFORMANCE CRITERIA
Surrogates	Two per sample: 2,4,5,6-Tetrachloro-metaxylene (TCMX) and Decachlorobiphenyl (DCB)	%Rs must meet the laboratory statistically-derived control limits. Current limits are provided in Appendix G. [1]	No corrective will be taken when one surrogate is within criteria. If surrogates recoveries are high and sample is <LOQ, then no corrective action is taken. If surrogates recoveries are low, then the affected samples are re-extracted and reanalyzed.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
LCS LCSD (not required)	One is performed for each batch of up to 20 samples.	%Rs must meet the laboratory statistically-derived control limits. Current limits are provided in Appendix G. [1] RPD must be ≤30% (for LCS/LCSD).	If an MS/MSD was performed and is acceptable, then narrate. If an LCS/LCSD was performed and only one of the set was unacceptable, then narrate. If the LCS recovery is high, but the sample results are <LOQ, then narrate. Otherwise, re-extract blank and affected sample batch.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/ Bias Precision also, if LCSD is analyzed	Same as Method/SOP QC Acceptance Limits.

Matrix	Soil, Solid IDW, and Aqueous IDW
Analytical Group	Pesticides / PCBs
Analytical Method/ SOP Reference	SW-846 8081B/8082A Empirical SOP- 343/302/211

QC SAMPLE	FREQUENCY/ NUMBER	METHOD/SOP QC ACCEPTANCE LIMITS	CORRECTIVE ACTION	PERSON(S) RESPONSIBLE FOR CORRECTIVE ACTION	DATA QUALITY INDICATOR (DQI)	MEASUREMENT PERFORMANCE CRITERIA
MS/MSD	One per 20 samples of similar matrix.	%Rs should meet the laboratory statistically-derived control limits. Current limits are provided in Appendix G. [1] RPD should be ≤ 30%.	Evaluate the samples and associated QC and if the LCS results are acceptable, then narrate. If both the LCS and MS/MSD are unacceptable, then re-prepare the samples and QC.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy / Bias / Precision	Same as Method/SOP QC Acceptance Limits.
Second Column Confirmation	All positive results must be confirmed.	Results between primary and second column - RPD must be ≤ 40%.	None.	Analyst, Laboratory Department Manager, and Data Validator	Precision	Same as Method/SOP QC Acceptance Limits.

2 Please note that limits are updated periodically and may change from the issuance of the final SAP to the time data validation is performed. The limits used for validation will be the limits that are current at the time of analysis.

Matrix	Soil, Solid IDW, and Aqueous IDW
Analytical Group	Metals (including Mercury)
Analytical Method / SOP Reference	SW-846 6010C/7470A/7471 A Empirical SOP- 100-103/104/105

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 digestion batch of 20 or fewer samples.	No analytes detected > ½ the LOQ.	If the blank value > LOQ, then report sample results. If the blank value < LOQ or > 10x the blank value; then redigest. If blank value is less than negative LOQ, then report sample results. If > 10x the absolute value of the blank result, then redigest.	Analyst, Laboratory Department Manager, and Data Validator	Bias/Contamination	Same as Method/SOP QC Acceptance Limits.
LCS LCSD (not required)	One is performed for each batch of up to 20 samples.	The %R must be within 80-120%. RPD must be ≤30% (for LCS/LCSD).	Redigest and reanalyze all associated samples for affected analyte.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias Precision also, if LCSD is analyzed	Same as Method/SOP QC Acceptance Limits.
Duplicate Sample	One per preparation batch of 20 or fewer samples of similar matrix.	The RPD should be ≤20% for duplicate samples.	Narrate any results that are outside control limits.	Analyst, Laboratory Department Manager, and Data Validator	Precision	Same as Method/SOP QC Acceptance Limits.
MS	One per 20 samples of similar matrix.	The %R should be within 80-120%, if sample < 4x spike added.	Flag results for affected analytes for all associated samples with"N".	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.

Matrix	Soil, Solid IDW, and Aqueous IDW
Analytical Group	Metals (including Mercury)
Analytical Method / SOP Reference	SW-846 6010C/7470A/7471 A Empirical SOP- 100-103/104/105

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	One is performed for each preparation batch with sample concentration(s) > 50x MDL.	The result must agree within ± 10% of the original sample result.	Perform Post Digestion Spike	Analyst, Laboratory Department Manager, and Data Validator	Precision	Same as Method/SOP QC Acceptance Limits.
Post Digestion Spike (does not apply to mercury)	One is performed when serial dilution fails or analyte concentration(s) in all samples < 50x MDL.	The result must agree within 75-125% of expected result.	Flag results of samples of same matrix as estimates in SDG narrative.	Analyst, Laboratory Department Manager, and Data Validator	Precision	Same as Method/SOP QC Acceptance Limits.

Laboratory SOPs are provided in Appendix D.

SAP Worksheet #29 – Project Documents and Records Table

(UFP-QAPP Manual Section 3.5.1)

Document	Where Maintained
Sample Collection Documents and Records Field logbook (and sampling notes) Field sample forms (e.g., boring logs, sample log sheets, drilling logs, etc.) Chain-of-custody records Sample shipment airbills Equipment calibration logs Photographs F T MR forms Field Sampling SOPs	Tetra Tech Project File, results will be discussed in subject document.
Laboratory Documents and Records Sample receipt/login forms Sample analysis run logs Corrective action forms Reported field sample results Reported results for standards, quality control checks, and quality control samples Data completeness checklists Sample storage and disposal records Telephone logs Extraction/clean-up records Raw data	Tetra Tech Project File, long-term data package storage at third-party professional document storage firm, results will be discussed in subject document.
Data Assessment Documents and Records Field Sampling Audit Checklist (if an audit is conducted) Analytical Audit Checklist (if an audit is conducted) Data Validation Memoranda Investigation Report	Tetra Tech Project File, results will be discussed in subject document.

SAP Worksheet #30 – Analytical Services Table

(UFP-QAPP Manual Section 3.5.2.3)

Matrix	Analytical Group	Sample Locations/ ID Numbers	Analytical Method	Data Package Turnaround Time	Laboratory/Organization	Backup Laboratory/ Organization
Soil and Aqueous IDW	SVOCs and low level PAHs	See Worksheet #18	SW-846 8270C	21 calendar days	Kim Kostzer Empirical Laboratories, LLC 621 Mainstream Drive Suite 270 Nashville, TN 37228 (615) 345-1115 ext. 240 kkostzer@empirlabs.com	NA
	Pesticides/ PCBs	See Worksheet #18	SW-846 8081B/8082A			
	TAL Metals	See Worksheet #18	SW-846 6010C 7470A/7471A			
	VOCs (if warranted by PID readings)	See Worksheet #18	SW-846 8260B			
Solid IDW	Reactivity/ Ignitibility/ pH	See Worksheet #18	SW-846 9012A/chapter 7/1010/9045/ Empirical SOP-149/156/164/175/187	7 calendar days	Kim Kostzer Empirical Laboratories, LLC 621 Mainstream Drive Suite 270 Nashville, TN 37228 (615) 345-1115 ext. 240 kkostzer@empirlabs.com	NA
	Phenolics	See Worksheet #18	SW-846 9066/Empirical SOP-168/181			
	Odor/Density/ Color/Paint Filter/Water Content	See Worksheet #18	SM2150B/SM2710F /SM2120B/SW-846 9095/ Empirical SOP-170/171/191			
	Total PCBs	See Worksheet #18	SW-846 8082A			
	TCLP Organics	See Worksheet #18	SW-846 1311 followed by 8260B, 8270C, 8081A, 8151A			
	TCLP Inorganics	See Worksheet #18	SW-846 1311 followed by 6010B, 7470A			

SAP Worksheet #31 – Planned Project Assessments Table

(UFP-QAPP Manual Section 4.1.1)

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing Corrective Actions	Person(s) Responsible for Monitoring Effectiveness of Corrective Actions
Field Sampling System Audit	One per contract year[1]	Internal	Tetra Tech	Person assigned by Tetra Tech QAM	Tetra Tech PM and FOL	Auditor and Tetra Tech PM	Tetra Tech CLEAN QAM
Laboratory System Audit (1)	Every 2 years	External	DoD ELAP Accrediting Body	DoD ELAP Accrediting Body Auditor	Empirical Laboratory QAM or Laboratory Manager	Empirical Laboratory QAM or Laboratory Manager	Empirical Laboratory QAM or Laboratory Manager

1 The selected analytical laboratory (Empirical) has successfully completed the laboratory assessment process required as part of the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) and as described in the "Department of Defense Quality Systems Manual for Environmental Laboratories (DoD QSM)" , Version 4.1, April 2009. The DoD ELAP accreditation documentation is included in Appendix D.

SAP Worksheet #32 -- Assessment Findings and Corrective Action Responses

(UFP-QAPP Manual Section 4.1.2)

Assessment Type	**Nature of Deficiencies Documentation**	**Individual(s) Notified of Findings** (name, title, organization)	**Timeframe of Notification**	**Nature of Corrective Action Response Documentation**	**Individual(s) Receiving Corrective Action Response** (name, title, organization)	**Timeframe for Response**
Field Sampling System Audit	Audit checklist and written audit finding summary	Biff Cummings, PM, Tetra Tech TBD, FOL, Tetra Tech John Trepanowski, Program Manager, Tetra Tech Garth Glenn, Deputy Program Manager, Tetra Tech	Dependent on the finding, if major a stop work may be issue immediately, however if minor within 1 week of audit	Written memo	Biff Cummings, PM, Tetra Tech; TBD, FOL, Tetra Tech; Tom Johnston, North Atlantic QAM, Tetra Tech; TBD, Field Auditor, Tetra Tech; John Trepanowski, Program Manager, Tetra Tech; Garth Glenn, Deputy Program Manager, Tetra Tech;	Within 48 hours of notification
Laboratory System Audit	Written audit report	Rick Davis Laboratory Director, Randy Ward Laboratory QAM Empirical	Not specified by DoD ELAP	Letter	DOD ELAP Accrediting Body	Specified by DOD ELAP Accrediting Body

SAP Worksheet #33 -- QA Management Reports Table

(UFP QAPP Manual Section 4.2)

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)
Data validation report	Per SDG	Upon completion of data validation (usually within 3 weeks of receipt of laboratory data)	DVM and staff chemists, Tetra Tech	PM and project file, Tetra Tech
Major analysis problem identification (internal Tetra Tech Memorandum)	When persistent analysis problems are detected by Tetra Tech that may impact data usability	Immediately upon detection of problem (on the same day)	NAVFAC Atlantic QAM, Tetra Tech	PM, CLEAN QAM, Program Manager, and project file Tetra Tech
Project monthly progress report	Monthly for duration of project	Monthly	PM, Tetra Tech	Navy RPM, Navy; CLEAN QAM, Program Manager, and project file, Tetra Tech
Laboratory QA report	When significant plan deviations result from unanticipated circumstances	Immediately upon detection of problem (on the same day)	Laboratory PM, Empirical	PM and project file, Tetra Tech
Audit report	In conjunction with audits	After completion of audits (usually 3 weeks)	Tetra Tech or third party Auditor(s)	PM and QAM, Tetra Tech, and audited entity

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

(UFP-QAPP Manual Section 5.2.1)

Verification Input	Description	Internal / External	Responsible for Verification (name, organization)
Chain-of-Custody Forms	The Tetra Tech FOL or designee will review and sign the chain-of-custody form to verify that all samples listed are included in the shipment to the laboratory and the sample information is accurate. The forms will be signed by the sampler and a copy will be retained for the project file, the Tetra Tech PM, and the Tetra Tech Data Validators.	Internal	Sampler and FOL, Tetra Tech
	The Empirical Laboratory Sample Custodian will review the sample shipment for completeness, integrity, and sign accepting the shipment. The Tetra Tech Data Validators will check that the chain-of-custody form was signed and dated by the Tetra Tech FOL or designee relinquishing the samples and also by the Laboratory Sample Custodian receiving the samples for analyses.	Internal/ External	1 - Laboratory Sample Custodian, Empirical 2 - Data Validators, Tetra Tech
SAP Sample Tables/ Chain-of-Custody Forms	Verify that all proposed samples listed in the SAP tables have been collected.	Internal	FOL or designee, Tetra Tech
Sample Log Sheets	Verify that information recorded in the log sheets is accurate and complete.	Internal	FOL or designee, Tetra Tech
SAP/ Field Logs/ Analytical Data Packages	Ensure that all sampling SOPs were followed. Verify that deviations have been documented and MPCs have been achieved. Particular attention should be given to verify that samples were correctly identified, that sampling location coordinates are accurate, and that documentation establishes an unbroken trail of documented chain-of-custody from sample collection to report generation. Verify that the correct sampling and analytical methods/SOPs were applied. Verify that the sampling plan was implemented and carried out as written and that any deviations are documented.	Internal	PM or designee, Tetra Tech
Sample Coordinates	Ensure that sample locations are correct and in accordance with the SAP proposed locations. Document any discrepancies in the final report.	Internal	FOL or designee, Tetra Tech
SAP/ Analytical SOPs/ Analytical Data Packages	Ensure that all laboratory SOPs were followed. Verify that the correct analytical methods/SOPs were applied.	Internal	Laboratory QAM, Empirical
SAP/ Laboratory SOPs/ Raw Data/ Applicable Control Limits Tables	Establish that all method QC samples were analyzed and in control as listed in the analytical SOPs. If method QA is not in control, the Laboratory QAM will contact the Tetra Tech PM verbally or via e-mail for guidance prior to report preparation.	Internal	Laboratory QAM, Empirical
SAP/ Chain-of-Custody Forms	Check that field QC samples listed in Worksheet #20 were collected as required.	Internal	FOL or designee, Tetra Tech

Verification Input	Description	Internal / External	Responsible for Verification (name, organization)
Electronic Data Deliverables (EDDs)/ Analytical Data Packages	Each EDD will be verified against the chain-of-custody and hard copy data package for accuracy and completeness. Laboratory analytical results will be verified and compared to the electronic analytical results for accuracy. Sample results will be evaluated for laboratory contamination and will be qualified for false positives using the laboratory method/preparation blank summaries. Positive results reported between the DL and the LOQ will be qualified as estimated. Extraneous laboratory qualifiers will be removed from the validation qualifier.	External	Data Validators, Tetra Tech
Analytical Data Packages	All analytical data packages will be verified internally for completeness by the laboratory performing the work. The Laboratory QAM will sign the case narrative for each data package.	Internal	Laboratory QAM, Empirical
	Each data package will be verified for completeness by the Tetra Tech Data Validator. Missing information will be requested by the Tetra Tech Data Validator from the Laboratory PM.	External	Data Validators, Tetra Tech

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

(UFP-QAPP Manual Section 5.2.2) (Figure 37 UFP-QAPP Manual) (Table 9 UFP-QAPP Manual)

Step IIa / IIb	**Validation Input**	**Description**	**Responsible for Validation** (name, organization)
IIa	Chain-of-Custody Forms	Custody - Ensure that the custody and integrity of the samples was maintained from collection to analysis and the custody records are complete and any deviations are recorded. Review that the samples were shipped and store at the required temperature and sample pH for chemically-preserved samples meet the requirements listed in Worksheet #19. Ensure that the analyses were performed within the holding times listed in Worksheet #19.	Project Chemist or Data Validators, Tetra Tech
IIa/IIb	SAP/ Laboratory Data Packages/ EDDs	Accuracy - Ensure that the laboratory QC samples listed in Worksheet #28 were analyzed and that the MPCs listed in Worksheet #12 were met for all field samples and QC analyses. Check that specified field QC samples were collected and analyzed and that the analytical QC criteria set up for this project were met.	Project Chemist or Data Validators, Tetra Tech
		Precision - Check the field sampling precision by calculating the RPD for field duplicate samples. Check the laboratory precision by reviewing the RPD or percent difference values from laboratory duplicate analyses; MS/MSDs; and LCS/LCSD, if available. Ensure compliance with the methods and project MPCs accuracy goals listed in Worksheet #12.	
		Representativeness - Check that the laboratory recorded the temperature at sample receipt and the pH of the chemically preserved samples to ensure sample integrity from sample collection to analysis.	
		Completeness - Review the chain-of-custody forms generated in the field to ensure that the required analytical samples have been collected, appropriate sample identifications have been used, and correct analytical methods have been applied. The Tetra Tech Data Validator will verify that elements of the data package required for validation are present, and if not, the laboratory will be contacted and the missing information will be requested. Validation will be performed as per Worksheet #36. Check that all data have been transferred correctly and completely to the final SQL database.	

Step IIa / IIb	Validation Input	Description	Responsible for Validation (name, organization)
IIb	SAP/ Laboratory Data Packages/ EDDs	Sensitivity - Ensure that the project LOQs listed in Worksheet #15 were achieved.	Project Chemist or Data Validators, Tetra Tech
		PALs - Discuss the impact on reported DLs due to matrix interferences or sample dilutions performed because of the high concentration of one or more other contaminants, on the other target compounds reported as non-detected. Document this usability issue and inform the Tetra Tech PM. Review and add PSLs to the laboratory EDDs. Flag samples and notify the Tetra Tech PM of samples that exceed PSLs listed in Worksheet #15.	
		QA/QC - Ensure that all QC samples specified in the SAP were collected and analyzed and that the associated results were within prescribed SAP acceptance limits. Ensure that QC samples and standards prescribed in analytical SOPs were analyzed and within the prescribed control limits. If any significant QC deviations occur, the Laboratory QAM shall have contacted the Tetra Tech PM.	
		Deviations - Summarize deviations from methods, procedures, or contracts in the Data Validation Report. Determine the impact of any deviation from sampling or analytical methods and SOPs requirements and matrix interferences effect on the analytical results. Qualify data results based on method or QC deviation and explain all the data qualifications. Print a copy of the project database qualified data depicting data qualifiers and data qualifiers codes that summarize the reason for data qualifications. Determine if the data met the MPCs and determine the impact of any deviations on the technical usability of the data.	

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

(UFP-QAPP Manual Section 5.2.2.1) (Figure 37, page 110 UFP-QAPP Manual)

Step IIa / IIb	Matrix	Analytical Group	Validation Criteria	Data Validator (title and organizational affiliation)
IIa and IIb	Soil	SVOCs (including low level PAHs)	SW-846 8270C method-specific criteria and those criteria listed in Worksheet #12, #15,#24, and #28. If not included in these worksheets, then the logic outlined in USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review USEPA-540/R-99-008, October 1999, will be used to apply qualifiers to data. 50 percent full data validation will be performed.	Data Validators, Tetra Tech
IIa and IIb	Soil	Metals	SW-846 6010C method-specific criteria and those listed in Worksheet #12, #15, #24, and #28. If not included in these worksheets,then the logic outlined in USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review USEPA-540-R-04-004, October 2004, will be used to apply qualifiers to data. 50 percent full data validation will be performed.	Data Validators, Tetra Tech
IIa and IIb	Soil	PCBs and Pesticides	SW-846 8082A and 8081B method-specific criteria and those listed in Worksheet numbers #12, #15, #24, and #28. If not included in these worksheets, then the logic outlined in USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review USEPA-540/R-99-008, October 1999, will be used to apply qualifiers to data. 50 percent full data validation will be performed.	Data Validators, Tetra Tech

Notes: Solid and Aqueous IDW results will not be validated.

SAP Worksheet #37 -- Usability Assessment

(UFP-QAPP Manual Section 5.2.3)

Data Usability Assessment

The usability of the data directly affects whether project objectives can be achieved. The characteristics discussed below will be evaluated, at a minimum, as part of the data usability assessment. The results of these evaluations will be included in the project report. The characteristics will be evaluated for multiple concentration levels if the evaluator determines that this is necessary. To the extent required by the type of data being reviewed, the assessors will consult with other technically competent individuals to render sound technical assessments of these DQI characteristics.

Completeness

For each matrix that was scheduled to be sampled, the Tetra Tech FOL acting on behalf of the Project Team will prepare a table listing planned samples/analyses to collected samples/analyses. If deviations from the scheduled sample collection or analyses are identified, the Tetra Tech PM will determine whether the deviations compromise the ability to meet project objectives. If they do, the Tetra Tech PM will consult with the Navy RPM and other Project Team members, as necessary (determined by the Navy RPM), to develop appropriate corrective actions.

Precision

The tetra Tech Project Chemist acting on behalf of the Project Team will determine whether precision goals for field duplicates and laboratory duplicates were met. This will be accomplished by comparing duplicate results to precision goals identified in Worksheets #12 and #28. This will also include a comparison of field and laboratory precision with the expectation that field duplicate results will be no less precise than laboratory duplicate results. If the goals are not met, or, if data have been flagged as estimated (J qualifier), limitations on the use of the data will be described in the project report.

Accuracy

The Tetra Tech Project Chemist acting on behalf of the Project Team will determine whether the accuracy/bias goals were met for project data. This will be accomplished by comparing percent recoveries of LCS, LCSD, MS, MSD, and surrogate compounds to accuracy goals identified in Worksheet #28. This assessment will include an evaluation of field and laboratory contamination; instrument calibration variability; and analyte recoveries for surrogates, MS, and LCSs. If the goals are not met, limitations on the use of the data will be described in the project report. Bias of the qualified

results and a description of the impact of identified non-compliances on a specific data package or on the overall project data will be described in the project report.

Representativeness

A Tetra Tech Project Scientist identified by the Tetra Tech PM and acting on behalf of the Project Team will determine whether the data are adequately representative of intended populations, both spatially and temporally. This will be accomplished by verifying that samples were collected and processed for analysis in accordance with this SAP, by reviewing spatial and temporal data variations, and by comparing these characteristics to expectations. The usability report will describe the representativeness of the data for each matrix and analytical fraction. This will not require quantitative comparisons unless the professional judgment of the Tetra Tech Project Scientist indicates that a quantitative analysis is required.

Comparability

The Tetra Tech Project Chemist acting on behalf of the Project Team will determine whether the data generated for this project are sufficiently comparable to historical site data generated by different methods and for samples collected using different procedures and under different site conditions. This will be accomplished by comparing overall precision and bias among data sets for each matrix and analytical fraction. This will not require quantitative comparisons unless the professional judgment of the Tetra Tech Project Chemist indicates that such quantitative analysis is required.

Sensitivity

The Tetra Tech Project Chemist acting on behalf of the Project Team will determine whether project sensitivity goals listed in Worksheet #15 are achieved. The overall sensitivity and DLs from multiple data sets for each matrix and analysis will be compared. If sensitivity goals are not achieved, the limitations on the data will be described. The Tetra Tech Project Chemist will enlist the help of the project risk assessor to evaluate deviations from planned sensitivity goals.

Project Assumptions and Data Outliers

The Tetra Tech PM and designated Project Team members will evaluate whether project assumptions were valid. This will typically be a qualitative evaluation but may be supported by quantitative evaluations. The type of evaluation will depend on the assumption being tested. Quantitative assumptions include assumptions related to data distributions (e.g., normal versus log-normal) and estimates of data variability. Potential outliers will be removed if a review of the associated documentation indicates that the results have an assignable cause that renders them inconsistent with

the rest of the data. During this evaluation, the team will consider whether outliers could be indications of unanticipated site conditions.

Describe the evaluative procedures used to assess overall measurement error associated with the project:

After the completion of data validation, the data and data quality will be reviewed to determine whether sufficient data of acceptable quality are available for decision making. In addition to the evaluations described above, a series of inspections and statistical analyses will be performed to estimate these characteristics. The statistical evaluations will include simple summary statistics for target analytes, such as maximum concentration, minimum concentration, number of samples with non-detected results, number of samples with detected results, and the proportion of samples with detected and non-detected results. The Project Team members identified by the Tetra Tech PM will assess whether the data collectively support the attainment of project objectives. They will consider whether any missing or rejected data have compromised the ability to make decisions or to make the decisions with the desired level of confidence. The data will be evaluated to determine whether missing or rejected data can be compensated for by other data. Although rejected data will generally not be used, there may be reason to use them in a weight-of-evidence argument, especially when they supplement data that have not been rejected. If rejected data are used, their use will be supported by technically defensible rationales.

Statistical comparisons and mathematical manipulations will be utilized in the evaluation of the results. Non-detected values will be substituted in these statistical comparisons and mathematical manipulations as appropriate to the statistical method used. For example, for UCL calculations, the method detection limit value will be used according to USEPA guidance. Duplicate results (original and duplicate) will not be averaged for the purpose of representing the range of concentrations. Duplicate samples will be used for quality control purposes, not for the statistical comparisons and mathematical manipulations in the evaluation of the results.

Identify the personnel responsible for performing the usability assessment:

The Tetra Tech PM, Tetra Tech Project Chemist, Tetra Tech FOL, and Tetra Tech Project Scientist will be responsible for conducting the listed data usability assessments. The data usability assessment will be reviewed with the Navy RPM, USEPA RPM, and Illinois EPA RPM. If deficiencies affecting the attainment of project objectives are identified, the review will take place either in a face-to-face meeting or a teleconference, depending on the extent of identified deficiencies. If no significant deficiencies are identified, the data usability assessment will simply be documented in the project report and reviewed during the normal document review cycle.

Describe the documentation that will be generated during the usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies:

The data will be presented in tabular format, including data qualifications such as estimation (J, UJ) or rejection (R). Written documentation will support non-compliant estimated or rejected data results. The project report will identify and describe the data usability limitations and suggest resampling or other corrective actions, if necessary.

P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\SITE_12_LOCATION_MAP.MXD 01/04/10 TW

DRAWN BY T.WHEATON	DATE 10/22/09	LOCATION MAP SITE 12 - HARBOR DREDGE SPOIL AREA NS GREAT LAKES GREAT LAKES, ILLINOIS	CONTRACT NUMBER F27A
CHECKED BY L. WANG	DATE 10/22/09		OWNER NUMBER —
REVISED BY —	DATE —		APPROVED BY — DATE —
SCALE AS NOTED			FIGURE NO. FIGURE 10-1 / REV 0

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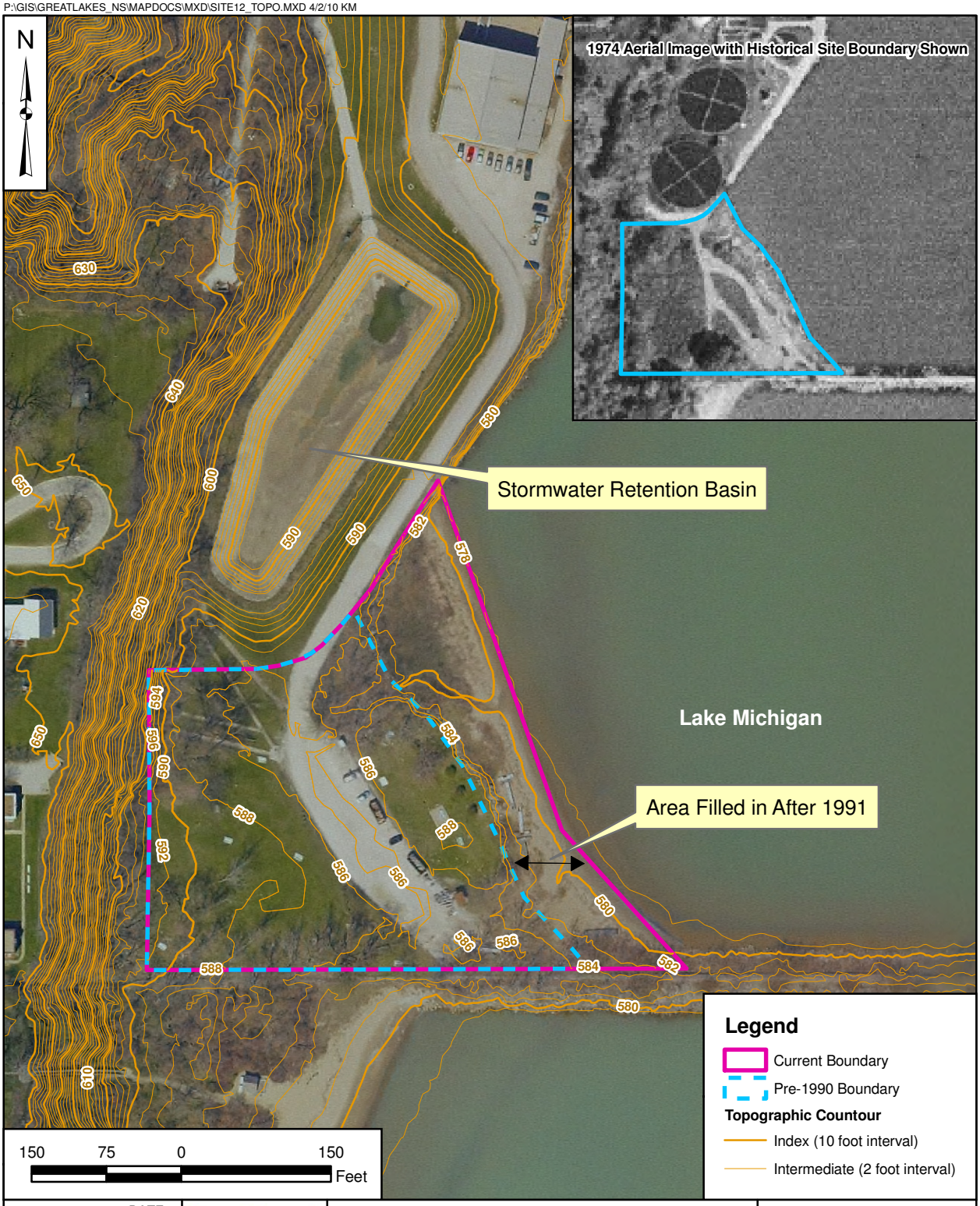
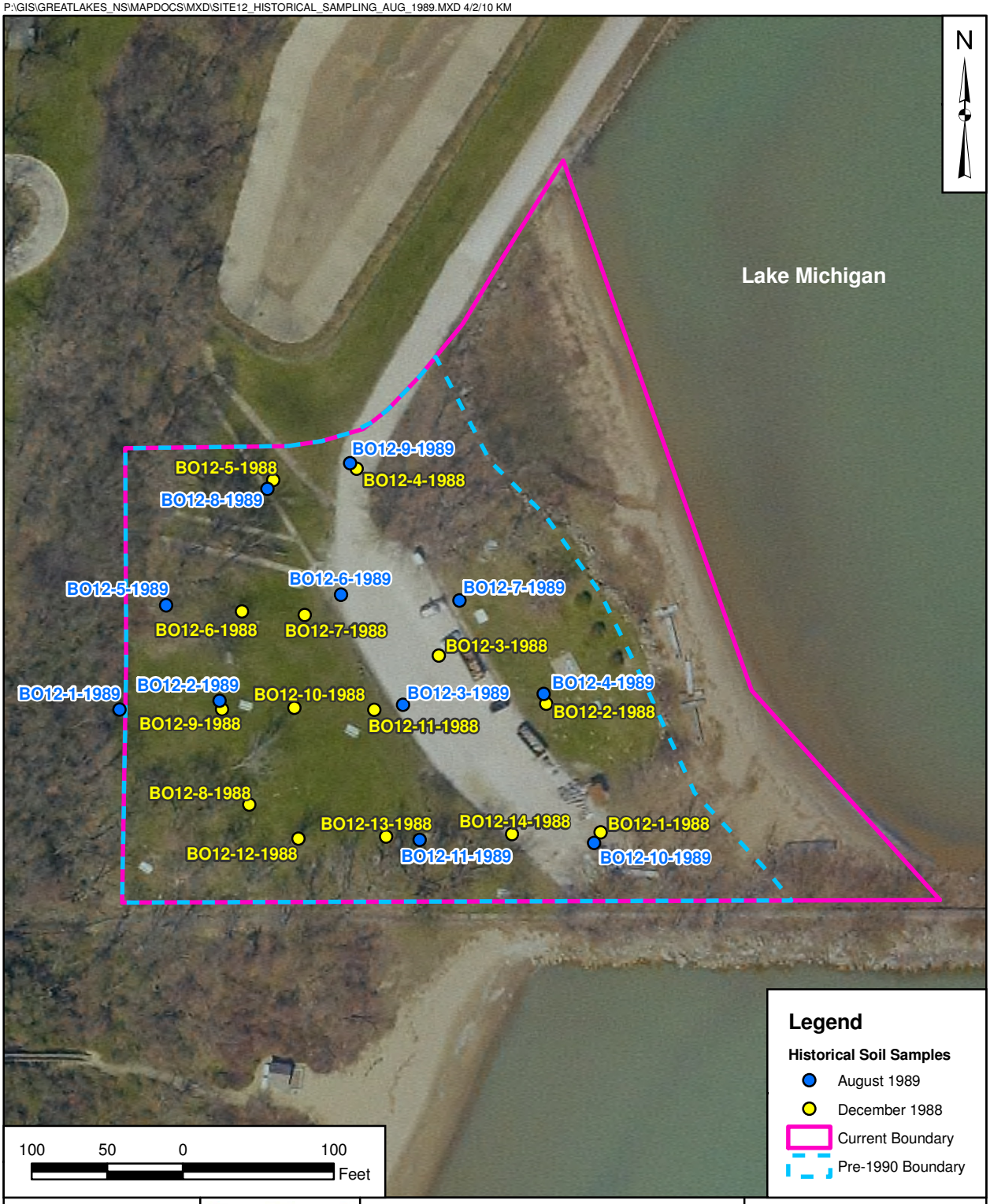
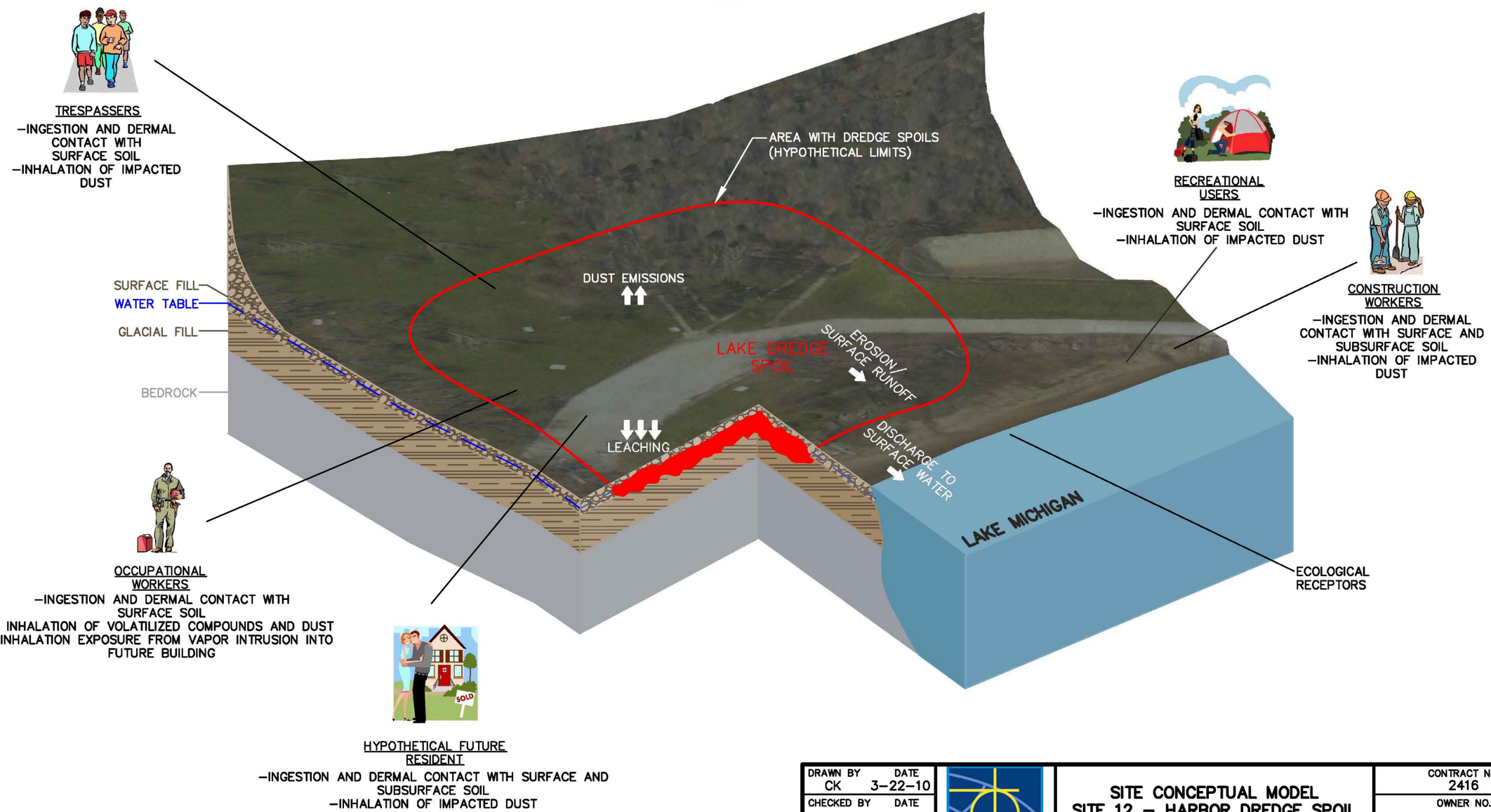


DRAWN BY T. WHEATON	DATE 01/11/10	NAVFAC	SITE OVERVIEW SITE 12 - HARBOR DREDGE SPOIL AREA NS GREAT LAKES GREAT LAKES, ILLINOIS	CONTRACT NUMBER F27A
CHECKED BY B. CUMMINGS	DATE 4/2/10			OWNER NUMBER —
REVISED BY —	DATE —			APPROVED BY — / DATE —
SCALE AS NOTED				FIGURE NO. FIGURE 10-2 / REV 0

P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\SITE12_HISTORICAL_SAMPLING_AUG_1989.MXD 4/2/10 KM



DRAWN BY T. WHEATON	DATE 11/04/09	HISTORICAL SOIL SAMPLING LOCATIONS SITE 12 - HARBOR DREDGE SPOIL AREA NS GREAT LAKES GREAT LAKES, ILLINOIS	CONTRACT NUMBER F27A
CHECKED BY B. CUMMINGS	DATE 4/2/10		OWNER NUMBER —
REVISED BY —	DATE —		APPROVED BY — DATE —
SCALE AS NOTED			FIGURE NO. FIGURE 10-3 / REV 0



DRAWN BY CK	DATE 3–22–10	SITE CONCEPTUAL MODEL SITE 12 – HARBOR DREDGE SPOIL AREA NS GREAT LAKES GREAT LAKES, ILLINOIS	CONTRACT NO. 2416
CHECKED BY	DATE		OWNER NO.
REVISED BY	DATE		APPROVED BY / DATE
SCALE NOT TO SCALE			DRAWING NO. FIGURE 10–4 / REV. 0

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P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\SITE12_PROP_SB_LOCS_REV.MXD 12/14/10 SS

Note:
Sample depths are 0 to 0.5 feet (surface) and 0.5 feet - bottom of fill (subsurface). All samples are to be analyzed for SVOCs, Metals, and Pesticides. Half of the subsurface samples (50% total) are to be analyzed for PCBs as well. PCB samples are to be subsurface materials which are oily or stained, or are dark in color.

DRAWN BY S. STROZ	DATE 02/10/10	PROPOSED SOIL SAMPLING LOCATIONS SITE 12 - HARBOR DREDGE SPOIL AREA NS GREAT LAKES GREAT LAKES, ILLINOIS	CONTRACT NUMBER F27A
CHECKED BY B. CUMMINGS	DATE 12/14/10		OWNER NUMBER —
REVISED BY —	DATE —		APPROVED BY — / DATE —
SCALE AS NOTED			FIGURE NO. FIGURE 17-1 / REV 0

APPENDIX A

HEALTH AND SAFETY PLAN

Health and Safety Plan
for
Field Investigation Activities
Site 12, Harbor Dredge Spoil Area

Naval Station Great Lakes
Great Lakes, Illinois

Naval Facilities Engineering Command
Midwest

Contract Number N62470-08-D-1001
Contract Task Order F27A

November 2009

HEALTH AND SAFETY PLAN

FOR

FIELD INVESTIGATION ACTIVITIES
SITE 12, HARBOR DREDGE SPOIL AREA
NAVAL STATION GREAT LAKES, ILLINOIS

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION-NAVY (CLEAN) CONTRACT

Submitted to:

Naval Facilities Engineering Command Midwest
201 Decatur Avenue, Building 1A
Great Lakes, Illinois 60088

Submitted by:

Tetra Tech NUS, Inc.
Foster Plaza 7
661 Anderson Road
Pittsburgh, Pennsylvania 15220

Contract Number N62470-08-D-1001
Contract Task Order F27A

November 2009

PREPARED UNDER THE SUPERVISION OF:

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1.0 INTRODUCTION

The objective of this Health and Safety Plan (HASP) is to provide the minimum safety practices and procedures to Tetra Tech NUS, Inc. (TtNUS) personnel conduct field activities at Site 12 at Naval Station Great Lakes, located in Great Lakes, Illinois.

This HASP has been prepared using the latest available information regarding known or suspected chemical contaminants and potential and foreseeable physical hazards associated with the planned work at Naval Station Great Lakes. This HASP has been designed to be used in accordance with the TtNUS Health and Safety Guidance Manual. The Guidance Manual provides detailed information pertaining to procedures to be performed on site as directed by the HASP, as well as TtNUS standard operating procedures.

This HASP supports proposed tasks and techniques associated with the scope of work (SOW) as presented in Section 4.0. Should the proposed work site conditions and/or suspected hazards change, or if new information becomes available, this document will be modified. Changes to the HASP will be made with the approval of the TtNUS CLEAN Health and Safety Manager (HSM) and the Project Manager (PM). The PM will notify affected personnel of changes.

The elements of this HASP are in compliance with the requirements established by OSHA 29 Code of Federal Regulations (CFR) 1910.120, "Hazardous Waste Operations and Emergency Response" (HAZWOPER). The information contained in this plan, as well as policies on conducting on site operations, has been obtained from the TtNUS Health and Safety Program and Naval Station Great Lakes policies and procedures.

1.1 AUTHORITY

This work is authorized under the Comprehensive Long - Term Environmental Action Navy (CLEAN) contract, administered through the U.S. Navy Naval Facilities Engineering Command Midwest, as defined under Contract Number N62470-08-D-1001; Contract Task Order F27A.

1.2 KEY PROJECT PERSONNEL AND ORGANIZATION

This section defines responsibilities for site safety and health for TtNUS and subcontractor employees conducting environmental sampling and other field activities. Personnel assigned to these positions shall exercise the primary responsibility for the on site health and safety. These persons will be the primary

point of contact for any questions regarding the safety and health procedures and the selected control measures.

- The TtNUS PM is responsible for the overall direction and implementation of health and safety for this work.

- The TtNUS Field Operations Leader (FOL) is responsible for implementation of this HASP. The FOL manages field activities, executes the work plan, and enforces safety procedures, as applicable to the work plan. Specifically, the FOL will:

  - Verify training and medical status of on-site personnel in relation to site activities.
  - Assist and represent TtNUS with emergency services (if needed)
  - Provide elements of site-specific training for on site personnel.

- The TtNUS Site Safety Officer (SSO) or their representative supports the FOL concerning the aspects of health and safety including, but not limited to:

  - Coordinating the health and safety activities
  - Selecting, applying, inspecting, and maintaining personal protective equipment (PPE)
  - Establishing work zones and control points
  - Implementing air monitoring procedures
  - Implementing hazard communication, respiratory protection, and other associated safety and health programs
  - Coordinating emergency services
  - Providing elements of site-specific training

- Compliance with these requirements is monitored by the Project Health and Safety Officer (PHSO) and is coordinated through the HSM.

ALL employees are empowered, authorized, and responsible to **STOP WORK** at any time when an imminent and uncontrolled safety or health hazard is perceived. In a Stop Work event (immediately after the involved task has been shut down and the work area has been secured in a safe manner) the employee shall contact the Project Manager and the Corporate Health and Safety Manager. Through observations and communication, all parties involved shall then develop, communicate, and implement corrective actions necessary and appropriate to modify the task and to resume work.

1.3 SITE INFORMATION AND PERSONNEL ASSIGNMENTS

Site Name: Naval Station Great Lakes Site 12 **Address:** Great Lakes, Illinois

Address: 201 Decatur Avenue

U.S. Navy Remedial Project Manager/Engineer-In-Charge/Site Point of Contact: Howard Hickey

Phone Number: (847) 688-2600 Ext. 243 and (847) 815-6719 (cell)

Purpose of Site Visit: TtNUS will conduct a remedial investigation and associated activities

Proposed Dates of Work: November 2009 through completion

Project Team:

Tetra Tech NUS Personnel:	Discipline/Tasks Assigned:
Robert Davis, P.E.	Project Manager (PM)
TBD	Field Operations Leader (FOL)
Chuck Metz	Technical Expert
Matthew M. Soltis, CIH, CSP	Health and Safety Manager (HSM)
Jennifer Carothers, PhD	Project Health and Safety Officer (PHSO)
TBD	Site Safety Officer (SSO)
TBD	Geologist

Subcontractor Personnel:	Discipline/Tasks Assigned:
TBD	Driller
TBD	Surveyor

Hazard Assessment (for purposes of 29 CFR 1910.132) for HASP preparation has been conducted by:

Prepared by: Jennifer Carothers, PhD

2.0 EMERGENCY ACTION PLAN

2.1 INTRODUCTION

This section has been developed as part of a planning effort to direct and guide field personnel in the event of an emergency. However, given the nature and scope of planned site activities, significant emergency situations are unlikely. In the event of an emergency, TtNUS personnel will provide emergency response support only to the capabilities of on site personnel. Emergency situations that are beyond the capabilities of on site TtNUS personnel will require assistance from outside emergency responders. In the event of emergencies that are beyond the capabilities of on site personnel, an evacuation will be initiated. In an evacuation, site personnel will move to a safe place of refuge and the appropriate emergency response agencies will be notified. The emergency response agencies listed in Table 2-1 of this plan are capable of providing the most effective response, and as such, will be designated as the primary responders. These agencies are located within a reasonable distance from the areas of site operations, which ensures adequate emergency response time. This emergency action plan conforms to the requirements of Occupational Safety and Health Administration (OSHA) Standard 29 CFR 1910.38(a), as allowed in OSHA 29 CFR 1910.120(l)(1)(ii).

TtNUS personnel will, through the necessary actions, provide incidental response measures for incidents such as:

- Incipient fire and spill prevention and response
- Removal of personnel from emergency situations
- Provision of initial medical support for injury/illnesses requiring only first-aid level support
- Provision of site control and security measures, as necessary

2.2 EMERGENCY PLANNING

Through the initial hazard/risk assessment effort, there is very minor potential for injury or illnesses resulting from exposure to chemical, physical, or other hazards, and subsequently little likelihood of emergency situations. To further minimize or eliminate potential emergency situations, pre-emergency planning activities associated with this project will be implemented. The FOL is responsible for:

- Coordinating response actions with Naval Station Great Lakes Emergency Services personnel to ensure that TtNUS emergency action activities are compatible with existing facility emergency response procedures.

- Identifying a chain of command for emergency action.

- Educating site workers to the hazards and control measures associated with planned activities at the site, and providing early recognition and prevention, where possible.

2.3 EMERGENCY RECOGNITION AND PREVENTION

2.3.1 Recognition

Foreseeable emergency situations that may be encountered during site activities will generally be recognizable by visual observation. Visual observation will be the principal method of identifying any hazards that may be associated with the proposed SOW. These potential hazards, the activities with which they have been associated, and the recommended control methods are discussed in detail in Sections 5.0 and 6.0 of this document.

2.3.2 Prevention

TtNUS personnel will minimize the potential for emergencies by ensuring compliance with the HASP, the Health and Safety Guidance Manual, applicable OSHA regulations, and by following directions given by those persons responsible for the health, safety, and welfare of site personnel.

2.4 SAFE DISTANCES AND PLACES OF REFUGE

In the event that the site must be evacuated, personnel will immediately stop activities and report to a pre-determined safe place of refuge. 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 and will be conveyed to personnel as part site-specific training and/or daily safety meetings. Upon reporting to the refuge location, personnel will remain there until directed otherwise by the TtNUS FOL or the On-Scene Incident Commander. The FOL will take a head count at this location to confirm the presence of site personnel. Emergency response agencies will be notified of any unaccounted for personnel.

2.5 EVACUATION ROUTES AND PROCEDURES

Once an evacuation is initiated, personnel will terminate site activities and proceed immediately to the designated place of refuge, unless doing so would further jeopardize the welfare of workers. In such an event, personnel will proceed to a designated alternate location and remain there until further notification

from the FOL. The use of these locations as assembly points provides communication and a direction point for emergency services, should they be needed.

2.5.1 Decontamination Procedures/Emergency Medical Treatment

During any site evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. Decontamination will be postponed if the incident warrants immediate evacuation.

TtNUS personnel will perform removal of personnel from emergency situations and may provide initial medical support for injury/illnesses requiring only first-aid level support. Medical attention above that level will require assistance and support from the designated emergency response agencies. Attachment I provides the procedure to follow when reporting an injury/illness, and the form to be used for this purpose. **If the emergency involves personnel exposures to chemicals, follow the steps provided in Figure 2-1.**

FIGURE 2-1
POTENTIAL EXPOSURE PROTOCOL

The purpose of this protocol is to provide guidance for the medical management of exposure situations. In the event of a personnel exposure to a hazardous substance or agent:

- Rescue, when necessary, employing proper equipment and methods.
- Give attention to emergency health problems -- breathing, cardiac function, bleeding, and shock.
- Transfer the victim to the medical facility designated in this HASP by suitable and appropriate conveyance (i.e. ambulance for serious events)
- Obtain as much exposure history as possible (a Potential Exposure Report is attached).
- If the exposed person is a TtNUS employee, call the medical facility and advise them that the patient(s) is/are being sent and that they can anticipate a call from the WorkCare physician. WorkCare will contact the medical facility and request specific testing which may be appropriate. The care of the victim will be monitored by WorkCare physicians. Site officers and personnel should not attempt to get this information, as this activity leads to confusion and misunderstanding.
- Call WorkCare at (800) 455-6155 (enter Ext. 109), or follow the voice prompt for after hours and weekend notification, and be prepared to provide:

  1) Any known information about the nature of the exposure.
  2) As much of the exposure history as was feasible to determine in the time allowed.
  3) Name and phone number of the medical facility to which the victim(s) has/have been taken.
  4) Name(s) of the exposed TtNUS, Inc. employee(s).
  5) Name and phone number of an informed site officer who will be responsible for further investigations.

- Fax appropriate information (e.g., Material Safety Data Sheets [MSDS]) to WorkCare at (714) 456-2154.
- Contact Corporate Health and Safety Department (Matt Soltis) and Human Resources Manager (Marilyn Duffy) at (412) 921-7090.

As environmental data is gathered and the exposure scenario becomes more clearly defined, this information should be forwarded to WorkCare.

WorkCare will compile the results of data and provide a summary report of the incident. A copy of this report will be placed in each victim's medical file in addition to being distributed to appropriately designated company officials.

Each involved worker will receive a letter describing the incident but deleting any personal or individual comments. This generalized summary will be accompanied by a personalized letter describing the individual's findings/results. A copy of the personal letter will be filed in the continuing medical file maintained by WorkCare.

FIGURE 2-1 (continued)

POTENTIAL EXPOSURE REPORT

Name: _____ Date of Exposure: _____

Social Security No.: _____ Age: _____ Sex: _____

Client Contact: _____ Phone No.: _____

Company Name: _____

I. Exposing Agent

Name of Product or Chemicals (if known):_____

_____

Characteristics (if the name is not known)

Solid Liquid Gas Fume Mist Vapor

II. Dose Determinants

What was individual doing?_____

How long did individual work in area before signs/symptoms developed? _____

Was protective gear being used? If yes, what was the PPE? _____

Was there skin contact?_____

Was the exposing agent inhaled?_____

Were other persons exposed? If yes, did they experience symptoms? _____

III. Signs and Symptoms (check off appropriate symptoms)

Immediately With Exposure:

Burning of eyes, nose, or throat
Tearing
Headache
Cough
Shortness of Breath
Chest Tightness / Pressure
Nausea / Vomiting
Dizziness
Weakness

Delayed Symptoms:

Weakness
Nausea / Vomiting
Shortness of Breath
Cough
Loss of Appetite
Abdominal Pain
Headache
Numbness / Tingling

IV. Present Status of Symptoms (check off appropriate symptoms)

Burning of eyes, nose, or throat
Tearing
Headache
Cough
Shortness of Breath
Chest Tightness / Pressure
Cyanosis
Nausea / Vomiting
Dizziness
Weakness
Loss of Appetite
Abdominal Pain
Numbness / Tingling

Have symptoms: (please check off appropriate response and give duration of symptoms)

Improved: _____ Worsened: _____ Remained Unchanged: _____

V. Treatment of Symptoms (check off appropriate response)

None: _____ Self-Medicated: _____ Physician Treated: _____

2.6 EMERGENCY ALERTING AND ACTION/RESPONSE PROCEDURES

Since TtNUS personnel will be working in close proximity to each other, voice commands will comprise the mechanisms to alert site personnel of an emergency. If an incident occurs, site personnel will initiate the following procedures:

- Initiate incident alerting procedures (if needed) verbally.
- Describe to the FOL (who will serve as the Incident Coordinator) what has occurred and provide as many details as possible.
- If the FOL determines that the situation is beyond the capabilities of the site personnel emergency services will be contact using the emergency reference information listed in Table 2-1. Explain the situation and the appropriate emergency services will be dispatched. **Stay on the phone and follow** the instructions of the emergency contact.

2.7 EMERGENCY CONTACTS

Prior to performing work at the site, personnel will be thoroughly briefed on the emergency procedures to be followed in the event of an accident. Table 2-1 provides a list of emergency contacts and their corresponding telephone numbers. This table will be made readily available to site personnel and copies will be placed in each of the site vehicles.

TABLE 2-1

EMERGENCY REFERENCE
NAVAL STATION GREAT LAKES

AGENCY	TELEPHONE
EMERGENCY	**9-1-1**
Police, Fire/Hazardous Materials Release, EMS	(847) 688-3333*
Base Contact, Mr. Howard Hickey	(847) 688-2600 x 243 (847) 815-6719
Hospital: North Chicago VA Medical Center	(847) 473-7830
Poison Control Center	(800) 222-1222
Project Manager, Biff Cummings	(412) 320-2220
CLEAN Health and Safety Manager, Matthew Soltis, CIH, CSP	(412) 921-8912
Project Health and Safety Officer, Jennifer Carothers, PhD	(412) 921-8083
Chemtrec	(800) 424-9300
National Response Center	(800) 424-8802
Tetra Tech NUS, Pittsburgh Office	(412) 921-7090

*** WHEN DIALING FROM A BASE TELEPHONE, USE THE LAST FOUR DIGITS ONLY**

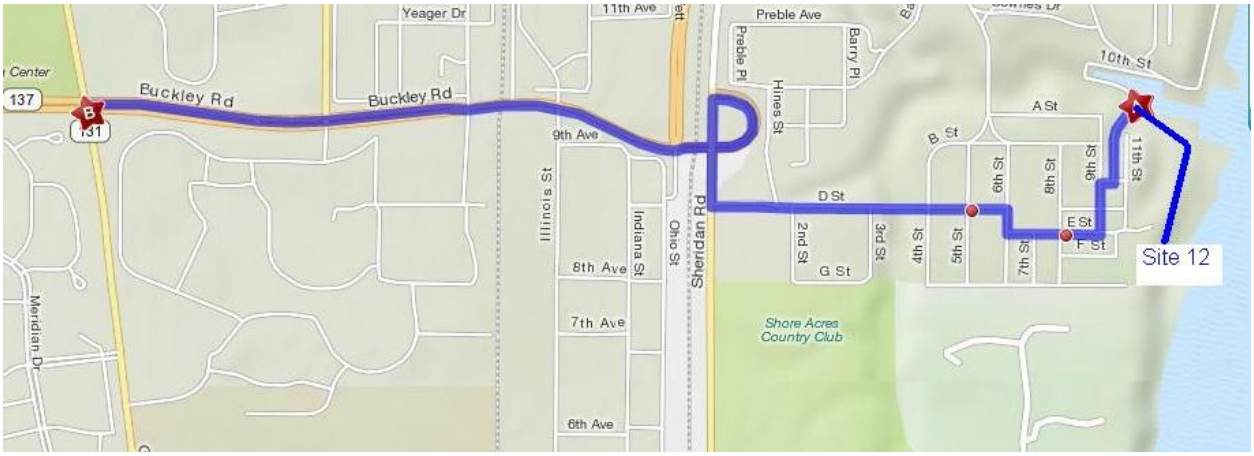
2.8 EMERGENCY ROUTE TO HOSPITAL

FIGURE 2-2
DIRECTIONS TO NORTH CHICAGO VA MEDICAL CENTER
FROM SITE 12

North Chicago VA Medical Center
3001 Green Bay Rd,
North Chicago, Illinois 60064
(847) 688-1900
http://www.northchicago.va.gov/
Total Travel Estimates: 7 minutes / 2.02 miles

A: Site 12

1: Start out going North to 10TH St 0.2 miles
2. Turn LEFT onto 10TH ST 0.2 miles
3. Turn RIGHT on E ST toward 6TH ST. 0.1 miles
4: Turn RIGHT onto 6TH ST 0.0 miles
5: Turn LEFT onto D ST. 0.4 miles
6: Turn RIGHT onto SHERIDAN RD 0.2 miles
7: Take the IL-137 ramp. 0.2 miles
8: Turn SLIGHT RIGHT onto IL-137 W/BUCKLEY RD/CR-20 W/DOWNEY RD. 0.8 miles
9: Turn LEFT onto IL-131/GREEN BAY RD 0.3 miles
10: 3001 GREEN BAY RD is on the LEFT. 0.0 miles
B: North Chicago VA Medical Center



2.9 INJURY AND ILLNESS REPORTING

Any pertinent information regarding allergies to medications or other special conditions will be provided to medical service personnel. This information is listed on Medical Data Sheets (see Attachment II) filed onsite. If an exposure to hazardous materials has occurred, provide hazard information from Table 6-1 to medical service personnel**.** As soon as possible, the Navy contact must be informed of any incident or accident that requires medical attention.

2.10 PPE AND EMERGENCY EQUIPMENT

First-aid kits, eye wash units (or bottles of disposable eyewash solution) and fire extinguishers will be maintained onsite and shall be immediately available for use in the event of an emergency. This equipment will be located in the field office or site vehicles. Personnel will only provide first-aid assistance to the level of their training.

3.0 SITE BACKGROUND

3.1 SITE DESCRIPTION

The Naval Station Great Lakes is located in Lake County, Illinois, on the shore of Lake Michigan about 50 miles north of downtown Chicago. Dedicated in 1911, Naval Station Great Lakes is the largest naval training center in the United States. Naval Station Great Lakes consists of approximately 1,650 acres with over 1,000 buildings.

3.2 SITE 12 (HARBOR DREDGE SPOIL AREA)

Site 12, the Harbor Dredge Spoil Area is approximately 4 acres located in a flat area on the shore of the Naval Training Center Outer Harbor. The Area is bounded by the lake on the east, beach to the north and south, and by an approximately 50-foot high bluff on the west. The area was used to deposit sediment from harbor dredging activities that occurred during in the 1950s and 1970s. In addition, the site has reportedly accepted demolition debris and other waste over the years. The area is currently grassed and is used for picnic and recreational purposes.

The Inner Harbor sediments are contaminated with heavy metals, PCB, and oils. The source of these contaminants was identified as the industries located upstream from the activity. Hazardous wastes generated by private industry upstream of the activity may have entered the harbor, and these wastes may pose a threat to the environment, even though there is no history of direct dumping in the harbor. Similarly, the sediments dredged from the harbor may contain concentrations of hazardous materials.

4.0 SCOPE OF WORK

This section discusses the specific tasks that are to be conducted as part of this SOW at Naval Station Great Lakes. These tasks are the only ones addressed by this HASP. Any tasks to be conducted outside of the elements listed here will be considered a change in scope requiring modification of this document. The PM or a designated representative will submit the requested modifications to this document to the HSM.

Specific tasks to be conducted include, but are not necessarily limited to, the following:

- Mobilization/demobilization
- Utility Clearance
- Monitoring well installation and soil and groundwater sampling via Direct Push Technology (DPT) and Hollow Stem Auger (HSA)
- Decontamination
- Investigation-derived waste management

For more detailed description of the associated tasks, refer to the Work Plan (WP).

5.0 IDENTIFYING AND COMMUNICATING TASK-SPECIFIC HAZARDS AND GENERAL SAFE WORK PRACTICES

The purpose of this section is to identify the anticipated hazards and appropriate hazard prevention/hazard control measures that are to be observed for each planned task or operation. These topics have been summarized for each planned task through the use of task-specific Safe Work Permits (SWPs) that are to be reviewed in the field by the SSO with task participants prior to initiating any task. Additionally, potential hazard and hazard control matters that are relevant but are not necessarily task-specific are addressed it the following portions of this section.

Section 6.0 presents additional information on hazard anticipation, recognition, and control relevant to the planned field activities.

5.1 GENERAL SITE SAFE WORK PRACTICES

In addition to the task-specific work practices and restrictions identified in the SWPs attached to this HASP, the following general safe work practices are to be followed when conducting work on-site.

- Eating, drinking, chewing gum or tobacco, taking medication, or smoking in contaminated or potentially contaminated areas or where the possibility for the transfer of contamination exists is prohibited.

- Wash hands and face thoroughly upon leaving a contaminated or suspected contaminated area. If a source of potable water is not available at the work site that can be used for hands-washing, the use of waterless hands cleaning products will be used, followed by actual hands-washing as soon as practicable upon exiting the site.

- Avoid contact with potentially contaminated substances including puddles, pools, mud, or other such areas. Avoid, kneeling on the ground or leaning or sitting on equipment. Keep monitoring equipment away from potentially contaminated surfaces.

- Plan and mark entrance, exit, and emergency evacuation routes.

- Rehearse unfamiliar operations prior to implementation.

- Buddies should maintain visual contact with each other and with other on-site team members by remaining in close proximity to assist each other in case of emergency.

- Establish appropriate safety zones including support, contamination reduction, and exclusion zones.
- Minimize the number of personnel and equipment in contaminated areas (such as the exclusion zone). Non-essential vehicles and equipment should remain within the support zone.
- Establish appropriate decontamination procedures for leaving the site.
- Immediately report all injuries, illnesses, and unsafe conditions, practices, and equipment to the SSO.
- Observe co-workers for signs of toxic exposure and heat or cold stress.
- Inform co-workers of potential symptoms of illness, such as headaches, dizziness, nausea, or blurred vision.

5.2 DPT/HSA SAFE WORK PRACTICES

The following Safe Work Practices are to be followed when working in or around the DPT/HSA Operations (HSGM, Section 7.0).

- Identify underground utilities and buried structures before commencing any DPT/HSA operations. Follow the TtNUS Utility Locating and Excavation Clearance Standard Operating Procedure.
- DPT/HSA rigs will be inspected by the SSO or designee, prior to the acceptance of the equipment at the site and prior to the use of the equipment. Repairs or deficiencies identified will be corrected prior to use. The inspection will be accomplished using the Equipment Inspection Checklist for DPT/HSA rigs provided in Attachment III. After the initial inspection and release for use on site, additional inspections will be performed at least at the beginning of every 5 or 10-day shift, or following any repairs or significant maintenance activities.
- Ensure that all machine guarding is in place and properly adjusted.
- Block the DPT/HSA rig and use levelers to prevent inadvertent movement.
- The work area around the point of operation will be cleared to the extent possible to remove any trip hazards near or surrounding operating equipment.

- The driller's helper will establish an equipment staging and laydown plan. The purpose of this is to keep the work area clear of clutter and slips, trips, and fall hazards. Mechanisms to secure heavy objects such as DPT/HSA flights will be provided to avoid the collapse of stacked equipment.

- Minimize contact to the extent possible with contaminated tooling and environmental media. Potentially contaminated tooling will be placed on polyethylene sheeting for storage and wrapped for transport to the centrally located equipment decontamination area

- Support functions (sampling and screening stations) will be maintained a minimum distance from the DPT/HSA rig of the height of the mast plus five feet, but not less than 25 feet around the rig.

- Only qualified operators and knowledgeable ground crew personnel will participate in the operation of the DPT/HSA rig.

- During maintenance, use only manufacturer provided/approved equipment (i.e. auger flight connectors, etc.)

- In order to minimize contact with potentially contaminated tooling and media and to minimize lifting hazards, multiple personnel should be used to move auger flights and other heavy tooling.

- Only personnel absolutely essential to the work activity will be allowed in the exclusion zone.

- Equipment used within the exclusion zone will undergo a complete decontamination and evaluation by the FOL and/or the SSO to determine cleanliness prior to moving to the next location, exiting the site, or prior to down time for maintenance.

- Motorized equipment will be fueled prior to the commencement of the day's activities.

- When not in use DPT/HSA rig will be shutdown, and emergency brakes set and wheels will be chocked to prevent movement.

Investigative areas will be restored to equal or better condition than original to remove any contamination brought to the surface and to remove any physical hazards. In situations where these hazards cannot be immediately removed, the area will be barricaded to limit access.

6.0 HAZARD ASSESSMENT

This section provides information regarding the chemical and physical hazards which may be associated with the Site and the activities that are to be conducted as part of the SOW. .

6.1 CHEMICAL HAZARDS

There has been limited data from previous site investigations conducted at Site 12, however based on an evaluation of the data and historical information, the primary site COCs from past history are, volatile organic compounds (VOCs), pesticides, and metals (primarily lead). Table 6-1 shows a comparison of the maximum concentrations of some of the primary COCs previously detected on the site, their worst-maximum concentrations previously detected, and to current Occupational Exposure Limits (OELs).

TABLE 6-1
COMPARISON OF COC CONCENTRATIONS
WITH CURRENT OCCUPATIONAL EXPOSURE LIMITS

Particulates			
Contaminant of Concern	Highest Concentration Previously Detected in Soil	Amount of Dust-in-Air that would have to be generated before PEL/TLV would be reached	Current OSHA PEL and ACGIH TLV
(Pesticides) DDT	0.830 mg/kg	301000 mg/m^3	ACGIH: 1 mg/m^3 OSHA: 1 mg/m^3
Lead	396.40 mg/kg	31.53 mg/m^3	OSHA & ACGIH:0.5 mg/m^3, TWA_8
Arsenic	20.85 mg/kg	119.90 mg/m^3	ACGIH: 0.01 mg/m^3 OSHA: 0.01 mg/m^3 ;TWA_8
VOCs			
Contaminant of Concern	Highest Concentration Previously Detected in Soil	Worst-Case-Scenario Air Concentration	Current OSHA PEL and ACGIH TLV
Acetone	169 ug/kg	24.48 ppm	ACGIH: 1 ppm OSHA: 1 ppm - TWA_8
Methylene Chloride	69 ug/kg	18.11 ppm	ACGIH: 50 ppm OSHA: 25 ppm - TWA_8; 125 ppm - STEL
Toluene	25 ug/kg	0.4 ppm	ACGIH: 20 ppm OSHA: 200 ppm - TWA_8 300 ppm - Ceiling; 500ppm - 10-min peak in 8 hour shift

Table Notes:

- TWA_8: Average air concentration over an 8-hour work period that is not to be exceeded
- TCE OSHA STEL: Concentration in air that is not to be exceed for more than 5 minutes in any 3 hour period
- ACGIH STEL: Concentration in air that is not be exceeded for more than 15 minutes more than 4 times per day

6.1.1 Volatile Organic Compounds (VOCs)

VOCs are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have adverse health effects. VOCs are emitted by a wide array of products numbering in the thousands. Examples include: paints and lacquers, paint strippers, cleaning supplies, pesticides, building materials and furnishings, office equipment such as copiers and printers, correction fluids and carbonless copy paper, graphics and craft materials including glues and adhesives, permanent markers, and photographic solutions.

Exposure to VOCs can cause irritation of the nose and throat and central nervous system (CNS) depression, with symptoms such as drowsiness, dizziness, giddiness, headache, loss of coordination. High concentrations can cause numbness and facial pain, reduced eyesight, unconsciousness, irregular heartbeat and death. Very high concentrations can cause death due to CNS effects, and, in rare cases, irregular heart beat. Permanent nervous system damage and/or liver injury have resulted from severe overexposure.

6.1.2 Pesticides

A pesticide is any substance or mixture of substance intended for preventing, destroying, repelling or mitigating any pest.

Symptoms of pesticide exposure include abdominal pain, dizziness, headaches, nausea, vomiting, as well as skin and eye problems.

6.1.3 Metals

There are 35 metals that concern us because of occupational or residential exposure; 23 of these are the heavy elements or "heavy metals": antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc.

Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. Long-term exposure may result in slowly progressing physical, muscular, and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy, and multiple sclerosis. Allergies are not uncommon and repeated long-term contact with some metals or their compounds may even cause cancer.

Lead, specifically, is a potential contaminant of concern at Site 12. Lead is a poisonous metal that can damage nervous connections and cause blood and brain disorders. Because of its low reactivity and solubility, lead poisoning usually only occurs in cases when the lead is dispersed, like when sanding lead based paint, or long term exposure in the case of pewter tableware. The effects of lead are the same whether it enters the body through breathing or swallowing. Lead can affect almost every organ and system in the body. The main target for lead toxicity is the nervous system, both in adults and children. Exposure to high lead concentrations can severely damage the brain and kidneys and ultimately cause death.

6.1.4 Inhalation

Based on an evaluation of the data concerning the metals previously detected on the site, the amount of dust-in-air that would have to be generated to reach current OELs is well within the spectrum visible to the naked eye (>2.0mg m^3). Therefore, the use of area wetting techniques to suppress dust generation is sufficient for this site to protect against the generation of metal-containing dust.

In addition, from a worst-case scenario, it is not thought that any of the VOCs concentrations immediately above a captured air phase above contaminated media (such as in the head space of a monitoring well) could reach concentrations that exceed permissible limits. In addition, it is important to recognize the following:

- the planned work area is outdoors, with ample natural ventilation that will reduce any airborne through dilution and dispersion

As a result of this, it is very unlikely that workers participating in this activity will encounter any airborne concentrations of VOCs that would represent an inhalation exposure concern. To monitor this route, real-time direct reading monitoring instruments will be used (as described in Section 7.0). This will performed during intrusive tasks, as these tasks are the most likely to involve encountering/releasing any VOCs and into the air phase.

6.1.5 Ingestion and Skin Contact

Potential exposure concerns to VOCs/pesticides/metals (lead) may also occur through ingesting or coming into direct skin contact with contaminated media. The likelihood of worker exposure concerns through these two routes are also considered very unlikely, provided that workers follow good personal hygiene and standard good sample collection/sample handling practices, and wear appropriate PPE as

specified in this HASP. Examples onsite practices that are to be observed that will protect workers from exposure via ingestion or skin contact include the following:

- No hand-to-mouth activities on site (eating, drinking, smoking, etc.)
- Washing hands upon leaving the work area and prior to performing any hand to mouth activities
- Wearing surgeon's-style gloves whenever handling potentially-contaminated media, including groundwater, bailing tools, and sample containers.

6.2 PHYSICAL HAZARDS

The following is a list of physical hazards that may be encountered at the site or may be present during the performance of site activities.

- Slip, trips, and falls
- Strain/muscle pulls from heavy lifting
- Heat/Cold Stress
- Pinch/compression points
- Natural hazards (snakes, ticks, poisonous plants, etc.)
- Vehicular and equipment traffic
- Inclement weather

These hazards are discussed further below, and are presented relative to each task in the task-specific SWPs.

6.2.1 Slips, Trips, and Falls

During various site activities there is a potential for slip, trip, and fall hazards associated with wet, steep, or unstable work surfaces. To minimize hazards of this nature, personnel required to work in and along areas prone to these types of hazards will be required to exercise caution, and use appropriate precautions (restrict access, guardrails, life lines and/or safety harnesses) and other means suitable for the task at hand. Site activities will be performed using the buddy system.

6.2.2 Strain/Muscle Pulls from Heavy Lifting

During execution of planned activities there is some potential for strains, sprains, and/or muscle pulls due to the physical demands and nature of this site work. To avoid injury during lifting tasks personnel are to lift with the force of the load carried by their legs and not their backs. When lifting or handling heavy

material or equipment use an appropriate number of personnel. Keep the work area free from ground clutter to avoid unnecessary twisting or sudden movements while handling loads.

6.2.3 Heat/Cold Stress

Because of the geographical location of the planned work, the likely seasonal weather conditions that will exist during the planned schedule, and the physical exertion that can be anticipated with some of the planned tasks, it will be necessary for the field team to be aware of the signs and symptoms and the measures appropriate to prevent heat/cold stress. This is addressed in detail in Section 4.0 of the TtNUS Health and Safety Guidance Manual, which the SSO is responsible for reviewing and implementing as appropriate on this project.

6.2.4 Pinch/Compression Points

Handling of tools, machinery, and other equipment on site may expose personnel to pinch/compression point hazards during normal work activities. Where applicable, equipment will have intact and functional guarding to prevent personnel contact with hazards. Personnel will exercise caution when working around pinch/compression points, using additional tools or devices (e.g., pinch bars) to assist in completing activities.

6.2.5 Vehicular and Equipment Traffic

Hazards associated with vehicular and equipment traffic are unlikely to exist during site activities. To minimize the potential for injuries associated with potential vehicular hazards, site personnel will be instructed to maintain awareness of traffic and moving equipment when performing site activities. When working near roadways, site personnel will wear high visibility vests.

6.3 NATURAL HAZARDS

Natural hazards such as poisonous plants, bites from poisonous or disease carrying animals or insects (e.g., snakes, ticks, mosquitoes) are often prevalent at sites that are being investigated as part of hazardous waste site operations. To minimize the potential for site personnel to encounter these hazards, nesting areas in and about work areas will be avoided to the greatest extent possible. Work areas will be inspected to look for any evidence that dangerous animals may be present.

During warm months (spring through early fall), tick-borne Lyme Disease may pose a potential health hazard. The longer a disease carrying tick remains attached to the body, the greater the potential for contracting the disease. Wearing long sleeved shirts and long pants (tucked into boots and taped) will prevent initial tick attachment, while performing frequent body checks will help prevent long term

attachment. Site first aid kits should be equipped with medical forceps and rubbing alcohol to assist in tick removal. For information regarding tick removal procedures and symptoms of exposure, consult Section 4.0 of the Health and Safety Guidance Manual.

West Nile Virus (WNV) and other mosquito-borne diseases may occur when an infected mosquito sucks blood from a person. About one in 150 people infected with WNV will develop severe illness. Severe symptoms can include high fever, headache, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, vision loss, numbness and paralysis. These symptoms may last several weeks, and neurological effects may be permanent. Up to 20 percent of the people who become infected have symptoms such as fever, headache, and body aches, nausea, vomiting, and sometimes swollen lymph glands or a skin rash on the chest, stomach and back. Symptoms can last for as short as a few days, though even healthy people have become sick for several weeks. Approximately 80 percent of people (about 4 out of 5) who are infected with WNV will not show any symptoms at all.

Although no longer common in the United States, malaria may occur when a mosquito or other infected insect sucks blood from an infected person, and the insect becomes the carrier to infect other hosts. The parasite reproduces within the mosquito, and is then passed on to another person through the biting action. Acute symptoms include chills accompanied by fever and general flu-like symptoms. This generally terminates in a sweating stage. These symptoms may recur every 48 to 72 hours.

Contact with poisonous plants and bites or stings from poisonous insects are other potential natural hazards. Long sleeved shirts and long pants (tucked into boots), and avoiding potential nesting areas, will minimize the potential for exposure. Additionally, insect repellents may be used by site personnel. Personnel who are allergic to stinging insects (such as bees, wasps and hornets) must be particularly careful since severe illness and death may result from allergic reactions. As with any medical condition or allergy, information regarding the condition must be listed on the Medical Data Sheet (see Attachment II of this HASP), and the FOL or SSO notified.

In general, avoidance of areas of known infestation or growth will be the preferred exposure control for insects/animals and poisonous plants. Specific discussion on principle hazards of concern follows:

6.3.1 Insect/Animal Bites and Stings

Various insects and animals may be present and should be considered. Areas to be investigated could be prime nesting and/or hiding locations for snakes and other insects. Personnel should avoid reaching into areas that are not visibly clear of snakes or insects. Snake chaps will be worn in areas of known or anticipated snake infestation. Site personnel who are allergic to stinging insects such as bees, wasps, and hornets must be particularly careful since severe illness and death may result from allergic reactions.

As with any medical condition or allergy, information regarding the condition must be listed on the Medical Data Sheet and the FOL and SSO notified.

6.3.2 Inclement Weather

Project tasks under this SOW will be performed outdoors. As a result, inclement weather may be encountered. In the event that adverse weather conditions arise (electrical storms, hurricanes, etc.), the FOL and/or the SSO will be responsible for temporarily suspending or terminating activities until hazardous conditions no longer exist.

7.0 HAZARD MONITORING – TYPES AND ACTION LEVELS

The primary COCs are not expected to be present in concentrations that could present an inhalation hazard according to previous data. However, since there is limited prior data and there has not been a complete characterization of the site, a direct reading instrument will be used to monitor worker exposures to possible chemical hazard. Either a Photoionization Detector (PID) with a lamp energy of 10.6 eV or a Flame Ionization Detector (FID) may be used to monitor the air when conducting intrusive activities.

In addition, workers will monitor for visible dust, and area wetting techniques will be used to suppress dust generation, if necessary.

7.1 INSTRUMENTS AND USE

Instruments will be used primarily to monitor source points and worker breathing zone areas, while observing instrument action levels. The SSO shall obtain and document the daily background (BG) reading at an upwind, unaffected area and observe for readings above that BG level. The SSO shall monitor source areas (e.g., monitoring wells) for the presence of any reading above the daily-established BG level. If elevated readings are observed, the SSO shall monitor the workers breathing zone (BZ) areas with the PID/FID. If the appropriate instrument Action Level is exceeded (see below), the following process will be followed:

- The SSO shall order all personnel to stop work and retreat upwind to a safe, unaffected area, where they will remain until further directed by the SSO.
- The SSO shall allow at least 5 minutes to pass so that the work area can ventilate, and will then re-approach the work area while continuously monitoring the BZ areas.
- Only when BG levels are regained in BZ areas will work be permitted to resume.
- If BG levels are not regained, the SSO will contact the HSM for additional direction.

Instrument Action Levels: The use of either a PID or a FID will be acceptable with any reading above 10 PPM in BZ areas for no more than three exposures of 5 minutes

7.2 INSTRUMENT MAINTENANCE AND CALIBRATION

Hazard monitoring instruments will be maintained and pre-field calibrated by the equipment provider (i.e., rental agency used). Operational checks and field calibration will be performed on site instruments each day prior to their use. Field calibration will be performed on instruments according to manufacturer's recommendations. These operational checks and calibration efforts will be performed in a manner that complies with the employees health and safety training, the manufacturer's recommendations, and with the applicable manufacturer standard operating procedure (which the SSO must assure are included with the instrument upon its receipt onsite). Field calibration efforts must be documented. Figure 7-1 is provided for documenting these calibration efforts. This information may instead be recorded in a field operations logbook, provided that the information specified in Figure 7-1 is recorded. This required information includes the following:

- Date calibration was performed
- Individual calibrating the instrument
- Instrument name, model, and serial number
- Any relevant instrument settings and resultant readings (before and after) calibration
- Identification of the calibration standard (lot no., source concentration, supplier)
- Any relevant comments or remarks

7.3 DOCUMENTING INSTRUMENT READINGS

The SSO is responsible for ensuring that air monitoring instruments are used in accordance with the specifications of this HASP and with manufacturer's specifications/recommendations. In addition, the SSO is also responsible for ensuring that all instrument use is documented. This requirement can be satisfied either by recording instrument readings on pre-printed sampling log sheets or in a field log book. **This includes the requirement for documenting instrument readings that indicate no elevated readings above noted daily background levels (i.e., no-exposure readings)**. At a minimum, the SSO must document the following information for each use of an air monitoring device:

- Date, time, and duration of the reading
- Site location where the reading was obtained
- Instrument used (e.g., FID, PID, etc.)
- Personnel present at the area where the reading was noted
- Other conditions that are considered relevant to the SSO (such as weather conditions, possible instrument interferences, etc.)

FIGURE 7-1
DOCUMENTATION OF FIELD CALIBRATION

SITE NAME: _____ **PROJECT NO.:**_____

Date of Calibration	Instrument Name and Model	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot Number)	Remarks/ Comments
				Pre-Calibration	Post-Calibration	Pre-Calibration	Post-Calibration		

8.0 TRAINING/MEDICAL SURVEILLANCE REQUIREMENTS

8.1 INTRODUCTORY/REFRESHER/SUPERVISORY TRAINING

TtNUS and subcontractor personnel who will engage in field associated activities as described in this HASP must have:

- Completed 40 hours of introductory hazardous waste site training or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120(e).
- Completed 8-Hour Refresher Training, if the identified persons had introductory training more than 12 months prior to site work.
- Completed 8-hour Supervisory training in accordance with 29 CFR 1910.120(e)(4), if their assigned function will involve the supervision of subordinate personnel.

Documentation of introductory training or equivalent work experience, supervisory, and refresher training as well as site-specific training will be maintained at the site. Copies of certificates or other official documentation will be used to fulfill this requirement.

8.2 SITE-SPECIFIC TRAINING

TtNUS will provide site-specific training to TtNUS employees and subcontractor personnel who will perform work on this project.

Figure 8-1 will be used to document the provision and content of the project-specific and associated training. Site personnel will be required to sign this form prior to commencement of site activities.

TtNUS will conduct a pre-activities training session prior to initiating site work. Additionally, a brief meeting will be held daily to discuss operations planned for that day. At the end of the workday, a short meeting may be held to discuss the operations completed and any problems encountered. This activity will be supported through the use of a Safe Work Permit System (See Section 10.4).

8.3 MEDICAL SURVEILLANCE

TtNUS and subcontractor personnel participating in project field activities will have had a physical examination. Physical examinations shall meet the minimum requirements of paragraph (f) of OSHA 29 CFR 1910.120. The physical examinations will be performed to ensure that personnel are medically qualified to perform hazardous waste site work using respiratory protection.

Documentation for medical clearances will be maintained at the job site and made available, as necessary. Subcontractor personnel may use an alternative documentation for this purpose. The "Subcontractor Medical Approval Form" can be used to satisfy this requirement, or a letter from an officer of the company. The letter should state that the persons listed in the letter participate in a medical surveillance program meeting the requirements contained in paragraph (f) of Title 29 of CFR Part 1910.120, entitled "Hazardous Waste Operations and Emergency Response." The letter should further state the following:

- The persons listed have had physical examinations under this program within the frequency as determined sufficient by their occupational health care provider
- Date of the exam
- The persons identified have been cleared, by a licensed physician, to perform hazardous waste site work and to wear positive- and negative- pressure respiratory protection.

A sample Subcontractor Medical Approval Form and form letter have been provided to eligible subcontractors in the Bid Specification package.

8.3.1 Medical Data Sheets

Each field team member, including subcontractors and visitors, entering the exclusion zone(s) shall be required to complete and submit a copy of the Medical Data Sheet that is available in Attachment II of this HASP. This shall be provided to the SSO, prior to participating in site activities. The purpose of this document is to provide site personnel and emergency responders with additional information that may be necessary in order to administer medical attention.

8.4 SUBCONTRACTOR EXCEPTION

If through the execution of their contract elements the subcontractor will not enter the exclusion zone and there is no potential for exposure to site contaminants, subcontractor personnel may be exempt from the training and medical surveillance requirements with the exception of Section 8.2. Examples of subcontractors who may qualify as exempt from training and medical surveillance requirements may include surveyors who perform surveying activities in site perimeter areas or areas were there is no potential for exposure to site contaminants and support or restoration services. Use of this Subcontractor Exception is strictly limited to the authority of the CLEAN HSM.

FIGURE 8-1
SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of performing field investigation activities at Naval Station Great Lakes, Illinois, and that I have received site-specific training that included the elements presented below:

- Names of designated personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present on site
- Use of personal protective equipment
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- Contents of the Health and Safety Plan
- Emergency response procedures (evacuation and assembly points)
- Incipient response procedures
- Review of the contents of relevant Material Safety Data Sheets
- Review of the use of Safe Work Permits
- Stop Work Authorization and Process

I have been given the opportunity to ask questions and that my questions have been answered to my satisfaction. The dates of my training and medical surveillance requirements indicated below are accurate.

Name (Printed and Signature)	Site-Specific Training Date	40-Hour Training (Date)	8-Hour Refresher Training (Date)	8-Hour Supervisory Training (Date)	Medical Exam

9.0 SPILL PREVENTION AND CONTAINMENT PROGRAM

9.1 SCOPE AND APPLICATION

It is anticipated that quantities of bulk potentially hazardous materials (greater than 55-gallons) will not be handled during the site activities. It is possible, however, that as the job progresses disposable PPE and other non-reusable items may be generated. As needed, 55-gallon drums will be used to contain unwanted items generated during sampling activities. The drum(s) will be labeled with the site name and address, the type of contents, and the date the container was filled as well as an identified contact person. As warranted, samples will be collected and analyzed to characterize the material and determine appropriate disposal measures. Once characterized the drum(s) will be removed from the staging area and disposed of in accordance with Federal, State and local regulations. Given the likely solid nature of drum contents, a comprehensive Spill Containment Program is not necessary. The following discussion is provided as contingency information only.

9.2 POTENTIAL SPILL AREAS

Potential spill areas will be periodically monitored in an ongoing attempt to prevent and control further potential contamination of the environment. Currently, limited areas are vulnerable to this hazard including:

- Resource deployment
- Waste transfer
- Central staging

It is anticipated that the IDW generated as a result of this SOW will be containerized, labeled, and staged to await further analyses. The results of these analyses will determine the method of disposal.

9.3 LEAK AND SPILL DETECTION

To establish an early detection of potential spills or leaks, periodic inspections by the SSO will be conducted during working hours to visually determine that containers are not leaking. If a leak is detected, the first approach will be to transfer the container contents using a hand pump into a new container. Other provisions for the transfer of container contents will be made and appropriate emergency contacts will be notified, if necessary. In most instances, leaks will be collected and contained using absorbents such as Oil-dry, vermiculite, and/or sand, which may be stored at the staging area in a conspicuously marked drum. This material too, will be containerized for disposal pending analyses. Inspections will be documented in the Project Logbook.

9.4 PERSONNEL TRAINING AND SPILL PREVENTION

Site personnel will be instructed on the procedures for spill prevention, containment, and collection of hazardous materials in the site-specific training. The FOL and/or the SSO will serve as the Spill Response Coordinator for this operation should the need arise.

9.5 SPILL PREVENTION AND CONTAINMENT EQUIPMENT

The following represents the types of equipment that may be maintained at the staging area for the purpose of supporting this Spill Containment Program (depending on the likelihood that drums and/or liquid wastes are generated):

- Sand, clean fill, vermiculite, or other noncombustible absorbent (oil-dry);
- Drums (55-gallon U.S. Department of Transportation [DOT] 1A1 or 1A2)
- Shovels, rakes, and brooms
- Labels

9.6 SPILL CONTROL PLAN

This section describes the procedures the TtNUS field crewmembers will employ upon the detection of a spill or leak.

- Notify the SSO or FOL immediately.

- Take immediate actions to stop the leak or spill by plugging or patching the drum or raising the leak to the highest point. Avoid contacting drum contents. Spread the absorbent material in the area of the spill covering completely.

It is not anticipated that a spill will occur in which the field crews cannot handle. Should this occur; however, the FOL or SSO will notify appropriate emergency response agencies.

10.0 SITE OPERATIONS AND CONTROL

This section outlines how TtNUS will delineate work zones and use these work zones to prevent the spread of contaminants. A three-zone approach will be used during work at this site. This three zone approach will utilize an exclusion zone, a contamination reduction zone, and a support zone. It is also anticipated that this control measure will be used to control access to site work areas. Use of such controls will restrict the general public, minimize the potential for the spread of contaminants, and protect individuals who are not cleared to enter work areas.

10.1 EXCLUSION ZONE

The exclusion zone will be considered the areas of the site of known or suspected contamination. It is anticipated that the areas around intrusive field activities will have the potential for contaminants to be brought to the surface. These areas will be marked and personnel will maintain safe distances. Once intrusive field activities have been completed and any surface contamination has been removed, the potential for exposure is again diminished and the area can then be reclassified as part of the contamination reduction zone. Therefore, the exclusion zones for this project will be limited to those areas of the site where intrusive field activities are being performed plus a designated area of at least the height of the mast plus 25 feet. Exclusion zones will be delineated as deemed appropriate by the FOL, through means such as erecting visibility fencing, barrier tape, cones, and/or postings to inform and direct personnel.

A pre-startup site visit will be conducted by members of the identified field team in an effort to identify proposed subsurface investigation locations, conduct utility clearances, and provide upfront notices concerning scheduled activities within the facility.

Subsurface activities will proceed only when utility clearance has been obtained. In the event that a utility is struck during a subsurface investigative activity, the emergency numbers provided in Section 2.0, Table 2-1, will be notified.

10.2 CONTAMINATION REDUCTION ZONE

The contamination reduction zone (CRZ) will be a buffer area between the exclusion zone and any area of the site where contamination is not suspected. This area will also serve as a focal point in supporting exclusion zone activities. This area will be delineated using barrier tape, cones, and postings to inform and direct facility personnel. Decontamination will be conducted at a central location. Equipment potentially contaminated will be bagged and taken to that location for decontamination.

10.3 SUPPORT ZONE

The support zone for this project will include a staging area where site vehicles will be parked, equipment will be unloaded, and where food and drink containers will be maintained. The support zones will be established at areas of the site where exposure to site contaminants would not be expected during normal working conditions or foreseeable emergencies.

10.4 SAFE WORK PERMITS

Work conducted in support of this project will be performed using SWPs to guide and direct field crews on a task by task basis. An example of the SWP to be used is provided in Figure 10-1. Partially completed SWPs for the work to be performed are attached (Attachment IV) to this HASP. These permits were completed to the extent possible as part of the development of this HASP. It is the SSO's responsibility to finalize and complete all blank portions of the SWPs based on current, existing conditions the day the task is to be performed, and then review that completed permit with all task participants as part of a pre-task tail gate briefing session. This will ensure that site-specific considerations and changing conditions are appropriately incorporated into the SWP, provide the SSO with a structured format for conducting the tail gate sessions, as well will also give personnel an opportunity to ask questions and make suggestions. All SWPs require the signature of the FOL or SSO.

Personnel identified on the permit as participating in the task will be made aware of its contents by the supervisor accepting the permit. Any problems which occurred throughout the task will be documented by the supervisor on the permit.

Permits will be returned to the FOL or the SSO at the end of the day.

FIGURE 10-1

SAFE WORK PERMIT

Permit No. _____ Date: _____ Time: From _____ to _____

I. Work limited to the following (description, area, equipment used): _____

II. Primary Hazards: _____

III. Field Crew: _____

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____TtNUS
Equipment Inspection required ☐ Yes ☐ No Initials of Inspector _____TtNUS

V. Protective equipment required
Level D ☐ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ Specify on the reverse
No ☐

Modifications/Exceptions: _____

VI.

Chemicals of Concern	Hazard Monitoring	Action Level(s)	Response Measures

Primary Route(s) of Exposure/Hazard: _____

(Note to FOL and/or SSO: Each item in Sections VII, VIII, and IX must be checked Yes, No, or NA)

VII. Additional Safety Equipment/Procedures

Hard-hat	☐ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☐ Yes	☐ No
Safety Glasses	☐ Yes	☐ No	Safety belt/harness	☐ Yes	☐ No
Chemical/splash goggles	☐ Yes	☐ No	Radio/Cellular Phone	☐ Yes	☐ No
Splash Shield	☐ Yes	☐ No	Barricades	☐ Yes	☐ No
Splash suits/coveralls	☐ Yes	☐ No	Gloves (Type – Work)	☐ Yes	☐ No
Impermeable apron	☐ Yes	☐ No	Work/rest regimen	☐ Yes	☐ No
Steel toe work shoes or boots	☐Yes	☐ No	Chemical Resistant Boot Covers	☐ Yes	☐ No
High Visibility vest	☐Yes	☐ No	Tape up/use insect repellent	☐ Yes	☐ No
First Aid Kit	☐Yes	☐ No	Fire Extinguisher	☐ Yes	☐ No
Safety Shower/Eyewash	☐Yes	☐ No	Other	☐ Yes	☐ No

Modifications/Exceptions: _____

VIII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Vehicle and Foot Traffic Routes Established/Traffic Control Barricades/Signs in Place	☐	☐	☐
Physical Hazards Identified and Isolated (Splash and containment barriers)	☐	☐	☐
Emergency Equipment Staged (Spill control, fire extinguishers, first aid kits, etc).	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☐ No
If yes, SSO to complete or contact Health Sciences, Pittsburgh Office (412)921-7090

X. Special instructions, precautions: _____

Permit Issued by: _____ Permit Accepted by: _____

10.5 SITE VISITORS

Potential site visitors that may be encountered during the performance of the field work could include the following:

- Personnel invited to observe or participate in operations by TtNUS.
- Regulatory personnel (i.e., Department of Defense [DOD], Illinois Environmental Protection Agency [IL EPA], U.S. EPA, OSHA, etc.)
- Navy personnel
- Other authorized visitors

Non-DOD personnel working on this project are required to gain initial access to the base by coordinating with the TtNUS PM or designee and following established base access procedures.

Once access to the base is obtained, personnel who require access to TtNUS work sites (areas of ongoing operations) will be required to obtain permission from the FOL and the Base Contact. Upon gaining access to the work site, site visitors wishing to observe operations in progress will be required to meet the minimum requirements as stipulated below.

- Site visitors will be routed to the FOL, who will sign them into the field logbook. Information to be recorded in the logbook will include the individuals name (proper identification required), who they represent, and the purpose for the visit. The FOL is responsible for ensuring that site visitors are always escorted while on site.

- Site visitors will be required to produce the necessary information supporting clearance on to the site. This includes information attesting to applicable training (40-hours of HAZWOPER training required for Navy Personnel), and medical surveillance as stipulated in Section 8.3, of this document. In addition, to enter the sites operational zones during planned activities, visitors will be required to first go through site-specific training covering the topics stipulated in Section 8.2 of this HASP.

Once the site visitors have completed the above items they will be permitted to enter the site and applicable operational areas. Visitors are required to observe the protective equipment and site restrictions in effect at the work areas visited. Any visitors not meeting the requirements as stipulated in this plan for site clearance will not be permitted to enter the site operational zones during planned activities. Any incidence of unauthorized site visitation will cause on-site activities to be terminated until that visitor can be removed. Removal of unauthorized visitors will be accomplished with support form the Base Contact, if necessary. At a minimum, the Base Contact will be notified of any unauthorized visitors.

10.6 SITE SECURITY

Site security will be accomplished using TtNUS field personnel. Security at this site will take place at the work site. Visitors and other parties will be referred to the FOL and Base Contact.

Security at the work areas will be accomplished using field personnel. This is a multiple person operation, involving multiple operational zones. TtNUS personnel will retain complete control over active operational zones. The Base Contact will serve as the focal point for base personnel and interested parties and will serve as the primary enforcement contact.

10.7 BUDDY SYSTEM

Personnel engaged in site activities will practice the "buddy system" to ensure the safety of the personnel involved in this operation.

10.8 MATERIAL SAFETY DATA SHEET (MSDS) REQUIREMENTS

TtNUS and subcontractor personnel will provide MSDSs for the chemicals brought on site. The contents of these documents will be reviewed by the SSO with the user(s) of the chemical substances prior to any actual use or application of the substances on site. A chemical inventory of the chemicals used on site will be developed using the Health and Safety Guidance Manual. The MSDSs will then be maintained in a central location (i.e., temporary office) and will be available for anyone to review upon request.

10.9 COMMUNICATION

As personnel will be working in proximity to one another during field activities, a supported means of communication between field crew members will not be necessary.

External communication will be accomplished by using the telephones at predetermined and approved locations. External communication will primarily be used for the purpose of resource and emergency resource communications. Prior to the commencement of activities at the Naval Station Great Lakes, the FOL will determine and arrange for telephone communications.

11.0 CONFINED SPACE ENTRY

It is not anticipated, under the proposed SOW, that confined space and permit-required confined space activities will be conducted. **Therefore, personnel under the provisions of this HASP are not allowed, under any circumstances, to enter confined spaces**. A confined space is defined as an area which has the following characteristics:

- Is large enough and so configured that an employee can bodily enter and perform assigned work.
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry).
- Is not designed for continuous employee occupancy.

A Permit-Required Confined Space is one that:

- Contains or has a potential to contain a hazardous atmosphere.
- Contains a material that has the potential to engulf an entrant.
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section.
- Contains any other recognized, serious, safety or health hazard.

For further information on confined space, consult the Health and Safety Guidance Manual or call the PHSO. If confined space operations are to be performed as part of the scope of work, detailed procedures and training requirements will have to be addressed, and the HSM will have to be notified.

12.0 MATERIALS AND DOCUMENTATION

The TtNUS Field Operations Leader (FOL) shall ensure the following materials/documents are taken to the project site and used when required.

- A complete copy of this HASP
- Health and Safety Guidance Manual
- Incident Reports
- Medical Data Sheets
- Material Safety Data Sheets for chemicals brought on site, including decontamination solutions, fuels, sample preservatives, calibration gases, etc.
- A full-size OSHA Job Safety and Health Poster (posted in the site trailer)
- Training/Medical Surveillance Documentation Form (Blank)
- First-Aid Supply Usage Form
- Emergency Reference Form (Section 2.0, extra copy for posting)
- Directions to the Hospital

12.1 MATERIALS TO BE POSTED OR MAINTAINED AT THE SITE

The following documentation is to be posted or maintained at the site for quick reference purposes. In situations where posting these documents is not feasible, (such as no office trailer), these documents should be separated and immediately accessible.

Chemical Inventory Listing (posted) - This list represents the chemicals brought on-site, including decontamination solutions, sample preservations, fuel, etc.. This list should be posted in a central area.

Material Safety Data Sheets (MSDS) (maintained) - The MSDSs should also be in a central area accessible to the site personnel. These documents should match the listings on the chemical inventory list for the substances employed on-site. It is acceptable to have these documents within a central folder and the chemical inventory as the table of contents.

The OSHA Job Safety & Health Protection Poster (posted) - this poster, as directed by 29 CFR 1903.2 (a)(1), should be conspicuously posted in places where notices to employees are normally posted. Each FOL shall ensure that this poster is not defaces, altered, or covered by other material.

Site Clearance (maintained) - This list is found within the training section of the HASP (See Figure 8-2). It identifies site personnel, dates of training (including site-specific training), and medical surveillance. It

also indicates clearance as well as status. If personnel do not meet these requirements, they do not enter the site while site personnel are engaged in activities.

Emergency Phone Numbers and Directions to the Hospital(s) (posted) - This list of numbers and directions will be maintained at the phone communications points and in each site vehicle.

Medical Data Sheets/Cards (maintained) - Medical Data Sheets will be filled out by on-site personnel and filed in a central location. The Medical Data Sheet will accompany any injury or illness requiring medical attention to the medical facility.

Hearing Conservation Standard (29 CFR 1910.95) (posted) - this standard will be posted anytime hearing protection or other noise abatement procedures are employed.

Personnel Monitoring (maintained) - The results generated through personnel sampling (levels of airborne toxins, noise levels, etc.) will be posted to inform individuals of the results of that effort.

Placards and Labels (maintained) - Where chemical inventories have been separated because of quantities and incompatibilities, these areas will be conspicuously marked using DOT placards and acceptable (Hazard Communication 29 CFR 1910.1200(f)) labels.

The purpose of maintaining or posting this information, as stated above, is to allow site personnel quick access. Variations concerning location and methods of presentation are acceptable, providing the objection is accomplished.

13.0 ACRONYMS / ABBREVIATIONS

BG	Background
BZ	Breathing Zone
C	Centigrade
CFR	Code of Federal Regulations
CIH	Certified Industrial Hygienist
CLEAN	Comprehensive Long Term Environmental Action Navy
COC	Contaminant of Concern
CRZ	Contamination Reduction Zone
CSP	Certified Safety Professional
dBA	Decibel
DOD	Department of Defense
DOT	Department of Transportation
DPT	Direct Push Technology
DRI	Direct Reading Instrument
EPA	Environmental Protection Agency
eV	Electron Volts
FID	Flame Ionization Detector
FOL	Field Operations Leader
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HI	Hazard Index
HSA	Hollow-stem Auger
HSM	Health and Safety Manager
IAS	Initial Assessment Study
IDW	Investigation Derived Waste
IL EPA	Illinois Environmental Protection Agency
LEL/LFL	Lower Explosive Limits / Lower Flammable Limits
mg/kg	milligrams per kilogram
MSDS	Material Safety Data Sheet
NIOSH	National Institute for Occupational Safety and Health
OOD	Officer of the Day
OSHA	Occupational Safety and Health Administration (U.S. Department of Labor)
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated biphenyls
PID	Photo Ionization Detector

PHSO	Project Health and Safety Officer
PM	Project Manager
PPE	Personal Protective Equipment
RI	Remedial Investigation
SOW	Scope of Work
SSO	Site Safety Officer
SVOCs	Semi-volatile Organic Compounds
SWP	Safe Work Permit
TBD	To be determined
TCL	Target Compound List
TtNUS	Tetra Tech NUS
US EPA	United States Environmental Protection Agency
WP	Work Plan

ATTACHMENT I

INCIDENT REPORT FORM

TETRA TECH, INC.
Safety Excellence

TETRA TECH, INC.
INCIDENT REPORT

Report Date	Report Prepared By	Incident Report Number

INSTRUCTIONS:

All incidents (including those involving subcontractors under direct supervision of Tetra Tech personnel) must be documented on the IR Form.

Complete any additional parts to this form as indicated below for the type of incident selected.

TYPE OF INCIDENT (Check all that apply)	Additional Form(s) Required for this type of incident	
Near Miss (No losses, but could have resulted in injury, illness, or damage)	☐	Complete IR Form Only
Injury or Illness	☐	Complete Form IR-A; Injury or Illness
Property or Equipment Damage, Fire, Spill or Release	☐	Complete Form IR-B; Damage, Fire, Spill or Release
Motor Vehicle	☐	Complete Form IR-C; Motor Vehicle

INFORMATION ABOUT THE INCIDENT

Description of Incident

_____

_____

_____

Date of Incident	Time of Incident
	_____ AM ☐ PM ☐ *OR* Cannot be determined ☐
Weather conditions at the time of the incident	**Was there adequate lighting?**
	_____ Yes ☐ No ☐

Location of Incident

_____ Was location of incident within the employer's work environment? Yes ☐ No ☐

Street Address	City, State, Zip Code and Country
Project Name	**Client:**
Tt Supervisor or Project Manager	**Was supervisor on the scene?**
	Yes ☐ No ☐

WITNESS INFORMATION (attach additional sheets if necessary)

Name	Company
Street Address	**City, State and Zip Code**

Telephone Number(s)

CORRECTIVE ACTIONS

Corrective action(s) immediately taken by unit reporting the incident:

_____

_____

_____

Corrective action(s) still to be taken (by whom and when):

_____

_____

_____

ROOT CAUSE ANALYSIS LEVEL REQUIRED

Root Cause Analysis Level Required: Level - 1 ☐ Level - 2 ☐ None ☐

Root Cause Analysis Level Definitions

Level - 1	**Definition:** A Level 1 RCA is conducted by an individual(s) with experience or training in root cause analysis techniques and will conduct or direct documentation reviews, site investigation, witness and affected employee interviews, and identify corrective actions. Activating a Level 1 RCA and identifying RCA team members will be at the discretion of the Corporate Administration office. The following events may trigger a Level 1 RCA: ▪ Work related fatality ▪ Hospitalization of one or more employee where injuries result in total or partial permanent disability ▪ Property damage in excess of $75,000 ▪ When requested by senior management
Level - 2	**Definition:** A Level 2 RCA is self performed within the operating unit by supervisory personnel with assistance of the operating unit HSR. Level 2 RCA will utilize the 5 Why RCA methodology and document the findings on the tools provided. The following events will require a Level 2 RCA: ▪ OSHA recordable lost time incident ▪ Near miss incident that could have triggered a Level 1 RCA ▪ When requested by senior management

Complete the Root Cause Analysis Worksheet and Corrective Action form. Identify a corrective action(s) for each root cause identified within each area of inquiry.

NOTIFICATIONS

Title	Printed Name	Signature	Telephone Number	Date
Project Manager or Supervisor				
Site Safety Coordinator or Office H&S Representative				
Operating Unit H&S Representative				
Other: _____				

The signatures provided above indicate that appropriate personnel have been notified of the incident.

_____

INSTRUCTIONS:

Complete all sections below for incidents involving injury or illness.
Do NOT leave any blanks.
Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)	

EMPLOYEE INFORMATION

Company Affiliation

Tetra Tech Employee? ☐ TetraTech subcontractor employee (directly supervised by Tt personnel)? ☐

Full Name	**Company (if not Tt employee)**
Street Address, City, State and Zip Code	**Address Type**
_____	Home address (for Tt employees) ☐
_____	Business address (for subcontractors) ☐

Telephone Numbers

Work: _____	Home: _____	Cell: _____

Occupation (regular job title)	**Department**
Was the individual performing regular job duties?	**Time individual began work**
Yes ☐ No ☐	_____ AM ☐ PM ☐ *OR* Cannot be determined ☐

Safety equipment

Provided? Yes ☐ No ☐

Used? Yes ☐ No ☐ If no, explain why

_____

_____

_____

Type(s) provided:
- ☐ Hard hat
- ☐ Protective clothing
- ☐ Gloves
- ☐ High visibility vest
- ☐ Eye protection
- ☐ Fall protection
- ☐ Safety shoes
- ☐ Machine guarding
- ☐ Respirator
- ☐ Other (list)

_____

NOTIFICATIONS

Name of Tt employee to whom the injury or illness was first reported	**Was H&S notified within one hour of injury or illness?**
	Yes ☐ No ☐
Date of report	**H&S Personnel Notified**
Time of report	**Time of Report**

If subcontractor injury, did subcontractor's firm perform their own incident investigation?

Yes ☐ No ☐ If yes, request a copy of their completed investigation form/report and attach it to this report.

INJURY / ILLNESS DETAILS

What was the individual doing just before the incident occurred? Describe the activity as well as the tools, equipment, or material the individual was using. Be specific. Examples: "Climbing a ladder while carrying roofing materials"; "Spraying chlorine from a hand sprayer"; "Daily computer key-entry"

_____

_____

_____

What Happened? Describe how the injury occurred. Examples: "When ladder slipped on wet floor and worker fell 20 feet"; "Worker was sprayed with chlorine when gasket broke during replacement"; Worker developed soreness in wrist over time"

_____

_____

_____

_____

Describe the object or substance that directly harmed the individual: Examples: "Concrete floor"; "Chlorine"; "Radial Arm Saw". If this question does not apply to the incident, write "Not Applicable".

_____

_____

MEDICAL CARE PROVIDED

Was first aid provided at the site: Yes ☐ No ☐ If yes, describe the type of first aid administered and by whom?

_____

Was treatment provided away from the site: Yes ☐ No ☐ If yes, provide the information below.

Name of physician or health care professional	**Facility Name**
Street Address, City State and Zip Code	**Type of Care?**
_____ _____	Was individual treated in emergency room? Yes ☐ No ☐ Was individual hospitalized overnight as an in-patient? Yes ☐ No ☐ Did the individual die? Yes ☐ No ☐ If yes, date: _____ Will a worker's compensation claim be filed? Yes ☐ No ☐
Telephone Number	

NOTE: Attach any police reports or related diagrams to this report.

SIGNATURES

I have reviewed this report and agree that all the supplied information is accurate

Affected individual (print)	**Affected individual (signature)**	**Telephone Number**	**Date**

This form contains information relating to employee health and must be used in a manner that protects the confidentiality of the employee to the extent possible while the information is being used for occupational safety and health purposes.

INSTRUCTIONS:

Complete all sections below for incidents involving property/equipment damage, fire, spill or release.
Do NOT leave any blanks.
Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)	

TYPE OF INCIDENT (Check all that apply)

Property Damage ☐	Equipment Damage ☐	Fire or Explosion ☐	Spill or Release ☐

INCIDENT DETAILS

Results of Incident: Fully describe damages, losses, etc.

_____

_____

_____

Response Actions Taken:

_____

_____

_____

Responding Agency(s) (i.e. police, fire department, etc.)	**Agency(s) Contact Name(s)**

DAMAGED ITEMS (List all damaged items, extent of damage and estimated repair cost)

Item:	**Extent of damage:**	**Estimated repair cost**

SPILLS / RELEASES (Provide information for spilled/released materials)

Substance	**Estimated quantity and duration**	**Specify Reportable Quantity (RQ)**
		_____ Exceeded? Yes ☐ No ☐ NA ☐

FIRES / EXPLOSIONS (Provide information related to fires/explosions)

Fire fighting equipment used? Yes ☐ No ☐ If yes, type of equipment: _____

NOTIFICATIONS

Required notifications	**Name of person notified**	**By whom**	**Date / Time**
Client: _____ Yes ☐ No ☐			
Agency: _____ Yes ☐ No ☐			
Other: _____ Yes ☐ No ☐			

Who is responsible for reporting incident to outside agency(s)? Tt ☐ Client ☐ Other ☐ Name: _____

Was an additional written report on this incident generated? Yes ☐ No ☐ If yes, place in project file.

INSTRUCTIONS:

Complete all sections below for incidents involving motor vehicle accidents. Do NOT leave any blanks. Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)	

INCIDENT DETAILS

Name of road, street, highway or location where accident occurred	**Name of intersecting road, street or highway if applicable**

County	**City**	**State**

Did police respond to the accident?	**Did ambulance respond to the accident?**
Yes ☐ No ☐	Yes ☐ No ☐
Name and location of responding police department	**Ambulance company name and location**
Officer's name/badge #	

Did police complete an incident report? Yes ☐ No ☐ If yes, police report number: _____
Request a copy of completed investigation report and attach to this form.

VEHICLE INFORMATION

How many vehicles were involved in the accident? _____ (Attach additional sheets as applicable for accidents involving more than 2 vehicles.)

Vehicle Number 1 – Tetra Tech Vehicle		**Vehicle Number 2 – Other Vehicle**	
Vehicle Owner / Contact Information		**Vehicle Owner / Contact Information**	
Color		**Color**	
Make		**Make**	
Model		**Model**	
Year		**Year**	
License Plate #		**License Plate #**	
Identification #		**Identification #**	

Describe damage to vehicle number 1	**Describe damage to vehicle number 2**
Insurance Company Name and Address	**Insurance Company Name and Address**

Agent Name		**Agent Name**	
Agent Phone No.		**Agent Phone No.**	
Policy Number		**Policy Number**	

DRIVER INFORMATION

Vehicle Number 1 – Tetra Tech Vehicle		Vehicle Number 2 – Other Vehicle	
Driver's Name		**Driver's Name**	
Driver's Address		**Driver's Address**	
Phone Number		**Phone Number**	
Date of Birth		**Date of Birth**	
Driver's License #		**Driver's License #**	
Licensing State		**Licensing State**	
Gender	Male ☐ Female ☐	**Gender**	Male ☐ Female ☐
Was traffic citation issued to Tetra Tech driver? Yes ☐ No ☐		Was traffic citation issued to driver of other vehicle? Yes ☐ No ☐	
Citation #		**Citation #**	
Citation Description		**Citation Description**	

PASSENGERS IN VEHICLES (NON-INJURED)

List all non-injured passengers (excluding driver) in each vehicle.
Driver information is captured in the preceding section.
Information related to persons injured in the accident (non-Tt employees) is captured in the section below on this form.
Injured Tt employee information is captured on FORM IR-A

Vehicle Number 1 – Tetra Tech Vehicle		Vehicle Number 2 – Other Vehicle	
How many passengers (excluding driver) in the vehicle? ____		How many passengers (excluding driver) in the vehicle? ____	
Non-Injured Passenger Name and Address		**Non-Injured Passenger Name and Address**	
Non-Injured Passenger Name and Address		**Non-Injured Passenger Name and Address**	
Non-Injured Passenger Name and Address		**Non-Injured Passenger Name and Address**	

INJURIES TO NON-TETRATECH EMPLOYEES

Name of injured person 1				Address of injured person 1		
Age	**Gender**	**Car No.**	**Location in Car**	**Seat Belt Used?**	**Ejected from car?**	**Injury or Fatality?**
	Male ☐ Female ☐			Yes ☐ No ☐	Yes ☐ No ☐	Injured ☐ Died ☐
Name of injured person 2				**Address of injured person 2**		
Age	**Gender**	**Car No.**	**Location in Car**	**Seat Belt Used?**	**Ejected from car?**	**Injury or Fatality?**
	Male ☐ Female ☐			Yes ☐ No ☐	Yes ☐ No ☐	Injured ☐ Died ☐

OTHER PROPERTY DAMAGE

Describe damage to property other than motor vehicles	
Property Owner's Name	**Property Owner's Address**

COMPLETE AND SUBMIT DIAGRAM DEPICTING WHAT HAPPENED

ATTACHMENT II

MEDICAL DATA SHEET

MEDICAL DATA SHEET

This Medical Data Sheet must be completed by on-site personnel and kept in the command post during the conduct of site operations. This data sheet will accompany any personnel when medical assistance is needed or if transport to hospital facilities is required.

Project _____

Name _____ Home Telephone _____

Address _____

Age _____ Height _____ Weight _____

Person to notify in the event of an emergency: Name: _____

Phone: _____

Drug or other Allergies: _____

Particular Sensitivities : _____

Do You Wear Contacts?_____

What medications are you presently using? _____

_____

Name, Address, and Phone Number of personal physician: _____

_____

_____

Note: Health Insurance Portability and Accountability Act (HIPAA) Requirements

HIPAA took effect April 14, 2003. Loosely interpreted, HIPAA regulates the disclosure of Protected Health Information (PHI) by the entity collecting that information. PHI is any information about health status (such as that you may report on this Medical Data Sheet), provision of health care, or other information. HIPAA also requires TtNUS to ensure the confidentiality of PHI. This Act can affect the ability of the Medical Data Sheet to contain and convey information you would want a Doctor to know if you were incapacitated. So before you complete the Medical Data Sheet understand that this form will not be maintained in a secure location. It will be maintained in a file box or binder accessible to other members of the field crew so that the can accompany an injured party to the hospital.

DO NOT include information that you do not wish others to know, only information that may be pertinent in an emergency situation or treatment.

_____ _____ _____

Name (Print clearly) Signature Date

ATTACHMENT III

EQUIPMENT INSPECTION CHECKLIST

FOR DPT/HSA RIGS

Equipment Inspection Checklist for HSA/DPT Rigs

Company:_____ **Unit/Serial No#:**_____

Inspection Date: _____/_____/_____ **Time:**_____:_____ **Equipment Type:**_____
(e.g, Drill Rigs Hollow Stem, Mud Rotary, Direct Push, HDD, MIP)

Project Name:_____ **Project No#:**_____

Yes	No	NA	Requirement	Comments
			Emergency Stop Devices	
☐	☐	☐	• Emergency Stop Devices (At points of operation)	
☐	☐	☐	• Have all emergency shut offs identified been communicated to the field crew?	
☐	☐	☐	• Has a person been designated as the Emergency Stop Device Operator?	
			Highway Use	
☐	☐	☐	• Cab, mirrors, safety glass?	
☐	☐	☐	• Turn signals, lights, brake lights, etc. (front/rear) for equipment approved for highway use?	
☐	☐	☐	• Seat Belts?	
☐	☐	☐	• Is the equipment equipped with audible back-up alarms and back-up lights?	
☐	☐	☐	• Horn and gauges	
☐	☐	☐	• Brake condition (dynamic, park, etc.)	
☐	☐	☐	• Tires (Tread) or tracks	
☐	☐	☐	• Windshield wipers	
☐	☐	☐	• Exhaust system	
☐	☐	☐	• Steering (standard and emergency)	
☐	☐	☐	• Wheel Chocks?	
☐	☐	☐	• Are tools and material secured to prevent movement during transport? Especially those within the cab?	
☐	☐	☐	• Are there flammables or solvents or other prohibited substances stored within the cab?	
☐	☐	☐	• Are tools or debris in the cab that may adversely influence operation of the vehicle (in and around brakes, clutch, gas pedals)	

Yes	No	NA	Requirement	Comments
☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	Fluid Levels: • Engine oil • Transmission fluid • Brake fluid • Cooling system fluid • Hoses and belts • Hydraulic oil	
☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	High Pressure Hydraulic Lines • Obvious damage • Operator protected from accidental release • Coupling devices, connectors, retention cables/pins are in good condition and in place	
☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐	Mast Condition • Structural components/tubing • Connection points • Pins • Welds • Outriggers • Operational • Plumb (when raised)	
☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐	Hooks • Are the hooks equipped with Safety Latches? • Does it appear that the hook is showing signs of wear in excess of 10% original dimension? • Is there a bend or twist exceeding 10% from the plane of an unbent hook? • Increase in throat opening exceeding 15% from new condition • Excessive nicks and/or gouges • Clips • Number of U-Type (Crosby) Clips (cable size 5/16 – 5/8 = 3 clips minimum) (cable size 3/4 – 1 inch = 4 clips minimum) (cable size 1 1/8 – 1 3/8 inch = 5 clips minimum)	

Yes	No	NA	Requirement	Comments
			Power cable and/or hoist cable	
☐	☐	☐	• Reduction in Rope diameter π (5/16 wire rope>1/64 reduction nominal size -replace) (3/8 to 1/2 wire rope>1/32 reduction nominal size-replace) (9/16 to 3/4 wire rope>3/64 reduction nominal size-replace)	
☐	☐	☐	• Number of broken wires (6 randomly broken wires in one rope lay) (3 broken wires in one strand)	
☐	☐	☐	• Number of wire rope wraps left on the Running Drum at nominal use (≥3 required)	
☐	☐	☐	- Lead (primary) sheave is centered on the running drum	
☐	☐	☐	• Lubrication of wire rope (adequate?)	
☐	☐	☐	• Kinks, bends – Flattened to > 50% diameter	
			Hemp/Fiber rope (Cathead/Split Spoon Hammer)	
☐	☐	☐	• Minimum ¾; maximum 1 inch rope diameter (Inspect for physical damage)	
☐	☐	☐	• Rope to hammer is securely fastened	
			Safety Guards –	
☐	☐	☐	• Around rotating apparatus (belts, pulleys, sprockets, spindles, drums, flywheels, chains) all points of operations protected from accidental contact?	
☐	☐	☐	• Hot pipes and surfaces exposed to accidental contact?	
☐	☐	☐	• High pressure lines	
☐	☐	☐	• Nip/pinch points	
			Operator Qualifications	
☐	☐	☐	• Does the operator have proper licensing where applicable, (e.g., CDL)?	
☐	☐	☐	• Does the operator, understand the equipment's operating instructions?	
☐	☐	☐	• Is the operator experienced with this equipment?	
☐	☐	☐	• Is the operator 21 years of age or more?	

Yes	No	NA	Requirement	Comments
			PPE Required for Drill Rig Exclusion Zone	
☐	☐	☐	• Hardhat	
☐	☐	☐	• Safety glasses	
☐	☐	☐	• Work gloves	
☐	☐	☐	• Chemical resistant gloves_____	
☐	☐	☐	• Steel toed Work Boots	
☐	☐	☐	• Chemical resistant Boot Covers	
☐	☐	☐	• Apron	
☐	☐	☐	• Coveralls Tyvek, Saranex, cotton)_____	
			Other Hazards	
☐	☐	☐	• Excessive Noise Levels? _____dBA	
☐	☐	☐	• Chemical hazards (Drilling supplies - Sand, bentonite, grout, fuel, etc.)	
☐	☐	☐	- MSDSs available?	
☐	☐	☐	• Will On-site fueling occur	
☐	☐	☐	- Safety cans available?	
☐	☐	☐	- Fire extinguisher (Type/Rating -_____ _)	

Approved for Use ☐ Yes ☐ No ☐ See Comments

_____ _____

Site Health and Safety Officer Operator

ATTACHMENT IV

SAFE WORK PERMITS

SAFE WORK PERMIT
MOBILIZATION AND DEMOBILIZATION ACTIVITIES
NAVAL STATION GREAT LAKES

Permit No. _____ Date: _____ Time: From _____ to _____

I. Work limited to the following (description, area, equipment used): Mobilization and demobilization activities

II. Primary Hazards: Lifting; slips, trips and falls; vehicular and foot traffic; insect/animal bites and stings; poisonous plants; inclement weather.

III. Field Crew: _____

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____TtNUS
Equipment Inspection required ☐ Yes ☐ No Initials of Inspector _____TtNUS

V. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ Specify on the reverse
No ☒

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, or coveralls, safety, glasses and safety footwear. Hard hats and hearing protection will be worn when working near operating equipment.

VI. Chemicals of Concern	**Hazard Monitoring**	**Action Level(s)**	**Response Measures**
None anticipated	None	None	None

Primary Route(s) of Exposure/Hazard: NA

(Note to FOL and/or SSO: Each item in Sections VII, VIII, and IX must be checked Yes, No, or NA)

VII. Additional Safety Equipment/Procedures

Hard-hat	☐ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☐ Yes	☐ No
Safety Glasses	☐ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio/Cellular Phone	☐ Yes	☒ No
Splash Shield	☐ Yes	☒ No	Barricades	☐ Yes	☒ No
Splash suits/coveralls	☐ Yes	☒ No	Gloves (Type – leather/cotton)	☒ Yes	☐ No
Impermeable apron	☐ Yes	☒ No	Work/rest regimen	☐ Yes	☒ No
Safety toe work shoes/boots	☒ Yes	☐ No	Chemical Resistant Boot Covers	☐ Yes	☐ No
High visibility vest	☐ Yes	☐ No	Tape up/use insect repellent	☐ Yes	☐ No
First Aid Kit	☐ Yes	☐ No	Fire Extinguisher	☐ Yes	☐ No
Safety Shower/Eyewash	☐ Yes	☐ No	Other	☐ Yes	☐ No

Modifications/Exceptions: Tyvek coverall to protect against natural hazards (e.g., ticks) if working/walking through areas of high grass. Use insect repellants containing at least 10% DEET and tape up in such areas. Follow manufacturer's recommendations for proper application and reapplication. Hard hat when overhead hazards exist. Safety glasses when near eye hazards. Hearing protection when in high noise areas.

VIII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Vehicle and Foot Traffic Routes Established/Traffic Control Barricades/Signs in Place	☐	☐	☐
Physical Hazards Identified and Isolated (Splash and containment barriers)	☐	☐	☐
Emergency Equipment Staged (Spill control, fire extinguishers, first aid kits, etc).	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.) ☐ Yes ☒ No
If yes, SSO to complete or contact Health Sciences, Pittsburgh Office (412)921-7090

X. Special instructions, precautions: Preview work locations to identify potential hazards (slips, trips, and falls, natural hazards, etc.) Review PPE needs based on activities being performed and the associated hazards. Use safe lifting procedures and obtain assistance when handling heavy or awkward objects. Suspend site activities in the event of inclement weather. Observe site workers for signs and symptoms of heat/cold stress. Use sun block (SPF > 15) to prevent sunburn if necessary.

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT
MONITORING WELL INSTALLATION
AND MULTIMEDIA SAMPLING ACTIVITIES
NAVAL STATION GREAT LAKES

Permit No. _____ Date: _____ Time: From _____ to _____

I. Work limited to the following (description, area, equipment used): Monitoring well installation and soil and groundwater sampling via DPT and Hollow Stem Augering (HSA)

II. Primary Hazards: Chemical contamination, transfer of contamination; heavy equipment hazards; elevated noise; energized systems/utilities; heavy lifting; slip, trip and fall; cuts and lacerations; vehicular and foot traffic; ambient temperature extremes; flying projectiles; insect/animal bites and stings, poisonous plants, inclement weather

III. Field Crew: _____

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____ TtNUS
Equipment Inspection required ☐ Yes ☐ No Initials of Inspector _____ TtNUS

V. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ Specify on the reverse
No ☒

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, or coveralls, safety, glasses and safety footwear. Hard hats and hearing protection will be worn when working near operating equipment.

VI.

Chemicals of Concern	Hazard Monitoring /Action Level(s)	Response Measures
VOCs	FID/PID with 10.6ev lamp >10 PPM in BZ for 3 exp of 5 mins	Suspend site activities and retreat to unaffected area. If readings are sustained contact SSO.
Metals (lead)	Visible dust	Area wetting techniques

Primary Route(s) of Exposure/Hazard: inhalation, dermal, ingestion

(Note to FOL and/or SSO: Each item in Sections VII, VIII, and IX must be checked Yes, No, or NA)

VII. Additional Safety Equipment/Procedures

Hard-hat	☒ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☒ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness/lifeline	☒ Yes	☒ No
Chemical/splash goggles	☐ Yes	☐ No	Radio/Cellular Phone	☐ Yes	☒ No
Splash Shield	☐ Yes	☐ No	Barricades	☐ Yes	☒ No
Splash suits/coveralls	☐ Yes	☐ No	Gloves (Type – nitrile)	☒ Yes	☐ No
Impermeable apron	☐ Yes	☒ No	Work/rest regimen	☐ Yes	☒ No
Safety toe work shoes/boots	☒ Yes	☐ No	Chemical Resistant Boot Covers	☐ Yes	☐ No
High visibility vest	☐ Yes	☐ No	Tape up/use insect repellent	☐ Yes	☐ No
First Aid Kit	☐ Yes	☐ No	Fire Extinguisher	☐ Yes	☐ No
Safety Shower/Eyewash	☐ Yes	☐ No	Other	☐ Yes	☐ No

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety footwear, and nitrile gloves Tyvek coverall to protect against natural hazards (e.g., ticks) if working/walking through areas of high grass. Use insect repellants containing at least 10% DEET and tape up in such areas. Follow manufacturer's recommendations for proper application and reapplication.

VIII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Vehicle and Foot Traffic Routes Established/Traffic Control Barricades/Signs in Place	☐	☐	☐
Physical Hazards Identified and Isolated (Splash and containment barriers)	☐	☐	☐
Emergency Equipment Staged (Spill control, fire extinguishers, first aid kits, etc).	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☒ No
If yes, SSO to complete or contact Health Sciences, Pittsburgh Office (412)921-7090

X. Special instructions, precautions: Preview work locations to identify potential hazards (slips, trips, and falls, natural hazards, etc.) Review PPE needs based on activities being performed and the associated hazards. Use safe lifting procedures and obtain assistance when handling heavy or awkward objects. Suspend site activities in the event of inclement weather. Observe site workers for signs and symptoms of heat/cold stress. Use sun block (SPF > 15) to prevent sunburn if necessary. Complete Equipment Inspection Checklist prior to beginning work.

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT
DECONTAMINATION ACTIVITIES
NAVAL STATION GREAT LAKES

Permit No. _____ Date: _____ Time: From _____ to _____

I. Work limited to the following (description, area, equipment used): Decontamination of sampling and heavy equipment.

II. Primary Hazards: Chemical exposure, transfer of contamination, inclement weather, noise.

III. Field Crew: _____

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____ TtNUS
Equipment Inspection required ☐ Yes ☐ No Initials of Inspector _____ TtNUS

V. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ Specify on the reverse
No ☒

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety glasses, safety footwear, and nitrile gloves. Impermeable aprons are preferred protection against soiling work clothes when lifting auger flights because of the need to carry close to the body. If it (impermeable apron) does not offer adequate protection, PVC rain suits or PE or PVC coated Tyvek should be employed. Chemical resistant boot covers if excessive liquids are generated or to protected footwear.

VI.

Chemicals of Concern	Hazard Monitoring	Action Level(s)	Response Measures
Decontamination Fluids	refer to MSDS	refer to MSDS	Re-wash and re-scan

Primary Route(s) of Exposure/Hazard: Inhalation and direct contact

(Note to FOL and/or SSO: Each item in Sections VII, VIII, and IX must be checked Yes, No, or NA)

VII. Additional Safety Equipment/Procedures

Hard-hat	☐ Yes	☒ No	Hearing Protection (Plugs/Muffs)	☐ Yes	☒ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio/Cellular Phone	☐ Yes	☒ No
Splash Shield	☒ Yes	☐ No	Barricades	☐ Yes	☒ No
Splash suits/coveralls	☐ Yes	☒ No	Gloves (Type – Nitrile)	☒ Yes	☐ No
Impermeable apron	☐ Yes	☐ No	Work/rest regimen	☐ Yes	☒ No
Safety toe work shoes or boots	☒ Yes	☐ No	Chemical Resistant Boot Covers	☐ Yes	☐ No
High Visibility vest	☐ Yes	☐ No	Tape up/use insect repellent	☐ Yes	☐ No
First Aid Kit	☐ Yes	☐ No	Fire Extinguisher	☐ Yes	☐ No
Safety Shower/Eyewash	☐ Yes	☐ No	Other	☐ Yes	☐ No

Modifications/Exceptions: Chemical resistant boot covers if excessive liquids are generated or to protect footwear.

VIII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☒
Vehicle and Foot Traffic Routes Established/Traffic Control Barricades/Signs in Place	☐	☐	☐
Physical Hazards Identified and Isolated (Splash and containment barriers)	☐	☐	☐
Emergency Equipment Staged (Spill control, fire extinguishers, first aid kits, etc).	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☒ No
If yes, SSO to complete or contact Health Sciences, Pittsburgh Office (412)921-7090

X. Special instructions, precautions: Suspend site activities in the event of inclement weather. Employ proper lifting techniques. When/where possible use heavy equipment to move and place containers.

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT
IDW MANAGEMENT
NAVAL STATION GREAT LAKES

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

I. **Work limited to the following (description, area, equipment used):** IDW management activities includes containerization, staging, monitoring for leaks of IDW accumulated wastes. Wastes types include purge and decontamination wash waters.

II. **Primary Hazards:** Lifting, pinches and compressions; flying projectiles; slips, trips, and falls and chemical contamination.

III. **Field Crew:** _____

IV. **On-site Inspection conducted** ☐ Yes ☐ No Initials of Inspector _____TtNUS
Equipment Inspection required ☐ Yes ☒ No Initials of Inspector _____TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

V. **Protective equipment required**
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ See Reverse
No ☒

Modifications/Exceptions: None anticipated

VI. **Chemicals of Concern** None anticipated
Hazard Monitoring /Action Level(s) none
Response Measures none

Primary Route of Exposure/Hazard: NA

(Note to FOL and/or SSO: Each item in Sections VII, VIII, and IX must be checked Yes or No)

VII. **Additional Safety Equipment/Procedures**

Hard-hat	☐ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☐ Yes	☒ No
Safety Glasses	☐ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio/Cellular Phone	☐ Yes	☐ No
Splash Shield	☐ Yes	☒ No	Barricades	☐ Yes	☐ No
Splash suits/coveralls	☐ Yes	☒ No	Gloves (Type – Leather/Cotton)	☒ Yes	☐ No
Impermeable apron	☐ Yes	☒ No	Work/rest regimen	☐ Yes	☒ No
Safety toe work shoes/boots	☒ Yes	☐ No	Chemical Resistant Boot Covers	☐ Yes	☒ No
High visibility vest	☐ Yes	☐ No	Tape up/use insect repellent	☐ Yes	☐ No
First Aid Kit	☒ Yes	☐ No	Fire Extinguisher	☐ Yes	☐ No
Safety Shower/Eyewash	☐ Yes	☒ No	Other	☐ Yes	☐ No

Modifications/Exceptions: If you are using pneumatic/electric power to open drums – Safety glasses are required. If power equipment is employed to move drums or you are working near operating equipment hard hats will be employed. Tyvek coverall to protect against natural hazards (e.g., ticks) if working/walking through areas of high grass. Use insect repellants containing at least 10% DEET if necessary. Follow manufacturer's recommendations for proper application and reapplication. If working in areas where snakes are a threat, wear snake chaps to protect against bites. High visibility vest if near active traffic areas.

VIII. **Site Preparation**

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☒
Vehicle and Foot Traffic Routes Established/Traffic Control Barricades/Signs in Place	☐	☐	☐
Physical Hazards Identified and Isolated	☐	☐	☐
Emergency Equipment Staged (Spill control, fire extinguishers, first aid kits, etc).	☐	☐	☐

IX. **Additional Permits required** (Hot work, confined space entry, excavation etc.) ☐ Yes ☒ No
If yes, SSO to complete or contact Health Sciences, Pittsburgh Office (412)921-7090

X. **Special instructions, precautions:** Suspend site activities in the event of inclement weather. Employ proper lifting techniques. When/where possible use heavy equipment to move and place containers. When placing drums – Place the label and retention ring nut on the outside where it is readily visible. Place 4-drums to a pallet. Maintain a minimum distance of 4-feet between pallet rows. An IDW inventory shall be generated to provide the number of drums, contents, and volumes. This inventory should be provided to the facility contact. Inspect equipment prior to use.

Permit Issued by:_____ Permit Accepted by:_____

ATTACHMENT V

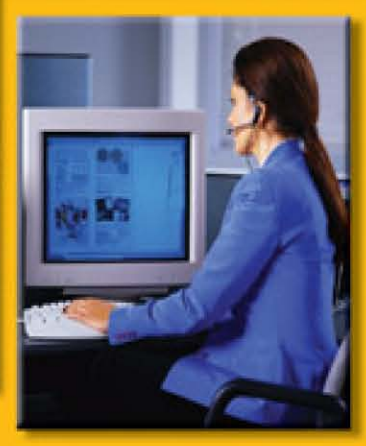
OSHA POSTER

Job Safety and Health

It's the law!

OSHA

Occupational Safety and Health Administration
U.S. Department of Labor



EMPLOYEES:

- You have the right to notify your employer or OSHA about workplace hazards. You may ask OSHA to keep your name confidential.
- You have the right to request an OSHA inspection if you believe that there are unsafe and unhealthful conditions in your workplace. You or your representative may participate in that inspection.
- You can file a complaint with OSHA within 30 days of retaliation or discrimination by your employer for making safety and health complaints or for exercising your rights under the *OSH Act*.
- You have the right to see OSHA citations issued to your employer. Your employer must post the citations at or near the place of the alleged violations.
- Your employer must correct workplace hazards by the date indicated on the citation and must certify that these hazards have been reduced or eliminated.
- You have the right to copies of your medical records and records of your exposures to toxic and harmful substances or conditions.
- Your employer must post this notice in your workplace.
- You must comply with all occupational safety and health standards issued under the *OSH Act* that apply to your own actions and conduct on the job.

EMPLOYERS:

- You must furnish your employees a place of employment free from recognized hazards.
- You must comply with the occupational safety and health standards issued under the *OSH Act*.

Free assistance in identifying and correcting hazards or complying with standards is available to employers, without citation or penalty, through OSHA-supported consultation programs in each state.

1-800-321-OSHA

www.osha.gov

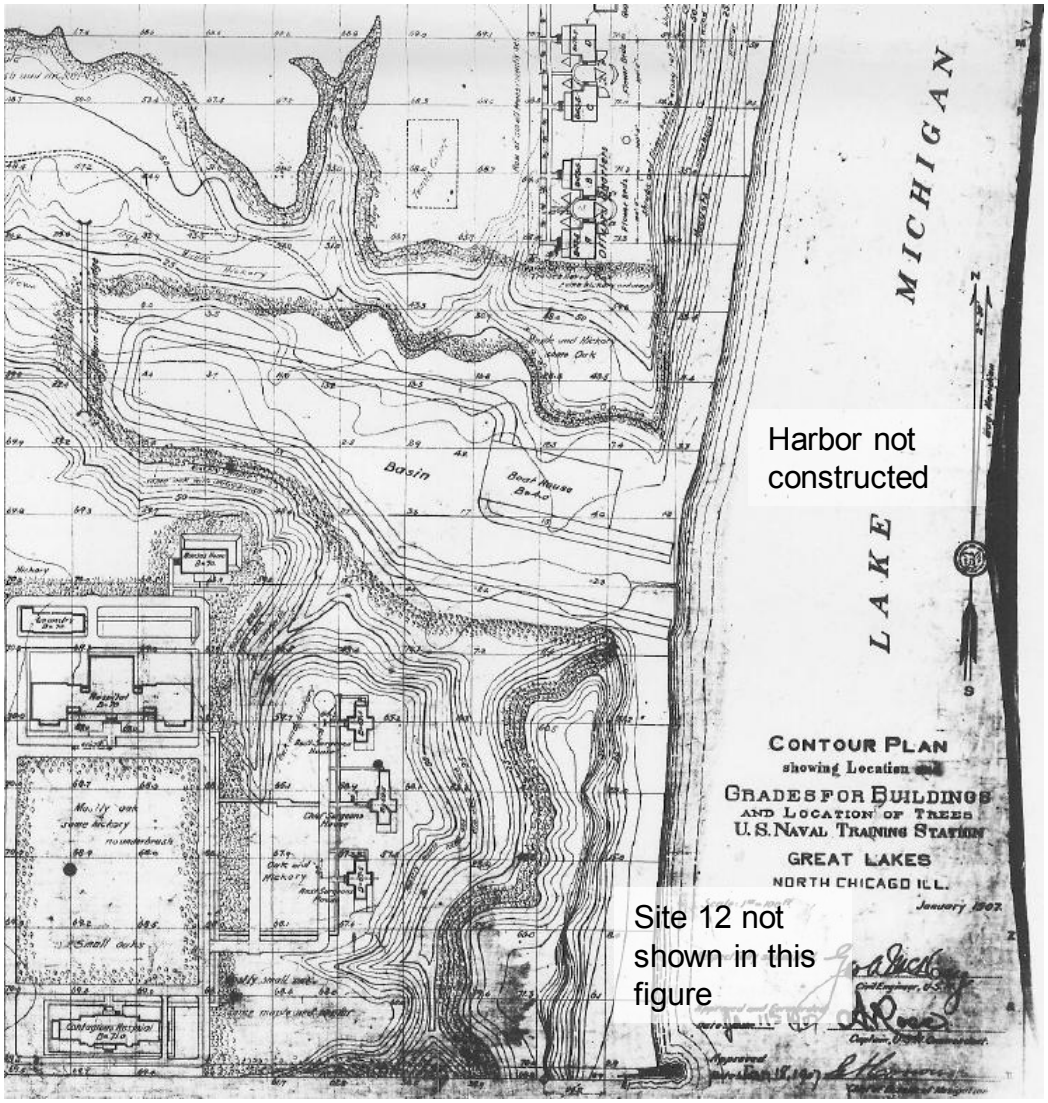
This free poster available from OSHA –
The Best Resource for Safety and Health

OSHA 3165-12-06R

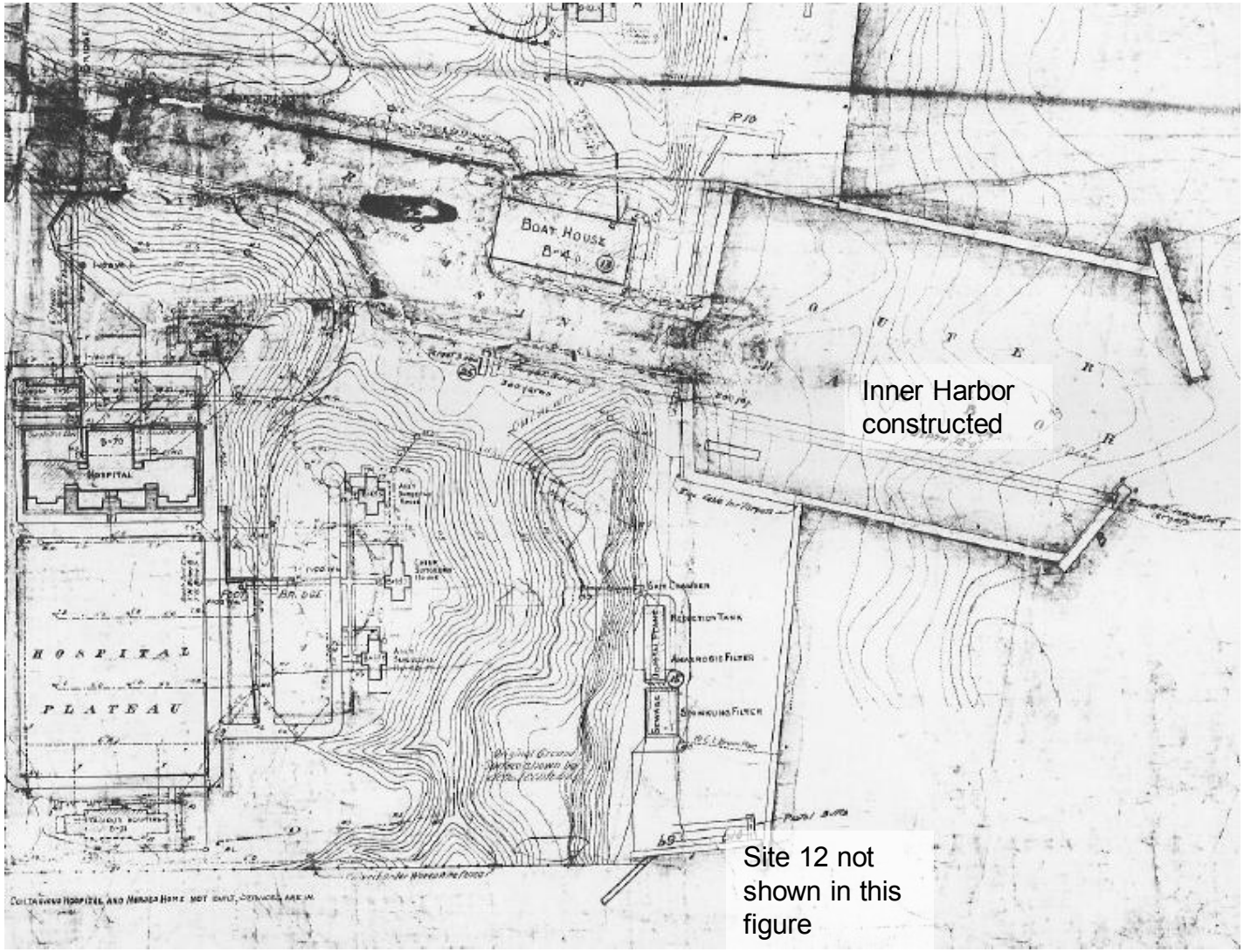
APPENDIX B

HISTORIC MAPS AND AERIAL PHOTOGRAPHS

1907 Drawing

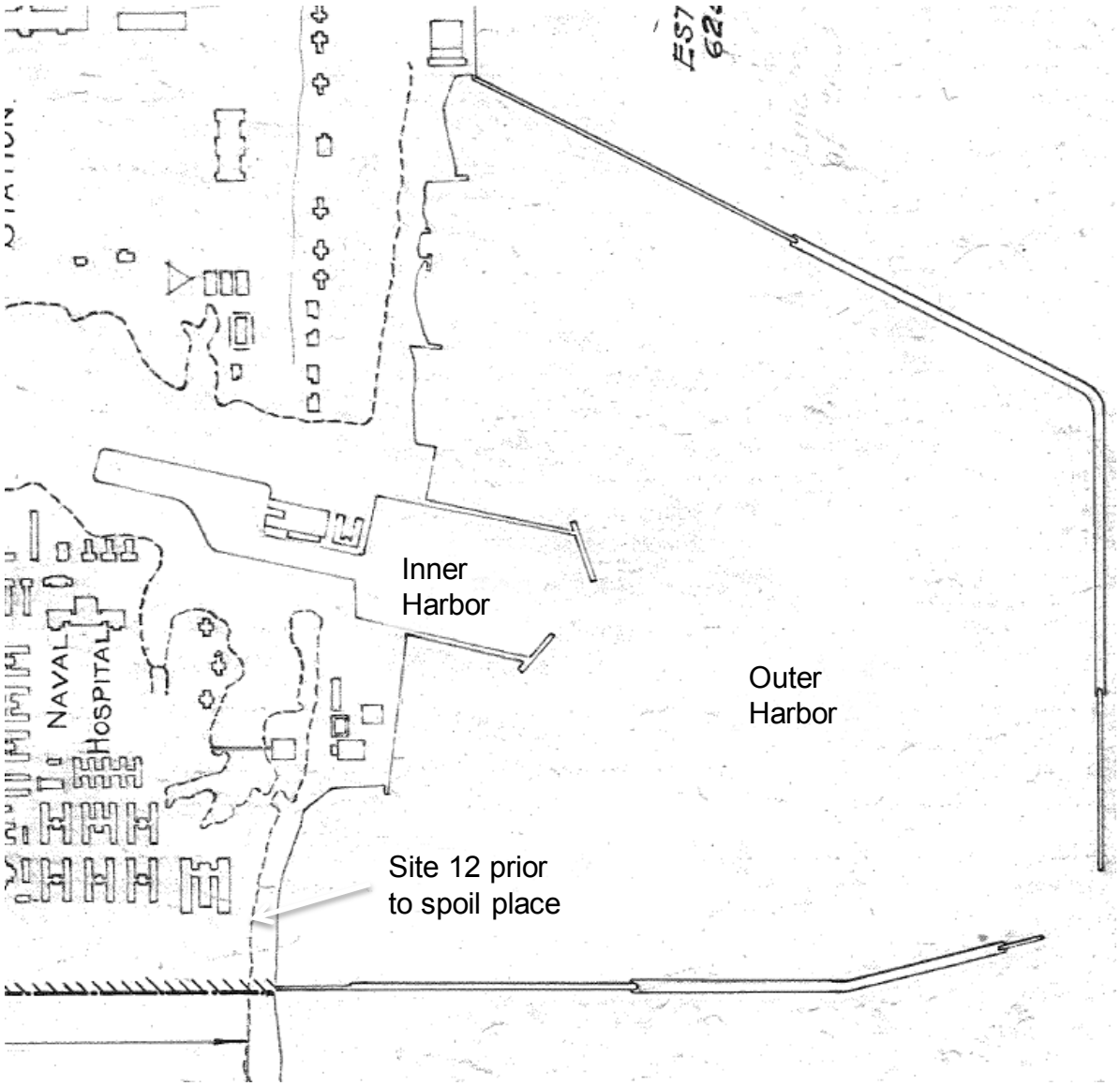


1909 Drawing



1923 Drawing

1929 Drawing



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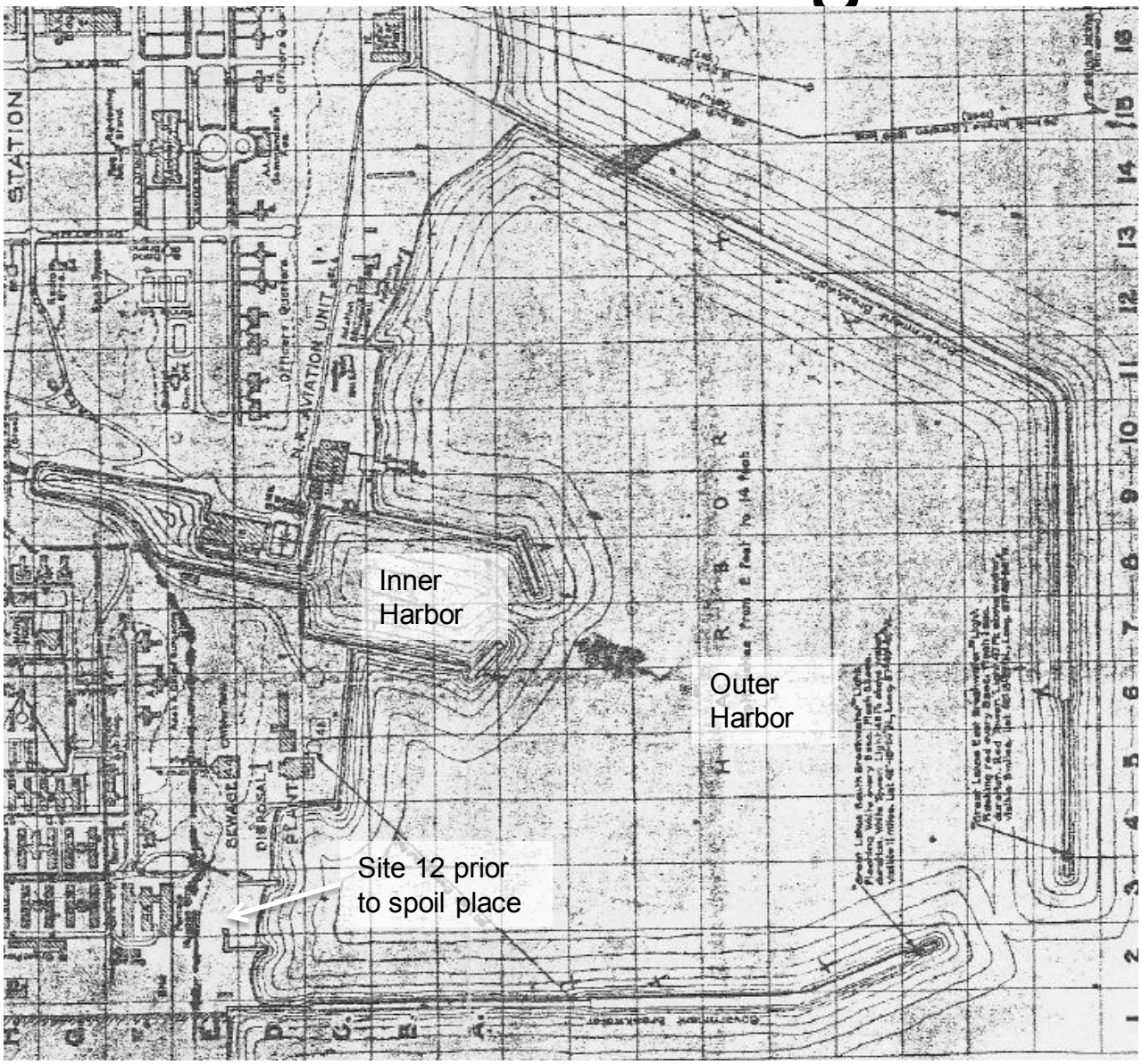

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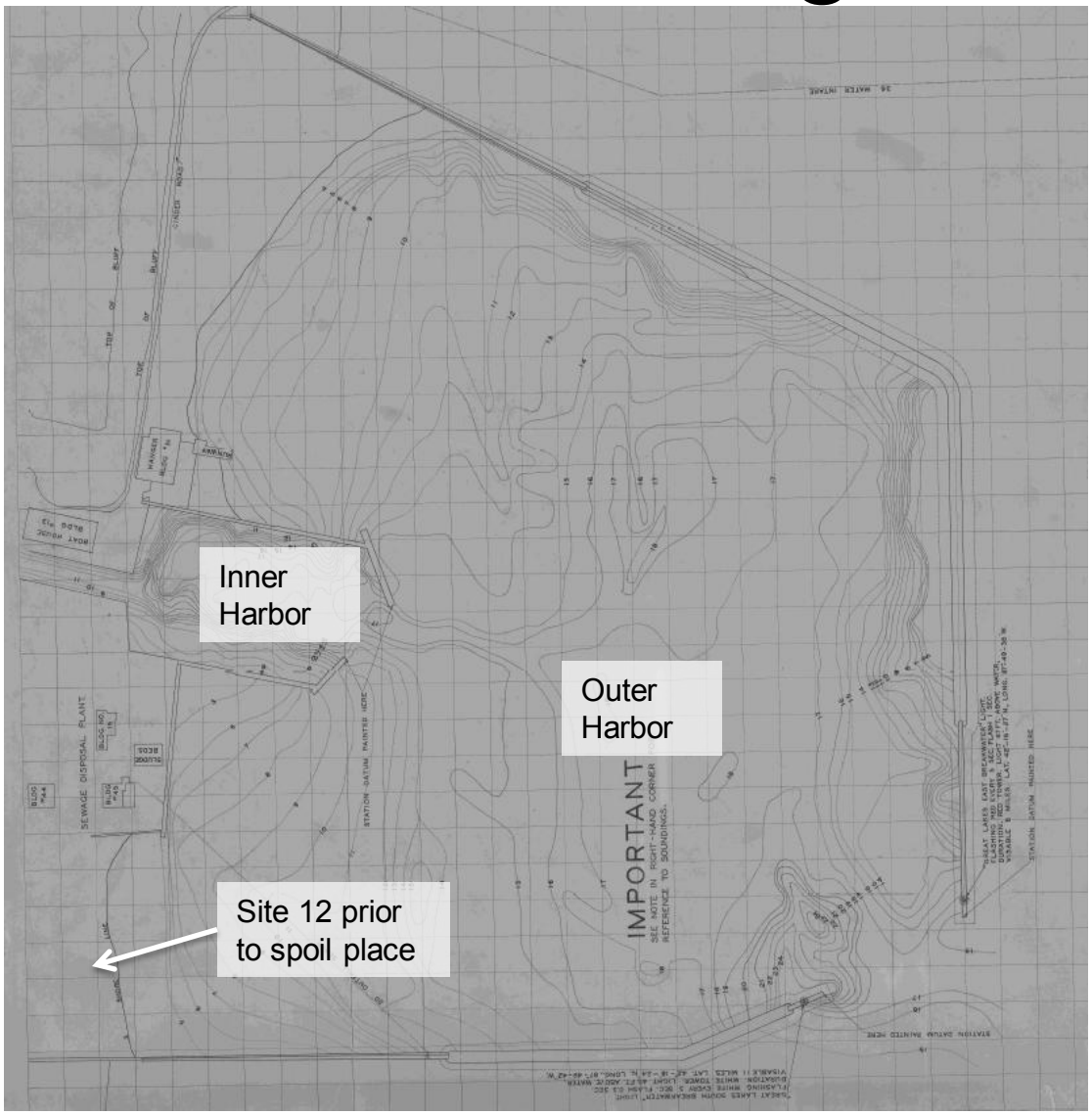

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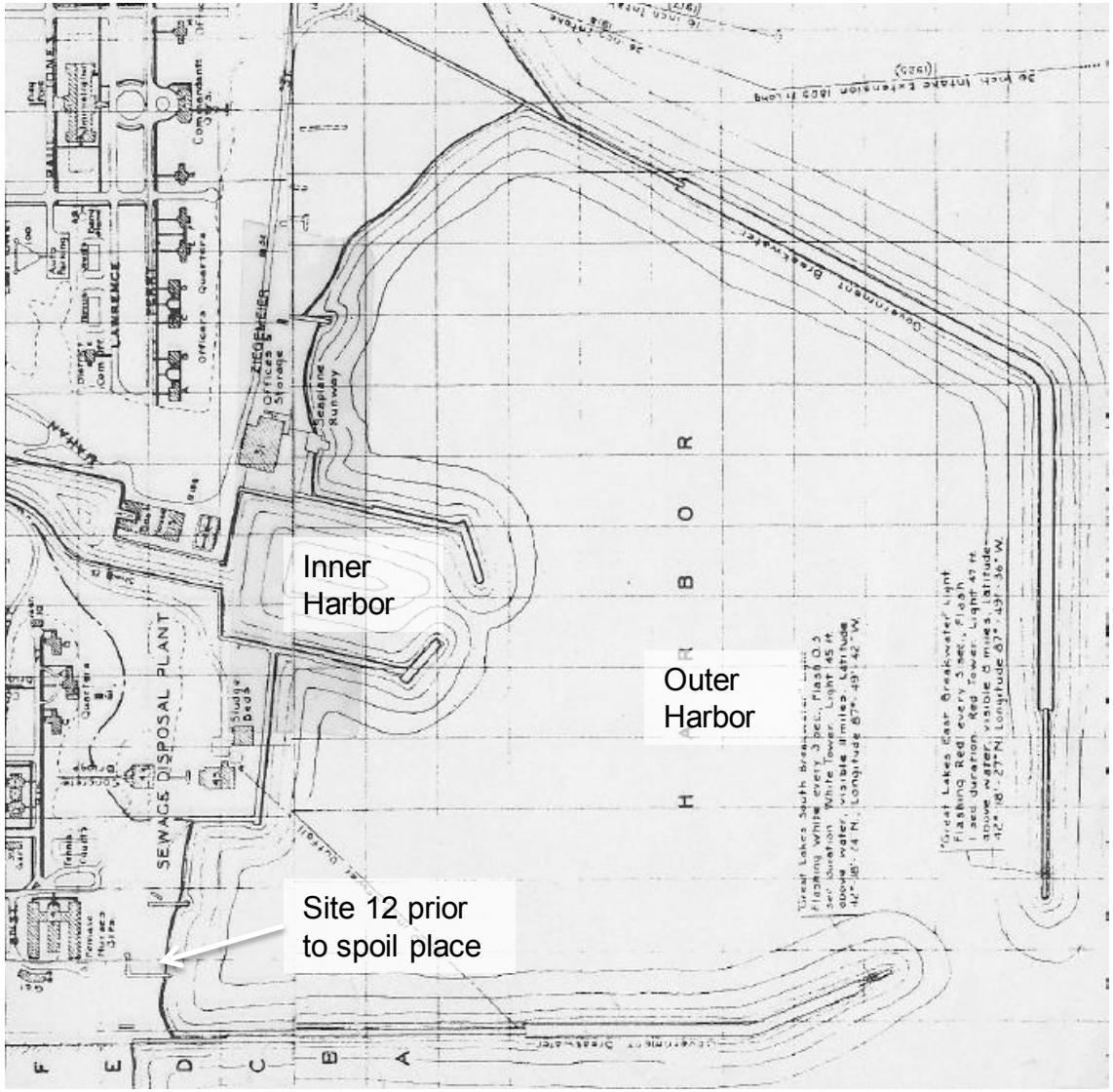

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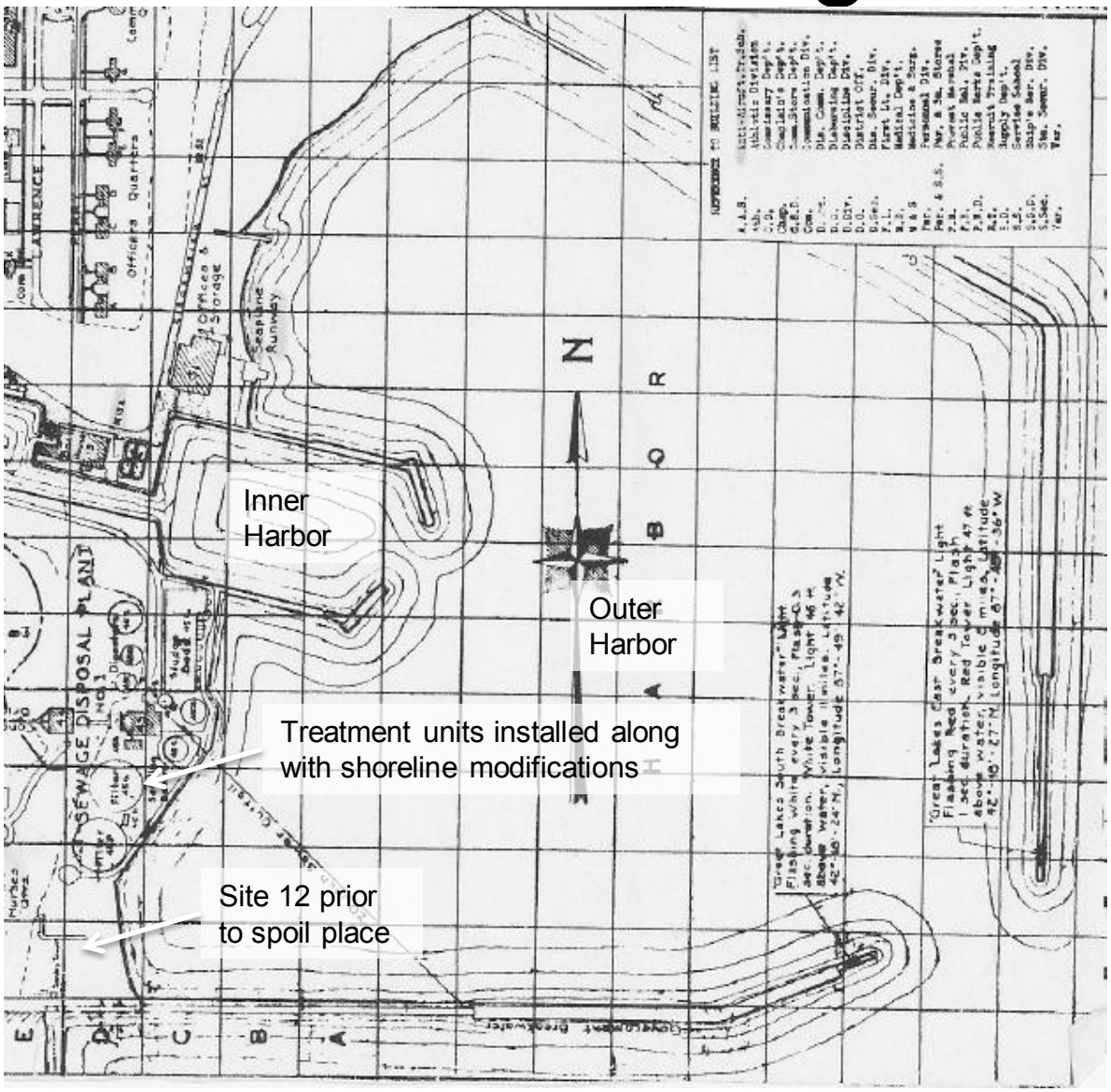

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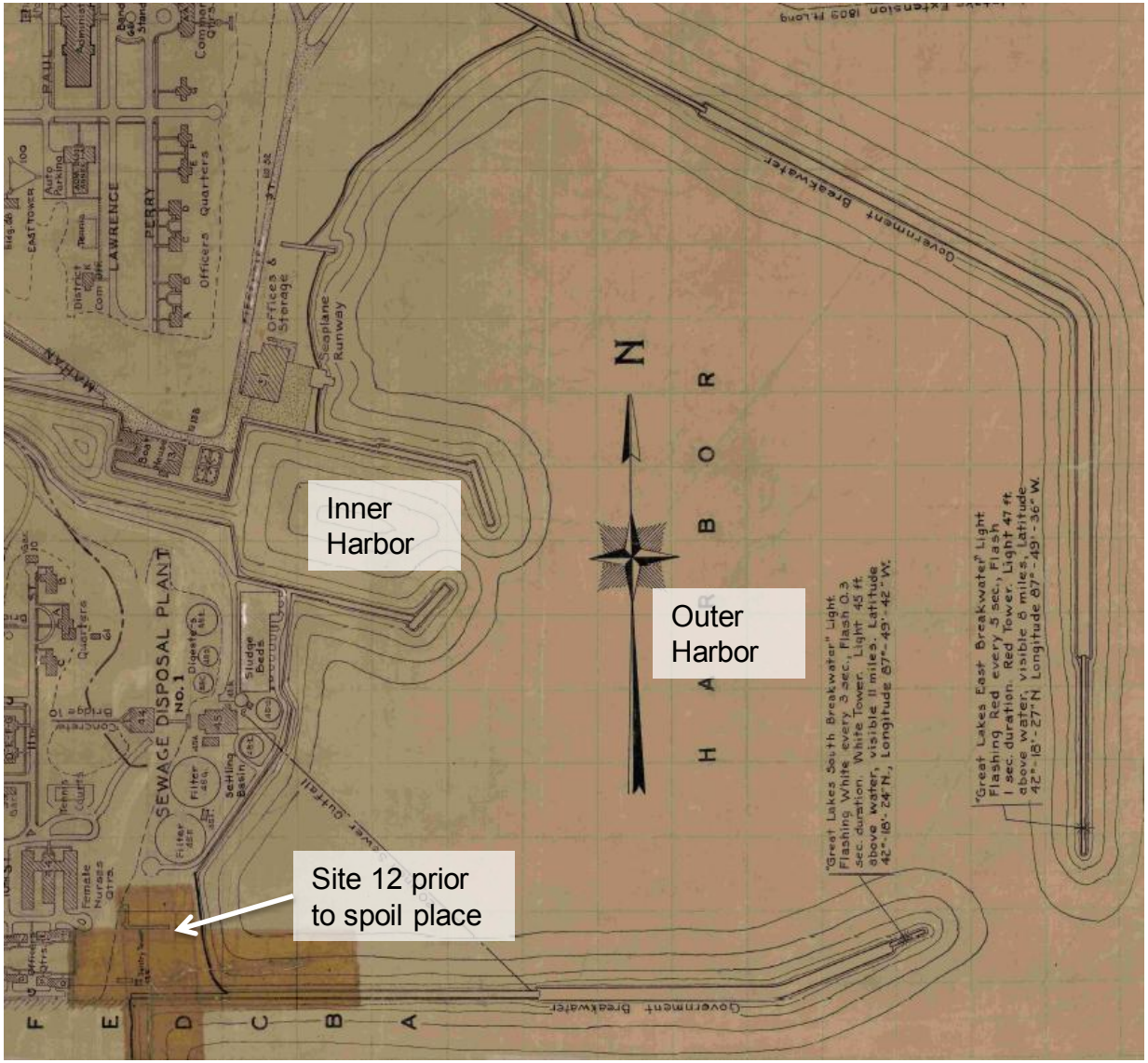

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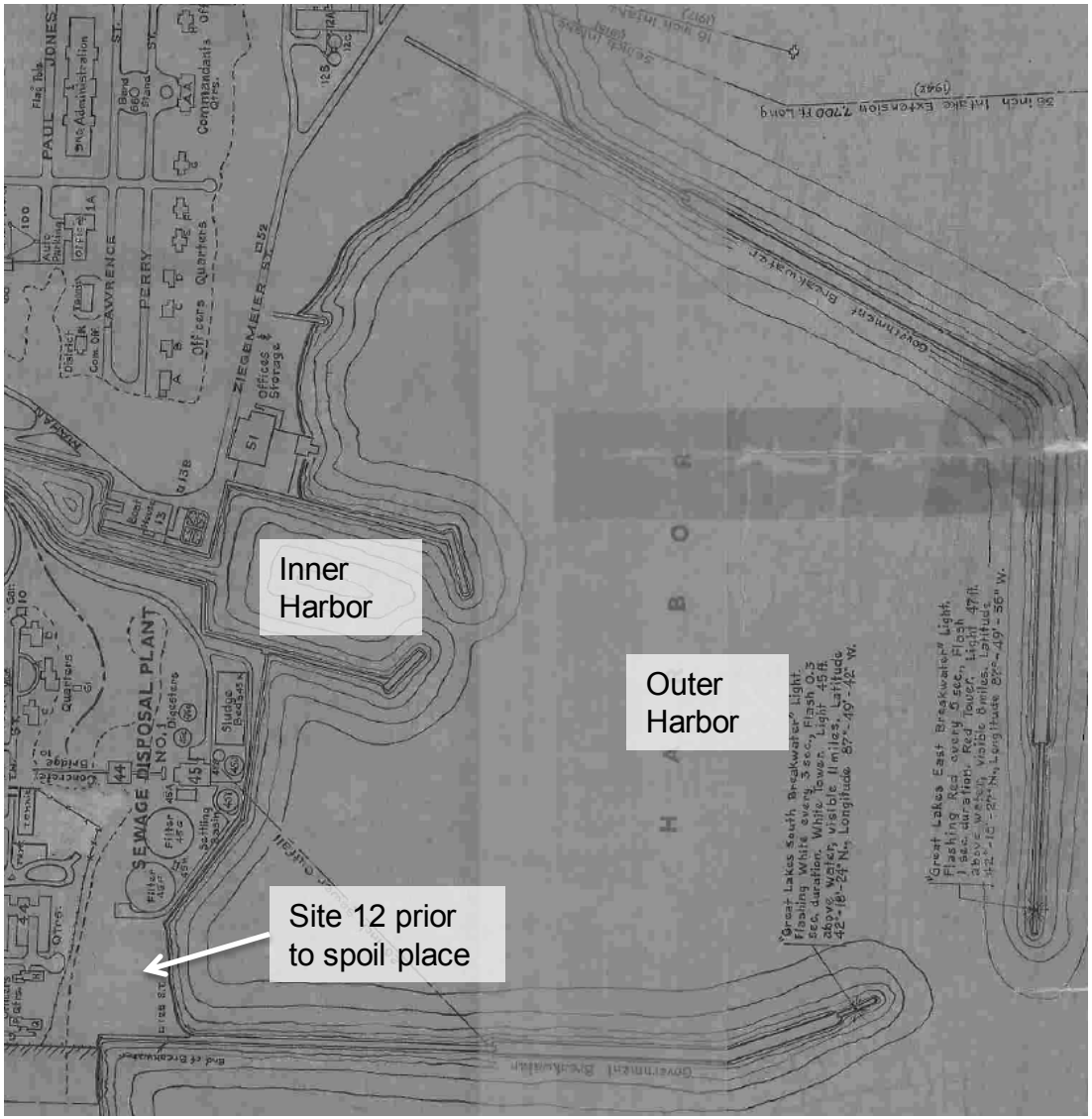

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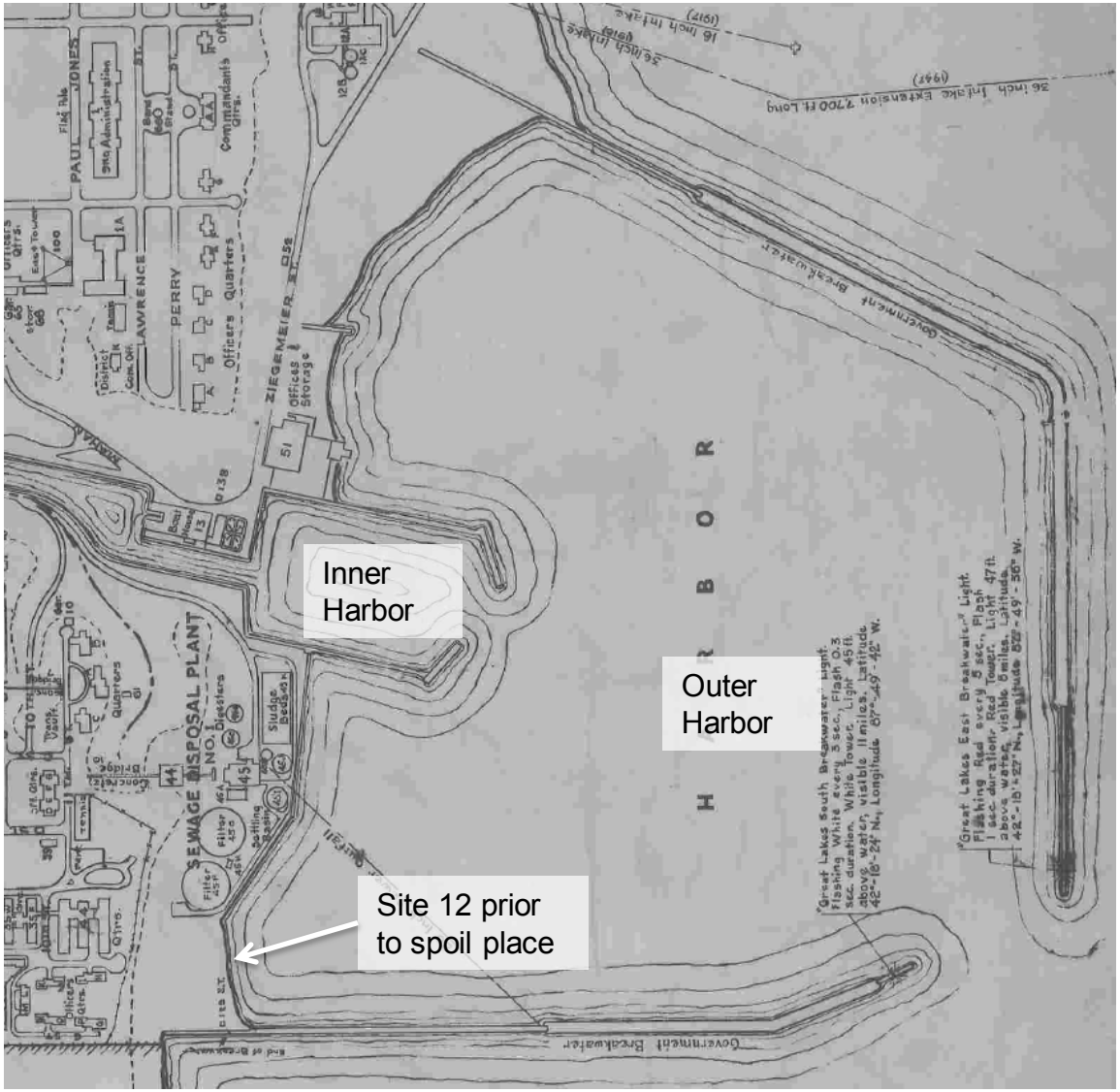

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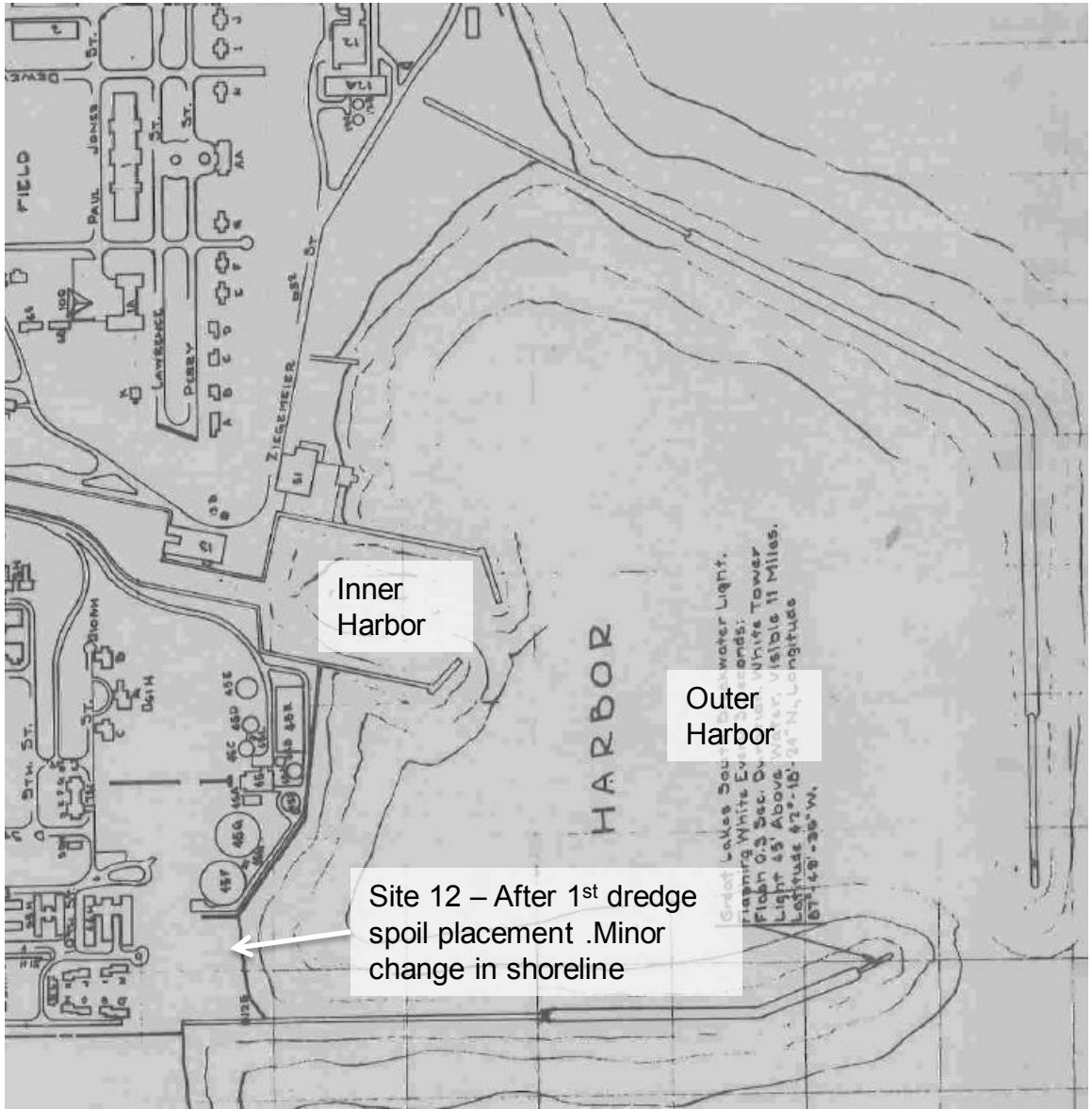

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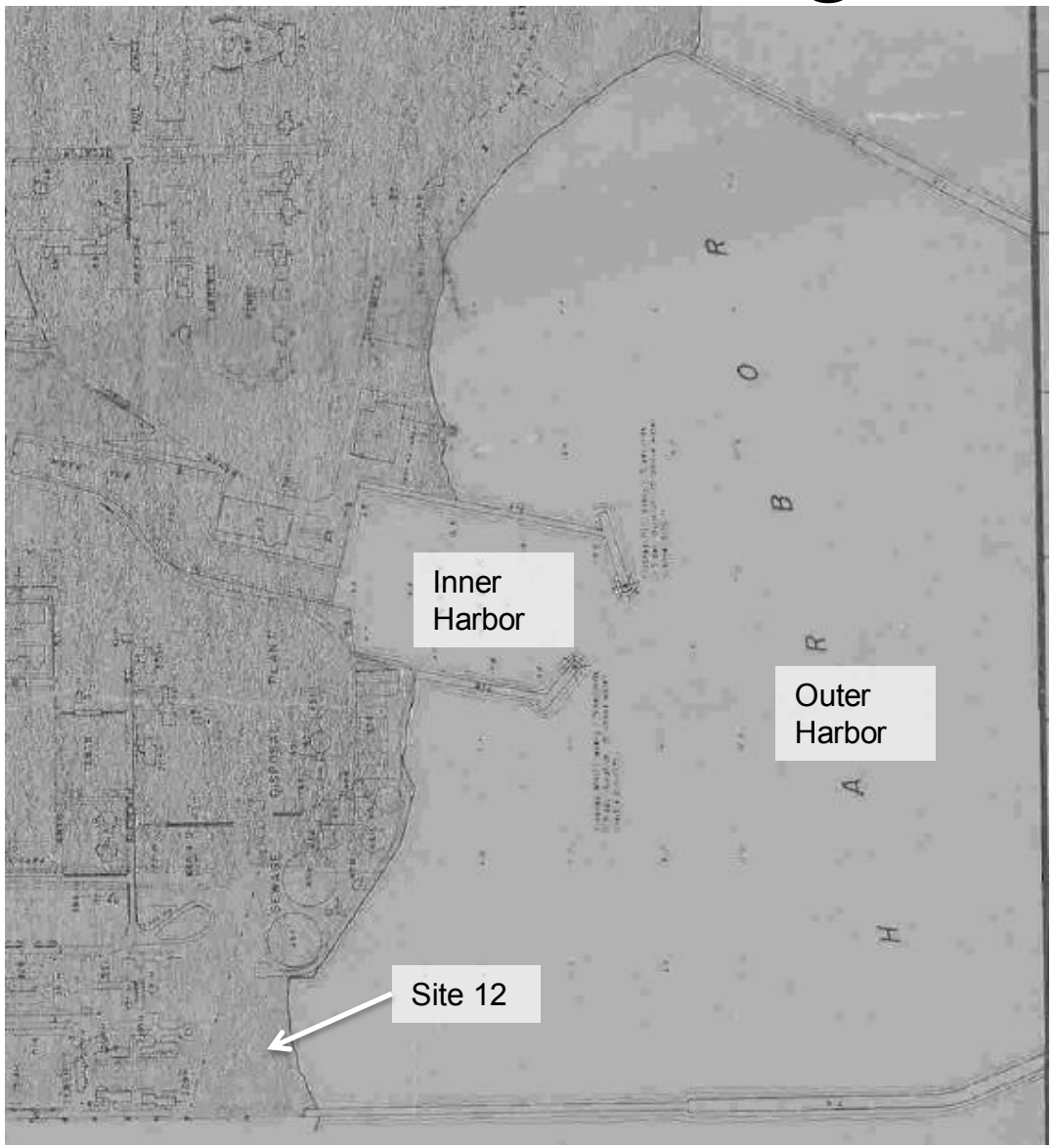

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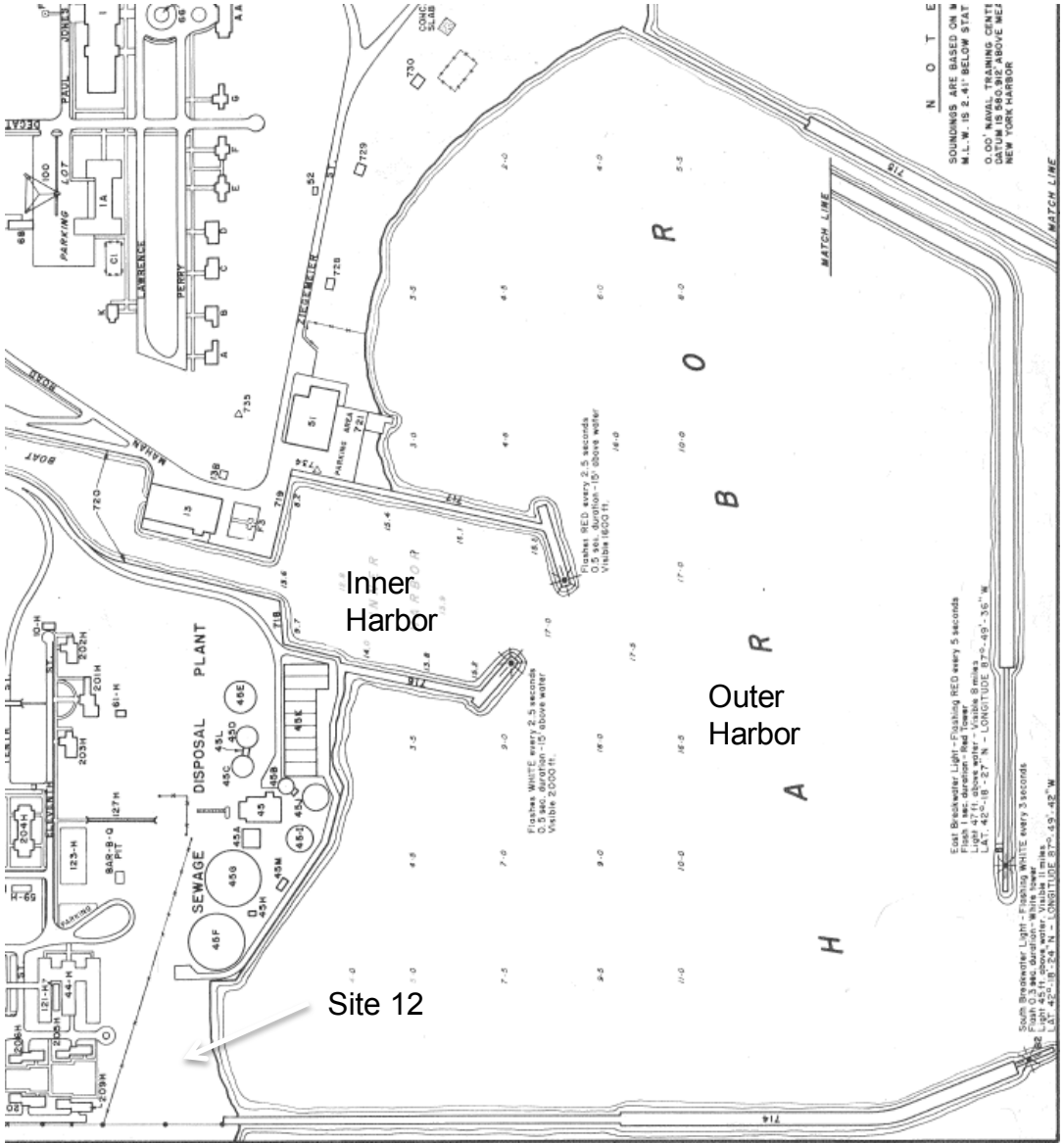
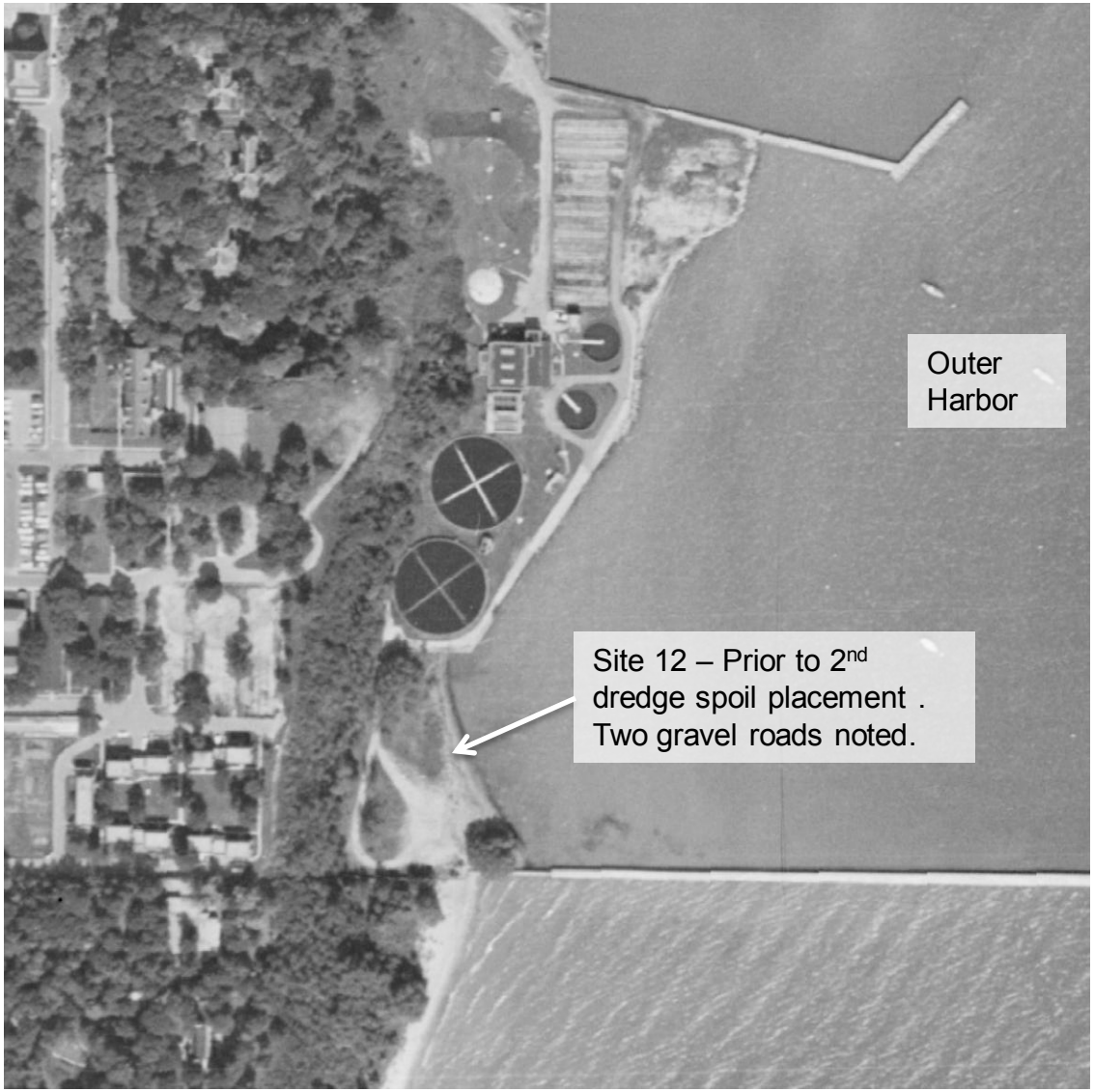
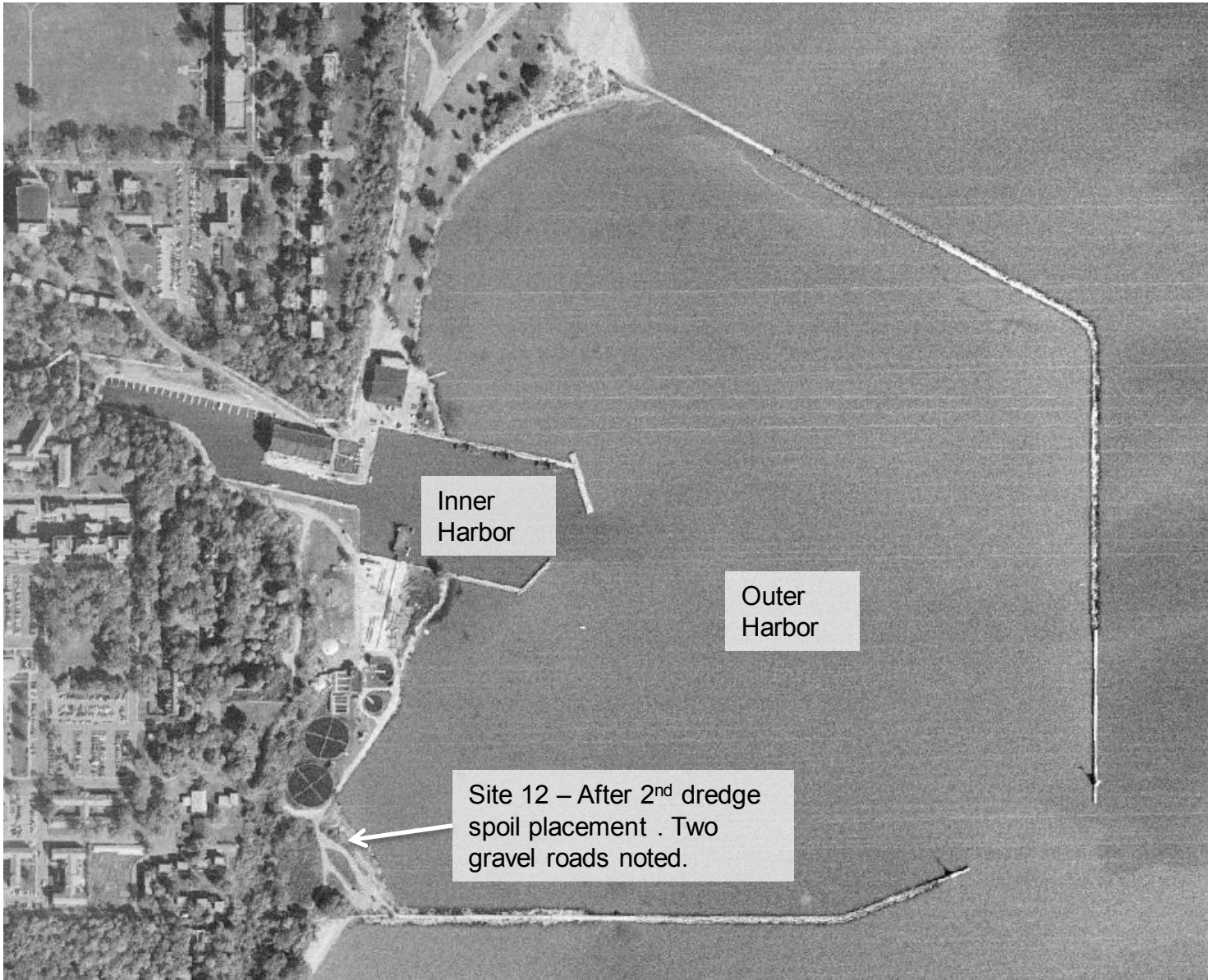


1961 Photo


Outer
Harbor
Site 12 – Prior to 2nd
dredge spoil placement .
Two gravel roads noted.

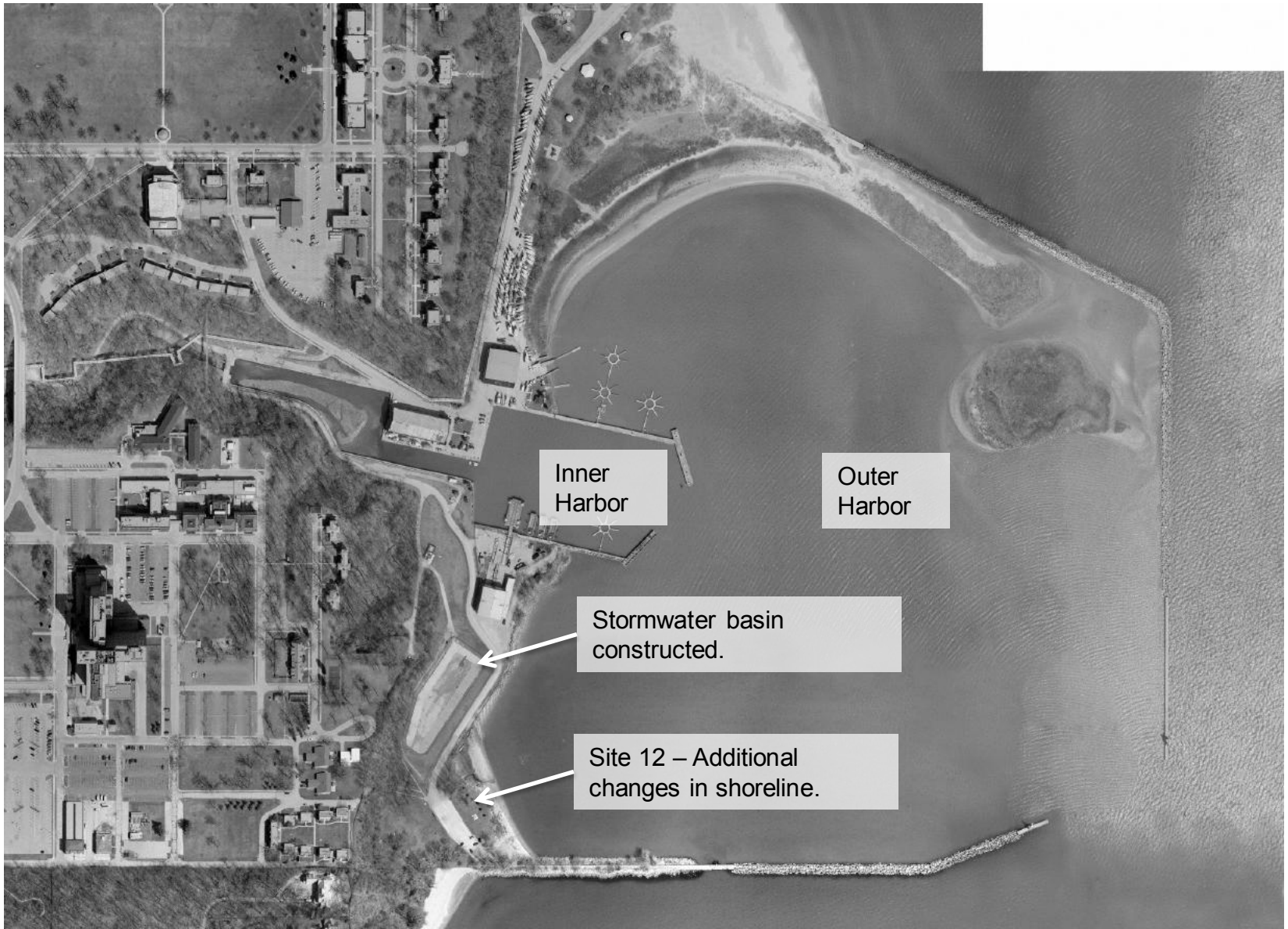
1974 Photo


Inner Harbor
Outer Harbor
Site 12 – After 2nd dredge spoil placement . Two gravel roads noted.

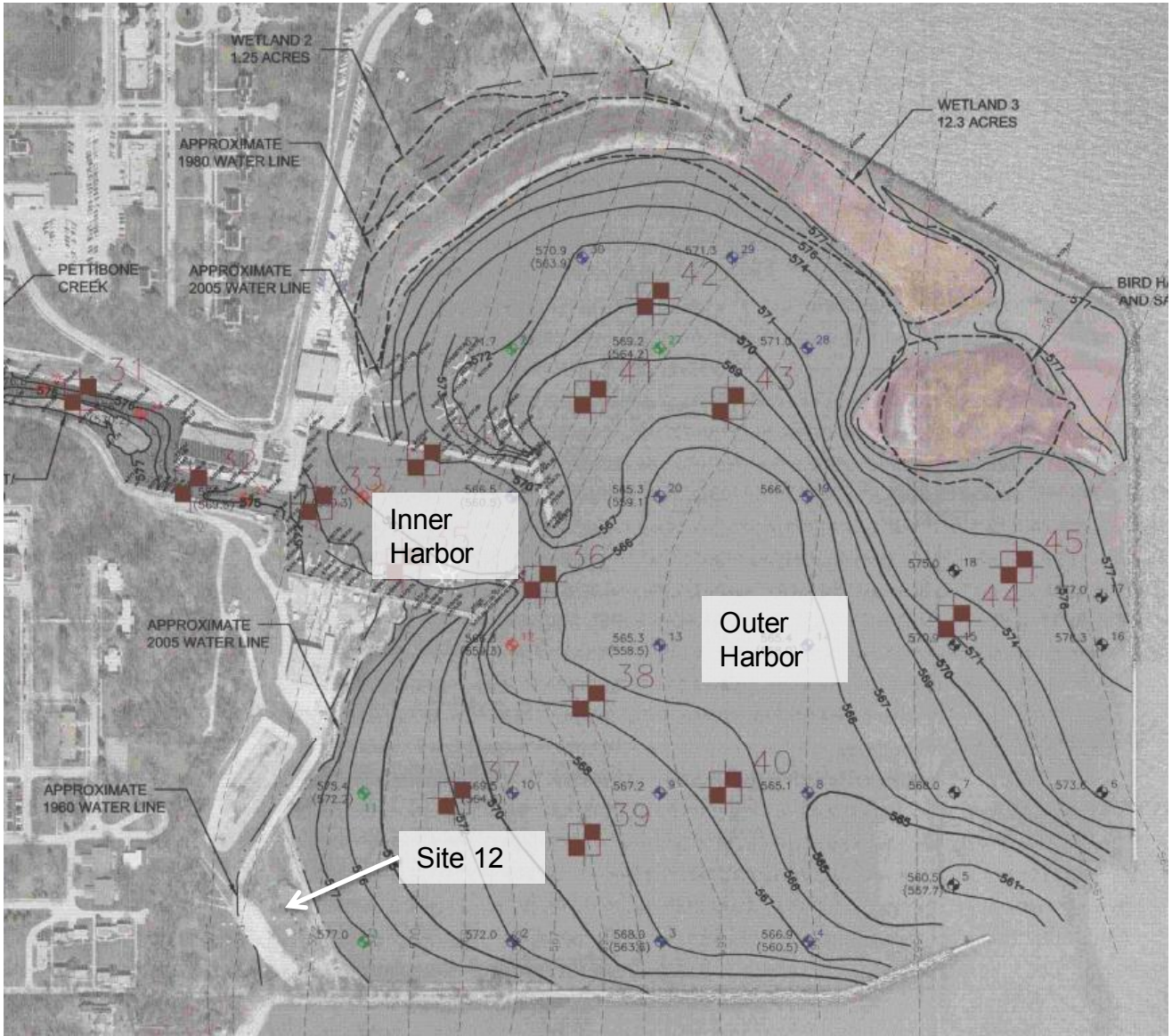
1988 Photo

Outer Harbor
Site 12 – After 2nd dredge spoil placement . Two gravel roads noted.

2002 Photo


Inner Harbor
Outer Harbor
Stormwater basin constructed.
Site 12 – Additional changes in shoreline.

2006 Drawing



Current Photo

APPENDIX C

HUMAN HEALTH RISK ASSESSMENT WORK PLAN

SITE 12 - HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

This section of the Uniform Federal Policy Sampling and Analysis Plan (UFP SAP) outlines the general methodologies and procedures that will be used to conduct the human health risk assessment (HHRA) for Site 12, the Harbor Dredge Spoil Area located at Naval Station Great Lakes. The objective of the risk assessment is to determine whether detected concentrations of chemicals at the site pose a significant threat to potential human receptors under current and/or future land use. The potential risks to human receptors will be estimated based on the assumption that no further actions are taken to control contaminant releases.

Three major aspects of chemical contamination and environmental fate and transport must be considered to evaluate potential risks: (1) contaminants with toxic characteristics must be found in environmental media and must be released by either natural processes or by human action, (2) potential exposure points must exist, and (3) human receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure. If any one of these factors is absent, the exposure route is regarded as incomplete, and no potential risks will be considered to exist for human receptors.

In accordance with United States Environmental Protection Agency (EPA) recommendations, the risk assessment process follows these steps:

- Data collection and evaluation
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Uncertainty analysis

The methodologies used in this risk assessment will comply with scientifically acceptable risk assessment practices and current EPA guidance, including but not limited to, the following risk assessment guidance documents that were used to develop the framework for the HHRA:

- USEPA, 1989. Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A). EPA 540/1-89/002. Office of Emergency and Remedial Response, Washington, D.C.

- USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03. Washington, D.C.

- USEPA, 1993. Preliminary Review Draft: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Office of Solid Waste and Emergency Response, Washington, D.C.

- USEPA, 1996. Soil Screening Guidance: Technical Background Document. EPA/540/R-95/128. Office of Solid Waste and Emergency Response. Washington, D.C.

- USEPA, 1997. Exposure Factors Handbook. EPA/600/P-95/002Fa. Office of Health and Environmental Assessment, Washington, D.C.

- Department of the Navy, 2001, Conducting Human Health Risk Assessments under the Environmental Restoration Program. Ser N453E/1U595168. Washington, D.C.

- USEPA, 2001. Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments).

- USEPA, December 2002a. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. Washington, D.C.

- USEPA, December 2002b. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10. Washington, D.C.

- USEPA, 2004. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final Guidance.

- Department of the Navy, 2004. Navy Final Policy on the Use of Background Chemical Levels.

- Illinois EPA, 2007. TACO (Tiered Approach to Corrective Action Objectives). Illinois Environmental Protection Agency, Bureau of Land, available online at http://www.epa.state.il.us/land/taco/.

1.0 DATA EVALUATION

Data evaluation, the first component of a HHRA, involves the compilation and evaluation of analytical data. The main objective of the data evaluation is to develop a media-specific list of chemicals of potential concern (COPCs) that will be used to quantitatively determine potential human health risks for

site media. As noted in RAGS Part D, "data quality is an important component of the risk assessment and the data quality should be documented."

Data quality will be evaluated as follows:

- To the extent available, the results of data validation conducted for the data sets used in the risk assessment will be summarized and presented.

- To the extent that the information is available, the "Data Usability Worksheet" suggested in RAGS Part D will be completed.

- The data evaluation narrative will discuss data quality issues identified during the completion of the "Data Usability Worksheet."

1.1 Data Usability

Data collected during the proposed field investigation will be used to assess risks to potential human receptors. The analytical data used in the quantitative estimation of potential risks will be subjected to data validation. A discussion of data validation protocol is provided in the UFP SAP. As stated above, a Data Evaluation/Usability Report will be generated for the results of the field investigation. This report will provide information on precision, accuracy, representativeness, completeness, comparability, and sensitivity. A brief summary of the results of the data validation also will be included.

Quantitative or qualitative analytical results from the target analyte lists for the proposed field investigation will be used in the risk evaluation. Field measurements, data regarded as unreliable (i.e., qualified as "R" during the data validation process) will not be used in the quantitative risk assessment. However, these data may be used to substantiate the conclusions of the quantitative risk analysis.

1.2 Selection of Chemicals of Potential Concern (COPCs)

The next step after data summary will be to compare chemical concentrations from the Site with screening criteria. Chemicals at concentrations higher than screening criteria will be selected as chemicals of potential concern (COPCs) that are carried through the risk assessment process. COPCs are selected through a qualitative screening process in order to limit the number of chemicals and exposure routes quantitatively evaluated in the HHRA to only those site-related constituents that dominate overall potential risks. Screening by use of risk-based concentrations and Illinois Environmental

Protection Agency (Illinois EPA) background levels will be used to focus the risk assessment on meaningful chemicals and exposure routes.

In general, a chemical will be selected as a COPC and retained for further quantitative risk evaluation if (1) the maximum detection in a sampled medium exceeds the lowest risk-based concentration and (2) for inorganic contaminants, if the chemical is determined to be present at concentrations exceeding concentrations in background samples. Chemicals eliminated from further evaluation at this time are assumed to present nominal risks to potential human receptors. If a detection limit is above the action levels for Site 12 for a specific compound, those compounds and their overall effect will be addressed on a case-by-case basis in the site-specific risk assessment and discussed in the Uncertainty Section of that assessment.

1.2.1 COPC Screening Criteria

Several screening criteria will be used to identify COPCs for Site 12. Screening concentrations based on risk-based cleanup objectives developed by Illinois EPA (Illinois EPA) and risk-based concentrations developed by Oak Ridge National Laboratory (ORNL) and recommended by the U.S. Environmental Protection Agency (USEPA) (referred to as the Regional Screening Levels for Chemical Contaminants at Superfund Sites) (ORNL) will be used, as well as other USEPA criteria (see lists below). The risk-based screening concentrations correspond to a systemic hazard quotient of 0.1 for noncarcinogens or an incremental lifetime cancer risk of $1x10^{-6}$ for carcinogens. Note that the Illinois EPA and the Regional Screening Levels for noncarcinogens are based on a hazard quotient of 1.0 while, the screening concentrations will be based on a hazard quotient of 0.1. The screening concentrations are based on a hazard quotient of 0.1 so that additive noncarcinogenic risks for the chemicals do not exceed 1.0. The screening levels to be used in the risk assessment are briefly discussed below.

The screening concentrations in Worksheet #15 of the Uniform Federal Policy-Sampling and Analysis Plan (UFP-SAP) that encompasses the Field Sampling Plan requirements and Quality Assurance Project Plan (QAPP) are based on risk-based cleanup objectives developed by Illinois EPA and risk-based concentrations developed by ORNL and recommended by the USEPA. The project action levels in Worksheet #15 are the lower of the respective criteria (Illinois EPA criteria or USEPA ORNL concentrations).

<u>Screening Levels for Soil</u>

The following criteria will be used to select COPCs for surface and subsurface soil:

- Illinois EPA Tier 1 Soil Remediation Objectives for Residential Properties, and for Construction Workers (Illinois EPA, online at http://www.ipcb.state.il.us/SLR/IPCBandIEPAEnvironmentalRegulations-Title35.asp). These include remediation objectives for the soil ingestion exposure route and for the inhalation exposure route. The lowest Tier I objective of the receptors (i.e., residential, industrial/commercial, or construction worker) listed in the Tier 1 Tables will be used for screening.

- ORNL Regional Screening Levels for Chemical Contaminants at Superfund Sites (USEPA ORNL).

- USEPA Generic Soil Screening Levels (SSLs) for the inhalation of volatiles and fugitive dusts calculated online at http://risk.lsd.ornl.gov/calc_start.shtml based on methodology from the USEPA's Soil Screening Guidance (USEPA)

- Soil Remediation Objectives for Residential and Industrial/Commercial Properties, and Construction Workers, Non-TACO Chemicals

- Proposed TACO Amendments of Provisional and Revised Screening Levels will be reviewed during the final risk assessment, and included in the COPC selection process if finalized by the Illinois EPA.

If the maximum concentration of a constituent exceeds any of these criteria, and, for inorganics only, if the constituent is considered to be present at concentrations greater than the concentrations of chemicals in background soil, the chemical will be selected as a COPC. The procedures for the elimination of chemicals on the basis of background concentrations will follow current U.S. Navy policy provided in the Navy Policy on the Use of Background Chemical Levels (Department of the Navy, January 2004). At the present time, facility background concentrations for naturally occurring or anthropogenic chemicals have not been determined for Naval Station Great Lakes. Therefore, maximum soil concentrations will be compared to the concentrations of inorganic chemicals provided by Illinois EPA in Appendix A, Table G of TACO.

The comparison of site soil data to USEPA Generic Inhalation SSLs for transfers from soil to air and Illinois EPA remediation objectives for inhalation will be used to identify whether a quantitative analysis of this exposure pathway is warranted. If the maximum soil concentration of a chemical exceeds the inhalation criteria, a quantitative evaluation of potential risks from inhalation will be performed. Otherwise,

the risks associated with the inhalation pathway will be considered insignificant, and the exposure pathway will be eliminated from further evaluation.

To evaluate the potential for chemicals detected in soil to impact groundwater, maximum chemical concentrations will be compared to SSLs for migration to groundwater. The comparisons will be presented in separate tables (from the COPC tables) and will not be used to select COPCs for soil. Migration to Groundwater SSLs are not used for COPC selection because quantitative risk assessments are typically based on direct contact with soil or particulates. There is no methodology available for quantitative risk evaluation of indirect exposure based on migration to groundwater. Therefore, it is not appropriate to select COPCs for quantitative risk evaluation for direct exposure on the basis of the indirect soil-to-groundwater pathway. The soil-to-groundwater SSLs provide an indication of potential impacts of contamination in soil on groundwater quality but are not indicators of quantitative risk.

The migration from soil to groundwater comparisons will be made using the following criteria:

- Illinois EPA Tier 1 Soil Remediation Objectives for Residential Properties for the Soil Component of the Groundwater Ingestion Exposure Route for Class I Groundwater (Illinois EPA, online at http://www.ipcb.state.il.us/SLR/IPCBandIEPAEnvironmentalRegulations-Title35.asp).

- USEPA Generic SSLs for Migration from Soil to Groundwater calculated online at http://risk.lsd.ornl.gov/calc_start.shtml based on methodology from the USEPA's Soil Screening Guidance (USEPA).

- ORNL Regional Screening Level for Protection of Groundwater (USEPA ORNL)

Results of the soil-to-groundwater comparisons will be qualitatively discussed in the risk assessment.

Because of the different exposure scenarios for potential human receptors, COPCs will be identified for subsurface soil. Subsurface soil will be defined as soil collected from depths greater than 1 foot below ground surface (bgs). Construction workers will be assumed to be exposed to subsurface soil. Exposure to subsurface soil for future residents will be evaluated to account for the possibility that subsurface soil may be brought to the surface in a future excavation project.

In addition to screening, the comparison of site soil data to USEPA Generic Inhalation SSLs for transfers from soil to air will be used to identify whether a quantitative analysis of this exposure pathway is

warranted. If the maximum soil concentration of a chemical exceeds the Inhalation SSL, a quantitative evaluation of potential risks from inhalation will be performed. Otherwise, the risks associated with the inhalation pathway will be considered insignificant, and the exposure pathway will be eliminated from further evaluation.

Screening Concentrations for Groundwater

Due to the likely impact of the lake on groundwater conditions, potential risks from exposure to groundwater at Site 12 will not be evaluated in this HHRA.

Surface Water and Sediment

Potential risks from exposure to surface water and sediment at Site 12 will not be evaluated in this HHRA.

Screening Concentrations for Lead

Limited criteria are available to evaluate the potential risks associated with lead. There are no risk-based concentrations for this chemical because the USEPA has not derived toxicity values for lead. However, recommended screening levels available for lead in soil are used to indicate the need for response activities. Guidance from both the Office of Prevention, Pesticides, and Toxic Substances (OPPTS) and the Office of Solid Waste and Emergency Response (OSWER) recommend 400 mg/kg as the lowest screening level for lead-contaminated soil in a residential setting, where children are frequently present (USEPA, July 1994). OPPTS identifies 2,000 to 5,000 mg/kg as an appropriate range for areas where contact with soil by children in a residential setting is less frequent

The TACO objectives of 800 and 700 mg/kg for the industrial/commercial and construction worker receptors, respectively will also be included for screening.

1.2.2 Essential Nutrients and Chemicals without Toxicity Criteria

Essential nutrients, including calcium, magnesium, potassium, and sodium will not be selected as COPCs for Site 12. These inorganic chemicals are naturally abundant in environmental matrices and are only toxic at high doses. In addition, because of the lack of toxicity criteria, risk-based COPC screening levels are not available for some chemicals (e.g., benzo(g,h,i)perylene and phenanthrene). Appropriate surrogates will be selected (with approval from the Illinois EPA) for some of these chemicals based on similar chemical structures. For example, pyrene will be used as the surrogate for benzo(g,h,i)perylene and phenanthrene..

1.2.3 Determination of Site-Related Chemicals

Chemicals in site media found at concentrations indicative of background concentrations are not considered to be site-related contaminants and will not be retained as COPCs for the quantitative risk assessment. In order to determine whether inorganic and anthropogenic organic chemicals are present at concentrations greater than background, the maximum detected concentrations of inorganic chemicals in soil will be compared with background levels provided by Illinois EPA (see Section 1.2.1).

The elimination of chemicals as site-related COPCs on the basis of background comparisons will follow the guidance provided in Navy Policy on the Use of Background Chemical Levels (Department of the Navy, January 2004). This document also presents the Navy's interpretation of USEPA guidance provided in the document titled Role of Background in the CERCLA Cleanup Program (USEPA, April 2002) and details the methodology to be used in evaluating background under the Navy's Environmental Restoration and Base Realignment and Closure (BRAC) programs. Navy policy as it applies to risk assessments requires the following:

1. A clear and concise understanding of chemicals released from a site, thus making sure the Navy is focusing on remediating the release.

2. The use of background data in the screening-level risk assessment.

    a. The comparison of site chemical levels to risk-based screening criteria.
    b. The comparison of site chemical levels to background concentrations.
    c. The identification of site-related COPCs based on screening criteria comparisons and background comparisons. Site-related COPCs are those chemicals with concentrations exceeding risk-based screening criteria and background concentrations. To the extent possible, site-related COPCs are further evaluated quantitatively in the risk assessment.

3. The consideration of background in the risk assessment.

    a. The calculation of risk estimates for site-related COPCs only.
    b. The further evaluation of non-site-related COPCs in the risk characterization section (e.g., the evaluation of chemicals detected at concentrations exceeding screening criteria but less than background concentrations). The Navy considers this comparison to be consistent with EPA's Role of Background in the CERCLA Cleanup Program (USEPA, April 2002). The uncertainty

associated with the elimination of chemicals on the basis of background will also be discussed in the uncertainty section of the risk assessment.

4. The selection of site cleanup remedial goals at concentrations not less than background levels. Additionally, cleanup levels should not be developed for chemicals not identified as chemicals of concern (COCs). As defined in the Navy guidance, COCs are site-related COPCs found to be the risk drivers in the risk assessment that may pose unacceptable human health risks.

1.2.4 Decision Rules for Establishing COPCs

The following decision rules will be used to select an initial list of COPCs:

- A chemical detected in soil will be selected as a COPC for soil if any detected chemical concentration exceeds the screening levels for soil and background screening indicates that the site concentrations are greater than Illinois EPA background concentrations.

Chemicals detected at concentrations greater than the screening levels but eliminated as COPCs on the basis of background comparisons and chemicals whose non-detection limits are greater than the site action limits will be further discussed in the risk characterization and uncertainty sections of the risk assessment.

1.3 COPC Summary Screening Tables

Media-specific tables summarizing the selection of COPCs will be included in the risk assessment. The tables will be prepared according to the guidelines established for preparation of Standard Table 2 of the RAGS Part D guidance. An example format of a typical COPC selection table is provided as Table 1.

2.0 EXPOSURE ASSESSMENT

The purpose of the Exposure Assessment is to predict the magnitude and frequency of potential human exposure to each of the COPCs. Actual or potential exposures at Site 12 will be determined based on the most likely pathways of contaminant release and transport, as well as human activity patterns. A complete exposure pathway has three components: (1) a source of chemicals that can be released to the environment, (2) a route of contaminant transport through an environmental medium, and (3) an exposure or contact point for a human receptor.

2.1 Conceptual Site Model (CSM)

The development of a CSM is an essential component of the exposure assessment. The CSM integrates information regarding the physical characteristics of the site, exposed populations, sources of contamination, and contaminant mobility (fate and transport) to identify potential exposure routes and receptors to be evaluated in the risk assessment. The site-specific CSM for Site 12 is presented in this section and illustrated in Figure 1. The CSM depicts the relationships among the following elements:

- Site sources of contamination
- Contaminant release mechanisms
- Transport/migration pathways
- Exposure routes
- Potential receptors

The CSM will be refined during the risk assessment process using the data and information collected as part of the proposed field investigation. Table 2 presents a summary of the exposure routes that will be addressed quantitatively for each human receptor. The elements of the CSM as they pertain to Site 12 are presented in the following sections.

2.1.1 Site Sources of Contamination

During harbor dredging activities in 1952 and the 1970s, dredge spoils from the boat slip area in the harbor were reportedly disposed at Site 12 (Rogers, Golden & Halpern, 1986). Dames & Moore (1991) reviewed aerial photographs taken between 1946 to 1985 which indicated evidence of some filling and other modifications of Site 12 over this period.

The harbor area receives flow from Pettibone Creek, which drains stormwater from the base and a number of off-base industries upstream of NS Great Lakes. Chemicals in the runoff may have settled in the sediments (Rogers, Golden & Halpern, 1986). The sediment reportedly dredged from the harbor and deposited on Site 12 could have high organic content and may contain heavy metals, oils (i.e., VOCs and SVOCs), pesticides, and polychlorinated biphenyls (PCBs) from industries upstream of the NS Great Lakes according to initial reports. These initial reports triggered an investigation of the site.
As part of a base-wide investigation Dames & Moore (1991) conducted the Verification Step of the Remedial Investigation (RI) at Site 12. Thirty-three surface and subsurface soil samples were collected from 11 soil borings there during three sampling events in 1988 and 1989. Samples were analyzed for VOCs, metals, pesticides and PCBs. Laboratory data for VOCs and metals could not be validated using

USEPA Level III data validation procedures and therefore were determined not usable for their intended purpose. The pesticide and PCB data was validated and considered usable. Dames & Moore (1991) did not present conclusions and recommendations in their report and, because of the validation issues; the document was issued as a Technical Memorandum. Following is some of the information provided:

- VOCs are not present in significant concentrations in the un-validated data; due to the nature of the sediment deposition, they probably were not present in significant concentrations in dredge spoils.
- Heavy metals, including antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc were detected in the un-validated data for site soils.
- Pesticides were detected above detection levels within the upper 5 feet throughout the site's areal extent,
- PCBs were not detected above the detection limits in any samples. However, due to the nature of past industrial development upstream of the site, they are still considered a possible contaminant.
- SVOCs have not been analyzed in soil samples from Site 12
- Groundwater levels and quality at the site have not been investigated. Both are expected to be strongly influenced by lake and harbor water conditions

2.1.2 Contaminant Release Mechanisms and Transport/Migration Pathways

Based on information regarding past practices at the site, plausible contaminant release and migration mechanisms include the following:

- Transport of chemicals deposited on surface and subsurface soil.

- Migration of fugitive dusts vapors from surface and subsurface soil to ambient air if construction/excavation activities occur in the future.

2.1.3 Potential Receptors/Exposure Routes

Naval Station Great Lakes is an active facility and will remain so for the foreseeable future. Under current land use, access to and use of Site 12 is primarily limited to military personnel. However, to aid in risk management decisions, the risk assessment will also consider potential receptors, such as future residents, who might be exposed to contaminants persisting in site media or migrating from the site. The potential receptors have been identified by analyzing current land use practices, potential future land

uses, and the identified areas of contamination in order to focus the risk assessment on potential site-related exposures. The general receptor classes include:

- Construction Workers - Potential receptors under future land uses. Construction workers are assumed to be civilian personnel who may be involved in a short-term, one-time construction project. Excavation and ground-intrusive activities may occur on the site in the future. If these excavation projects were to occur, construction workers could potentially be exposed to soil to an estimated depth of 10 feet bgs (conservative estimate based on available site information) by ingestion and dermal contact. Construction workers may also be exposed by inhaling dusts from soil or vapors emitted from soil during excavation.

- Occupational Workers – Potential receptors under future and current land use. Maintenance/occupational workers include personnel to account for the possibility that Naval Station Great Lakes might be developed for commercial/industrial uses at some future time. Maintenance/occupational workers will be assumed to be exposed to surface and subsurface soil by ingestion, dermal contact, and inhalation of fugitive dust and vapors.

- Future Military Residents (Adults/Children) – Potential receptor under future land use. Military residents are not potential receptors under current land use because they do not live on the site. They will be evaluated primarily for decision-making (risk management) purposes based on the assumption that the site could support military residential use in the future. Future military residents will be assumed to be exposed to subsurface soil by ingestion, dermal contact, and the inhalation of fugitive dust and vapors. Risks to military residents will be evaluated by reference to future civilian residents because risks for these receptors are the same or slightly less than civilian residents.

- Future Civilian Residents (Adults/Children) – Potential receptor under future land use. Hypothetical future residents are not potential receptors under current land use but will be evaluated to aid in risk management decisions by providing an indication of potential risks if the facility were to close and be developed for residential use. Future onsite residents will be assumed to be exposed to surface and subsurface soil by ingestion, dermal contact, and the inhalation of fugitive dust and vapors. Navy recruits were also considered as potential receptors at Site 12. However, exposure for the recruits was assumed to be negligible because of the limited time recruits spend at Naval Station Great Lakes (i.e., 12 weeks) and because the lack of idle time allocated to recruits during training. Therefore, risks to Navy recruits will not be evaluated in the risk assessment.

- Adult and adolescent recreational users/trespassers (e.g., picnickers) - Potential receptors under current/future land use. These receptors will be evaluated for exposure to surface soils at the site. Exposure to surface soils will be evaluated for ingestion, dermal contact, and inhalation of fugitive dust and vapors.

To aid risk managers in making remedial decisions for Site 12, potential future residents and maintenance/occupational workers will be evaluated for exposure to subsurface soil based on the assumption that subsurface soil could be brought to the surface in a future excavation project. If exposure to subsurface soil were to occur, a receptor may be exposed to soil via inadvertent ingestion of a small amount of soil, via dermal absorption of contaminants from the soil, or via inhalation of vapors or particulates. The results of this evaluation will be presented in the uncertainty section of the risk assessment.

Table 2 summarizes the exposure routes that will be addressed quantitatively for each receptor at Site 12.

2.2 Central Tendency Exposure vs. Reasonable Maximum Exposure

Traditionally, exposures evaluated in the HHRA were based on the concept of a Reasonable Maximum Exposure (RME) only, which is defined as "the maximum exposure that is reasonably expected to occur at a site" (USEPA, December 1989). However, more recent risk assessment guidance (USEPA, May 1993) indicates the need to address an average case or Central Tendency Exposure (CTE).

To provide a full characterization of potential exposure, both RME and CTE will be evaluated in the risk assessment for Site 12. The available guidance (USEPA, May 1993) concerning the evaluation of CTE is limited. Therefore, professional judgment will be exercised when defining CTE conditions for a particular receptor at the site.

2.3 Exposure Point Concentrations (EPCs)

EPCs, which are calculated for COPCs only, are estimates of chemical concentrations within an exposure unit (EU) that are likely to be contacted over time by a receptor and are used to estimate exposure intakes. The EUs evaluated and the guidelines for calculating the EPCs for the EUs within Site 12 are as follows:

- EUs for receptors potentially exposed to surface and subsurface soil will likely include the sampled locations within a study area unless the analytical data for soil suggest that significant contaminant hot spot(s)/sub-area(s) exist within the study area, and the hot spot(s)/sub-area(s) is (are) large enough to be considered an EU for one or more of the receptors being evaluated. For example, a residential lot size of ¼ acre to 2 acres is often used for the evaluation of a hypothetical future resident. The size of an EU will be based on the distribution of the chemical concentrations in soil and on presumed receptor activity patterns.

EPCs will be calculated for each medium at which receptors are assumed to be exposed. These media are:

- On-site surface and subsurface soil

The following guidelines will be used to calculate the EPCs:

- If a soil data set for an EU contains fewer than 10 samples, the EPC for the RME and CTE cases will be defined as the maximum detected concentration.

- If a soil data set for an EU contains 10 or more samples, the following receptor-specific EPCs will be used:

    - Current and future maintenance occupational workers along with current Navy personnel and adolescent trespassers will be assumed to be exposed to the upper confidence limit (UCL) on the arithmetic mean, which will be based on the distribution of the data set, for the RME and CTE cases. The EPCs will be calculated following USEPA's Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (USEPA, December 2002) using the USEPA's ProUCL Version , 4.00.05 software and guidance (USEPA, April 2007). Individual cases will be examined by a statistician who will make a decision on the appropriate value to use as the exposure concentration. Typically, recommendations made in Section 3 (Data Evaluation) of the ProUCL guidance or methods specified in Gilbert are used by the statistician. In keeping with past practice at Naval Station Great Lakes, Illinois EPA will be consulted for the non-typical cases.

    - Construction workers and future residents will be assumed to be exposed to the maximum detected concentration. The maximum detected concentration will be used as the EPC for

construction workers because of the possibility that construction workers might be exposed to a small highly concentrated area during the short exposure duration assumed for this receptor. The maximum concentration will be used to estimate risks for future residents based on the conservative assumption that a dwelling would be built on the most highly contaminated section of the site in the future.

- Risks for exposure to lead will follow the methodology presented in the preceding bullets. EPCs for construction workers and future residents will the maximum concentrations. The EPC for occupational workers will be the average lead concentration across the site, as per USEPA guidance for the child and adult lead models (Section 2.5).

Duplicate analytical results will not be used for the EPC calculations. The duplicate results will be used for sampling and analytical quality control purposes only. Data values less than sample-specific detection limits will be reported as the detection limit and the result designated as below detection by annotation.

2.4 Chemical Intake Estimation

The methodologies and techniques used to estimate exposure via ingestion, dermal contact, or inhalation are presented in this section of the Work Plan. Intakes for the identified potential receptor groups will be calculated using USEPA risk assessment guidance (USEPA, December 1989 and July 2004) and presented in the risk assessment spreadsheets which will be appended to the risk assessment as support documentation.

Noncarcinogenic intakes will be estimated using the concept of an average annual exposure. Carcinogenic intakes will be calculated as an incremental lifetime exposure that will assume a life expectancy of 70 years. Equations used to calculate estimated intakes are provided below.

Values of the exposure parameters and assumptions regarding exposure for receptors and exposure pathways are presented in Tables 3 and 4.

2.4.1 Dermal Contact with Soil

Direct physical contact with soil may result in the dermal absorption of chemicals. Exposures associated with the dermal route are estimated in the following manner (USEPA, December 1989 and July 2004):

$$\text{Intake}_{si} = (C_{si})(SA)(AF)(ABS)(CF)(EF)(ED) / (BW)(AT)$$

where:

$Intake_{si}$	=	amount of chemical "i" absorbed during contact with soil (mg/kg/day)
C_{si}	=	concentration of chemical "i" in soil (mg/kg)
SA	=	skin surface area available for contact (cm^2/day)
AF	=	skin adherence factor (mg/cm^2)
ABS	=	absorption factor (dimensionless)
CF	=	conversion factor ($1x10^{-6}$ kg/mg)
EF	=	exposure frequency (days/yr)
ED	=	exposure duration (yr)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/yr;
		for carcinogens, AT = 70 yrs x 365 days/yr

Exposed skin surface areas available for dermal contact are determined for each receptor based on assumed human activities and clothing worn during exposure events. USEPA guidance (USEPA, August 1997 and July 2004) is used to develop the default assumptions concerning the amount of skin surface area available for contact for a receptor. The skin surface areas that will be used in risk assessment calculations and the rationale for the selection of the surface areas are as follows:

- Occupational workers and construction/excavation workers are assumed to be exposed on the head, hands and forearms assuming that they wear a short-sleeved shirt, long pants, and shoes. As recommended in RAGS Part E (USEPA, July 2004), this skin surface area is assumed to be 3,300 cm^2 for the RME and CTE scenarios. This value represents the average of the 50th percentile areas of males and females more than 18 years old.

- For future military and civilian adult residents along with current Navy personnel and adolescent trespassers are assumed to be exposed to soil, the exposed surface areas available for contact will be the values for the adult skin surface area for exposure to soil recommended in RAGS Part E (USEPA, July 2004), 5,700 cm^2 for both the RME and CTE. This skin area assumes that head, hands, forearms, and lower legs of the adult are available for contact. For child residents assumed to be exposed to soil, the exposed surface areas available for contact will be the values for child skin surface area for exposure to soil recommended in RAGS Part E (USEPA, July 2004), 2,800 cm^2 for both the RME and CTE. This skin area assumes that head, hands, forearms, lower legs, and feet of the child are available for contact.

Values of soil adherence factors and chemical-specific dermal absorption factors provided in RAGS Part E (USEPA, July 2004) will be used to evaluate risks from exposure to soil. The following soil adherence factors will be used for the RME and CTE exposure scenarios:

- Construction Workers – 0.3 mg/cm^2 for the RME and 0.1 mg/cm^2 for the CTE (Exhibit 3.3, USEPA, July 2004).

- Occupational Workers – 0.2 mg/cm^2 for the RME and 0.02 mg/cm^2 for the CTE (Exhibit 3.5, USEPA, July 2004).

- Adolescent Recreational Users/Trespassers – 0.2 mg/cm^2 for the RME and 0.04 mg/cm^2 for the CTE. (Exhibit 3.5, U.S. EPA, July, 2004).

- Future Adult Residents and Adult Recreational Users/Trespassers – 0.07 mg/cm^2 for the RME and 0.01 mg/cm^2 for the CTE (Exhibit 3.5, U.S. EPA, July, 2004)

- Future Child Residents – 0.2 mg/cm^2 for the RME and 0.04 mg/cm^2 for the CTE (Exhibit 3.5, USEPA, July 2004).

For the constituents identified as COPCs in soil, the following absorption factors will be used (USEPA, July 2004):

- Arsenic – 0.03
- Cadmium – 0.001
- PAHs – 0.13
- Semivolatiles – 0.1
- Other Inorganics and Volatile Organics – not evaluated for dermal contact with soil (USEPA, July 2004)

2.4.2 Incidental Ingestion of Soil

Incidental ingestion of soil by potential receptors is assumed to coincide with dermal exposure. Exposures associated with incidental ingestion are estimated in the following manner (USEPA, December 1989):

$$Intake_{si} = (C_{si})(IR_s)(FI)(EF)(ED)(CF) / (BW)(AT)$$

where:

$Intake_{si}$	=	intake of contaminant "i" from soil (mg/kg/day)
C_{si}	=	concentration of contaminant "i" in soil (mg/kg)
IR_s	=	ingestion rate (mg/day)
FI	=	fraction ingested from contaminated source (dimensionless)
EF	=	exposure frequency (days/yr)
ED	=	exposure duration (yr)
CF	=	conversion factor ($1x10^{-6}$ kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/yr;
		for carcinogens, AT = 70 yrs x 365 days/yr

The same exposure frequencies and durations used in the estimation of dermal intakes will be used to estimate exposure via incidental ingestion. A default value of 1.0 (USEPA, December 1989) will be used for the fraction ingested from the contaminated source for the RME and CTE scenarios. For the RME scenario, the ingestion rate is set at 330 mg/day for the construction worker (USEPA, December 2002), 200 mg/day for the future child resident, and 100 mg/day for the other potential receptors (the occupational worker and future adult resident) (USEPA, May 1993). Ingestion rates for the CTE are assumed to be one-half of the RME values.

2.4.3 Inhalation of Air Containing Fugitive Dust/Volatiles Emitted from Soil

The inhalation pathway will be quantitatively evaluated only if it is determined to be necessary by a comparison with USEPA SSLs for the migration of chemicals from soil to air. These modeled air concentrations are calculated by Tetra Tech using the methodology and equations based on USEPA's Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites for the migration of chemicals from soil to air (OSWER 9355.4-24, December 2002) and equations published at http://rais.ornl.gov/epa/ssl1.shtml, since these values are more recent than those published in the 1996 and 2002 SSL guidance documents.

For those chemicals that exceed their respective SSLs, this pathway is quantitatively evaluated and these are compared with unit risk and RFCs to calculated inhalation risks and noncancer hazards for this

pathway. If it is determined that a quantitative evaluation is not required, the potential risks associated with the inhalation pathway will be regarded as minimal and no further evaluation will be performed.

The amount of chemical a receptor takes in as a result of respiration is determined using the concentration of the contaminant in air. Intakes of both particulates and vapors from soil will be calculated using the following equation (USEPA, December 1991 and July 1996):

$$Intake_{ai} = [C_{si} \times IR_a \times ET \times EF \times ED \times (1/PEF + 1/VF)] / (BW \times AT)$$

where:	$Intake_{ai}$	=	intake of chemical "i" from air via inhalation (mg/kg/day)
	C_{si}	=	concentration of chemical "i" in soil (mg/kg)
	IR_a	=	inhalation rate (m^3/hr or day)
	ET	=	exposure time (hours/day)
	EF	=	exposure frequency (days/yr)
	ED	=	exposure duration (yr)
	PEF	=	Particulate Emission Factor (m^3/kg)
	VF	=	Volatilization Factor (chemical-specific) (m^3/kg)
	BW	=	body weight (kg)
	AT	=	averaging time (days);
			for noncarcinogens, AT = ED x 365 days/yr;
			for carcinogens, AT = 70 yr x 365 days/yr

The concentration of a chemical in air is calculated using the methodology provided in the USEPA's Soil Screening Guidance (USEPA, July 1996 and December 2002) and measured soil concentrations, site-specific information such as the fraction of organic carbon (f_{oc}), chemical-specific data, and model default values. The following inhalation rates are used to calculate the inhalation intakes: for workers, 2.5 m^3 per hour for the RME and 1.5 m^3 per hour for the CTE (USEPA, August 1997 and December 2002), 20 m^3 per day for adult residents for the CTE and RME (USEPA, December 1989 and March 1991), and 10 m^3 per day for child residents six years of age and under (USEPA, August 1997) for the CTE and RME.

2.5 Exposure to Lead

The equations and methodology presented in the previous section cannot be used to evaluate exposure to lead because of the absence of published dose-response parameters. If lead is identified as a COPC, exposure to lead will be assessed using the latest version of the USEPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model for lead (USEPA, May 2002). This model is designed to estimate blood levels

of lead in children (under 7 years of age) based on either default or site-specific input values for air, drinking water, diet, dust, and soil exposure.

Studies indicate that infants and young children are extremely susceptible to adverse effects from exposure to lead. Considerable behavioral and developmental impairments have been noted in children with elevated blood lead levels. The threshold for toxic effects from this chemical is believed to be in the range of 10 µg/dL to 15 µg/dL. Blood lead levels greater than 10 µg/dL are considered to be a "concern."

Adult exposure to lead in soil will be quantified by the model provided by the USEPA's Technical Review Workgroup for Lead (USEPA, November 2003). In this model, adult exposure to lead in soil is addressed by an evaluation of the relationship between the site soil lead concentration and the blood lead concentration in the developing fetuses of adult women. The adult lead model will generate a spreadsheet for each exposure scenario evaluated (i.e., workers and adult residents). The spreadsheets will calculate a range of 95th percentile fetal blood lead concentrations from central estimates of blood lead concentrations in pregnant adult women. The spreadsheets also calculate 95th percentile blood lead concentrations in fetuses born to women exposed to lead in soil.

No models are currently available to evaluate the periodic exposure of adolescent trespassers to lead. Therefore, guidance provided in the USEPA's Assessing Intermittent or Variable Exposures to Lead Sites (USEPA, 2003) will be used to evaluate the periodic exposure expected for this receptor. This guidance makes use of such options as time weighting, varying intensity of exposure, and seasonal variability, in conjunction with the IEUBK and ALM models, to estimate exposure to lead in soil

3.0 TOXICITY ASSESSMENT

The objective of the toxicity assessment is to identify the potential health hazards and adverse effects in exposed populations. Quantitative estimates of the relationship between the magnitude and type of exposures and the severity or probability of human health effects will be defined for the identified COPCs. Quantitative toxicity values determined during this component of the risk assessment will be integrated with outputs of the exposure assessment to characterize the potential for the occurrence of adverse health effects for each receptor group.

The toxicity value used to evaluate noncarcinogenic health effects is the Reference Dose (RfD). Carcinogenic effects are quantified using the Cancer Slope Factor (CSF).

3.1 Toxicity Criteria

Oral and inhalation RfDs and CSFs to be used in the site-specific risk assessment for Site 12 will be obtained from the following primary literature sources (USEPA, December 2003):

- Integrated Risk Information System (IRIS) (Online at http://www.epa.gov/iris/subst/index.html).

- USEPA Provisional Peer Reviewed Toxicity Values (PPRTVs) – The Office of Research and Development/National Center for Environmental Assessment (NCEA) Superfund Health Risk Technical Support Center develops PPRTVs on a chemical specific basis when requested by the USEPA's Superfund program.

- Annual Health Effects Assessment Summary Tables (HEAST) (USEPA, July 1997) for chronic and subchronic toxicity values.

- Other Toxicity Values – These sources include but are not limited to California Environmental Protection Agency (Cal EPA) toxicity values, the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs).

- Illinois EPA Bureau of Land at http://www.epa.state.il.us/land/taco/toxicity-values.xls for subchronic toxicity values

- The Risk Assessment Information System (RAIS) http://rais.ornl.gov/tox/toxvals.shtml for subchronic toxicity values.

- Although RfDs and CSFs can be found in several toxicological sources, USEPA's IRIS online database is the preferred source for toxicity values. The ORNL Regional Screening Levels for Chemical Contaminants at Superfund Sites (ORNL, June 2008) will also be used as sources of toxicity criteria. Guidance provided in RAGS-Part C (USEPA, October 1991) and by Illinois EPA will also be used when evaluating subchronic risks for the construction worker.

3.2 Toxicity Criteria for Dermal Exposure

RfDs and CSFs found in literature may be expressed as administered doses; therefore, these values are considered to be inappropriate for estimating the risks associated with dermal routes of exposure. Oral dose-response parameters based on administered doses must be adjusted to absorbed doses before the comparison to estimated dermal exposure intakes is made. Because this information is not always readily available, oral dose-response parameters will be adjusted to an absorbed dose using chemical-specific absorption efficiencies published in available guidance (USEPA, July 2004) and the following equations:

$$RfD_{dermal} = (RfD_{oral})(ABS_{GI})$$

$$CSF_{dermal} = (CSF_{oral}) / (ABS_{GI})$$

where:

ABS_{GI} = absorption efficiency in the gastrointestinal tract

Absorption efficiencies used in the risk assessments will reflect the USEPA's current dermal assessment guidance (USEPA, July 2004).

3.3 Toxicity Criteria for Chromium

Toxicity criteria are available for two different forms of chromium, the trivalent state and the hexavalent state, of which the latter is considered to be more toxic. The screening of chromium will be conducted assuming that 100 percent of the reported total chromium is hexavalent. Should chromium, assumed to be hexavalent, prove to be a significant contributor to risk, further investigation regarding the presence and valence state of chromium may be necessary. The uncertainty associated with the assumption that all chromium is hexavalent chromium will be discussed in the uncertainty section of the risk assessment.

4.0 RISK CHARACTERIZATION

Potential risks (noncarcinogenic and carcinogenic) for human receptors resulting from the exposures outlined in the exposure assessment are quantitatively determined during the risk characterization component of the human health risk assessment.

A summary and interpretive discussion of the quantitative risk estimates will be provided in the text of the risk assessment. During the interpretive risk discussion, COPCs that contribute significantly to elevated risks will be identified as "risk drivers" or chemicals of concern (COCs). The numeric estimates of risk will be contained in the risk assessment spreadsheets that will be appended to the risk assessment as support documentation.

4.1 Quantitative Analysis

Quantitative estimates of risk will be calculated according to risk assessment methods outlined in USEPA guidance (USEPA, December 1989). Lifetime cancer risks will be expressed in the form of dimensionless probabilities, referred to as incremental lifetime cancer risks (ILCRs), based on CSFs. Noncarcinogenic risk estimates will be presented in the form of Hazard Quotients (HQs) that are determined through a comparison of intakes with published RfDs.

ILCR estimates are generated for each COPC using estimated exposure intakes and published CSFs, as follows:

$$\text{ILCR} = \text{Estimated Exposure Intake} \times \text{CSF}$$

If the above equation results in an ILCR greater than 0.01, the following equation (USEPA, December 1989) will be used:

$$\text{ILCR} = 1-(\exp-[\text{Estimated Exposure Intake} \times \text{CSF}])$$

An ILCR of 1×10^{-6} indicates that the exposed receptor has a one-in-one-million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons.

As mentioned previously, noncarcinogenic risks will be assessed using the concept of HQs and Hazard Indices (HIs). The HQ for a COPC is the ratio of the estimated intake to the RfD, as follows:

$$\text{HQ} = \text{Estimated Exposure Intake} \div \text{RfD}$$

An HI will be generated by summing the individual HQs for the COPCs. The HI is not a mathematical prediction of the severity of toxic effects and therefore is not a true "risk"; it is simply a numerical indicator of the possibility of the occurrence of noncarcinogenic (threshold) effects.

4.2 Comparison of Quantitative Risk Estimates to Benchmarks

Quantitative risk estimates will be compared to USEPA and Illinois EPA benchmarks to interpret the quantitative risks and to aid risk managers in determining the need for remediation at a site. Calculated ILCRs will be interpreted using the USEPA's "target range" ($1x10^{-4}$ to $1x10^{-6}$) and HIs are evaluated using a value of 1.0. The Illinois EPA goal for carcinogenic risks, as specified in TACO, is $1x10^{-6}$.

The USEPA has defined the range of $1x10^{-4}$ to $1x10^{-6}$ as the ILCR target range for most hazardous waste facilities addressed under CERCLA and RCRA. Individual or cumulative ILCRs greater than $1x10^{-4}$ are typically not considered as protective of human health, and ILCRs less than $1x10^{-6}$ are typically regarded as protective. Risk management decisions are necessary when the ILCR is within the $1x10^{-4}$ to $1x10^{-6}$ cancer risk range. Risks greater than $1x10^{-6}$ will be discussed in the risk assessment.

An HI exceeding unity (1.0) indicates that there may be potential noncarcinogenic health risks associated with exposure. If an HI exceeded unity, a segregation of target organs effects associated with exposure to COPCs is performed. Only those chemicals that affect the same target organ(s) or exhibit similar critical effect(s) are regarded as truly additive. Consequently, it may be possible for a cumulative HI to exceed 1.0, but have no anticipated adverse health effects if the COPCs do not affect the same target organ or exhibit the same critical effect.

4.3 Qualitative Analysis

A qualitative evaluation of risk will be made for several exposure situations.

- The soil inhalation pathway will be initially evaluated by a comparison of maximum site soil concentrations to USEPA Generic SSLs for transfers from soil to air and Illinois EPA Tier 1 Soil Remediation Objectives for Residential Properties for the inhalation exposure route. If the maximum site concentration exceeds the SSL for a chemical, a quantitative analysis of this exposure pathway will be performed.

- The potential for the migration of soil contaminants to groundwater will be assessed by a comparison of maximum and average soil concentrations to Illinois EPA and USEPA Generic SSLs for transfers from soil to groundwater. SSLs based on dilution and attenuation factors (DAFs) of 1 and 20, respectively, will be used in the evaluation. The comparisons will be presented in tables and results of the analysis will be discussed in the risk assessment.

5.0 UNCERTAINTY ANALYSIS

The goal of the uncertainty analysis is to identify important uncertainties and limitations associated with the HHRA. Uncertainties related to each component of the assessment (i.e., data evaluation, exposure assessment, toxicity assessment, and risk characterization) will be presented. In addition, the effect of a particular uncertainty on the outcome of the assessment (i.e., risk estimates) will also be discussed, where possible. The following subsections present an overview of uncertainties that may be addressed in the risk assessment uncertainty section.

5.1 Uncertainty in Data Evaluation

This section may discuss uncertainties in the risk assessment associated with the analytical data and data quality. This may also involve a discussion of uncertainty in the COPC selection process, the inclusion or exclusion of COPCs in the risk assessment on the basis of background concentrations, the uncertainty in COPC screening levels, and the omission of constituents for which health criteria are not available. The discussion will be based, in part, on the evaluation in the “Data Usability Worksheet” as suggested in RAGS Part D (USEPA, December 2001).

5.2 Uncertainty in the Exposure Assessment

This section will include a discussion of the following: assumptions related to current and future land use; the uncertainty in EPCs (e.g., the use of maximum concentrations to estimate risks); uncertainty in the selection of potential receptors and exposure scenarios; and uncertainty in the selection of exposure parameters (RME vs. CTE). If predictive models are used in the risk estimation, the uncertainty associated with the model and modeling parameters will be evaluated.

5.3 Uncertainty in the Toxicity Assessment

The uncertainties inherent in RfDs and CSFs and use of available criteria will be discussed. A discussion of the uncertainty in hazard assessment that deals with characterizing the nature and strength of the evidence of causation, or the likelihood that a chemical that induces adverse effects in animals will also induce adverse effects in humans, will be provided. This section will also discuss uncertainty in the dose-response evaluations for the COPCs that relates to the determination of a CSF for the carcinogenic assessment and derivation of an RfD or Reference Concentration (RfC) for the noncarcinogenic assessment. In addition, a discussion of the uncertainty in the toxicity of specific constituents, such as arsenic and chromium will be presented, if applicable.

5.4 Uncertainty in the Risk Characterization

This section will discuss the uncertainty in risk characterization that results primarily from assumptions made regarding additivity/synergism of effects from exposure to multiple COPCs affecting different target organs across various exposure routes. The risk assessment will discuss the uncertainty inherent in summing risks for several substances across different exposure pathways. It should be noted that probabilistic risk assessment techniques may also be used to further define the uncertainty attached to the risk characterization results. However, the exposure assumptions (e.g., probability distributions) used to prepare the probabilistic risk assessment will be reviewed with the regulatory reviewers before they are incorporated into the uncertainty section of the risk assessment.

TABLE 1

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SITE 12 - HARBOR DREDGE SPOIL AREA
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

Scenario Timeframe:
Medium:
Exposure Medium:
Exposure Point:

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)

1 Minimum/maximum detected concentration.
2 N/A - Refer to supporting information for background discussion.
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information.
3 Provide reference for screening toxicity value.
4 Rationale Codes Selection Reason: Infrequent Detection but Associated Historically (HIST).
Frequent Detection (FD)
Toxicity Information Available (TX0)
Above Screening Levels (ASL)
Deletion Reason: Infrequent Detection (IFD)
Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Definitions: N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAC/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
MCL = Federal Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

TABLE 2

HUMAN HEALTH RISK ASSESSMENT
EXPOSURE ROUTES FOR POSSIBLE QUANTITATIVE EVALUATION
SITE 12 – HARBOR DREDGE SPOIL AREA
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

Receptors	Exposure Routes*
Construction Workers (future land use)	• Surface and Subsurface Soil - Dermal Contact • Surface and Subsurface Soil - Incidental Ingestion • Surface and Subsurface Soil - Inhalation of Vapor and Dust
Occupational Workers (future land use)	• Surface and Subsurface Soil - Dermal Contact • Surface and Subsurface Soil - Incidental Ingestion • Subsurface Soil – Inhalation of Vapors • Surface Soil – Inhalation of Dusts
Recreational User/ Trespasser (Adult/Children)	• Surface Soil - Dermal Contact • Surface Soil - Incidental Ingestion • Subsurface Soil – Inhalation of Vapors • Surface Soil – Inhalation of Dusts
Future Residents (Adult/Children)	• Surface and Subsurface Soil - Dermal Contact • Surface and Subsurface Soil - Incidental Ingestion • Subsurface Soil – Inhalation of Vapors • Surface Soil – Inhalation of Dusts

*Complete pathways dependent on exceedances of COPCs to screening criteria.

TABLE 3

SUMMARY OF EXPOSURE INPUT PARAMETERS, REASONABLE MAXIMUM EXPOSURES
SITE 12 - HARBOR DREDGE SPOIL AREA
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

Exposure Parameter	Construction Worker	Occupational Worker	Adolescent Recreational User/Trespasser	Adult Recreational User/Trespasser	On-Site Child Resident	On-Site Adult Resident
All Exposures						
C_{soil}/C_{sed} (mg/kg)	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
C_{gw} (µg/L)	Average	Average	NA	NA	Average	Average
C_{sw} (µg/L)	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
ED (years)	1[2]	25[3]	10[4]	24[5]	6[5]	24[5]
BW (kg)	70[5]	70[5]	42[6]	70[5]	15[5]	70[5]
AT_n (days)	42[7]	9,125[8]	3,650[8]	8,760[8]	2,190[8]	8,760[8]
AT_c (days)	25,550[8]	25,550[8]	25,550[8]	25,550[8]	25,550[8]	25,550[8]
Incidental Ingestion/Dermal Contact with Soil						
IR (mg/day)	330[9]	100[5]	100[5]	100[5]	200[5]	100[5]
EF-Soil (days/year)	30[10]	250[5]	26[4]	26[4]	350[5]	350[5]
FI (unitless)	1[5]	1[5]	1[5]	1[5]	1[5]	1[5]
SA (cm^2/day)	3,300[11]	3,300[11]	3,280[7]	3,300[11]	2,800[11]	5,700[11]
AF (mg/cm^2)	0.3[11]	0.2[11]	0.2[11]	0.2[11]	0.2[11]	0.07[11]
ABS (unitless)	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]
CF (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Inhalation Fugitive Dust/Volatile Emissions from Soil						
C_{air} (mg/m^3)	calculated[9]	calculated[9]	calculated[10]	calculated[9]	calculated[9]	calculated[9]
InhR (m^3/hour)	2.5[6]	2.5[10]	1.9[7]	2.5[10]	10 m^3/day[6]	20 m^3/day[9]
ET (hours/day)	8[12]	8[10]	2[4]	2[4]	24[6]	24[9]
EF-Soil (days/year)	30[10]	250[5]	26[4]	26[4]	350[5]	350[5]
PEF (m^3/kg)	1.27E+06[13]	1.36E+9[10]	1.36E+9[10]	1.36E+9[10]	1.36E+09[9]	1.36E+09[9]

Notes:

A	Skin surface area available for contact	EF	Exposure frequency
ABS	Absorption factor	ET	Exposure time
AF	Soil-to-skin adherence factor	EV	Event frequency
AT_c	Averaging time for carcinogenic effects	FI	Fraction ingested from contaminated source
AT_n	Averaging time for non-carcinogenic effects	InhR	Inhalation rate

TABLE 3

SUMMARY OF EXPOSURE INPUT PARAMETERS, REASONABLE MAXIMUM EXPOSURES
SITE 12 - HARBOR DREDGE SPOIL AREA
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

B	Bunge Model partitioning coefficient	IR	Ingestion rate (soil or groundwater)
BW	Body weight	K_p	Permeability coefficient from water through skin
CF	Conversion factor	SA	Skin surface area available for contact
IR	Ingestion rate	PEF	Particulate emission factor
$C_{soil/sed}$	Exposure concentration for soil/sediment	τ	Lag time
$C_{gw/sw}$	Exposure concentration for groundwater/surface water	t*	Time it takes to reach steady-state conditions
C_{air}	Exposure concentration for air	t_{event}	Duration of event
ED	Exposure duration		

1 - U.S. EPA, 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.
2 - Professional judgment.
3 - U.S. EPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.
4 - Adolescents ages 7 to 16 years old.
5 - U.S. EPA, 1993: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
6 - U.S. EPA, 1997: Exposure Factors Handbook. EPA/600/8-95/002FA.
7 - IEPA, Janaury 2003.
8 - U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A.
9 - U.S. EPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9365.4-24.
10 - IEPA, April 2004.
11 - U.S. EPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. PA/540/R/99/005.
12 - Assume an 8-hour work shift.
13 - The PEF for construction workers is calculated using the equations presented in the Supplemental Guidance For Developing Soil Screening Levels For Superfund Sites

Note: The exposure factors for future civilian and military residents are the same, except for exposure duration (ED) for adult military residents.
Exposure duration for adult military residents is assumed to be the typical enlistment times of 6 years, for the RME and CTE.

TABLE 4

SUMMARY OF EXPOSURE INPUT PARAMETERS, CENTRAL TENDENCY EXPOSURES
SITE 12 - HARBOR DREDGE SPOIL AREA
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

Exposure Parameter	Construction Worker	Occupational Worker	Adolescent Recceational User/Trespasser	Adult Recreational User/Trespasser	On-Site Child Resident	On-Site Adult Resident
All Exposures						
C_{soil}/C_{sed} (mg/kg)	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
C_{gw} (µg/L)	Average	Average	NA	NA	Average	Average
C_{sw} (µg/L)	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
ED (years)	1[2]	9[3]	10[4]	7[3]	2[3]	7[3]
BW (kg)	70[3]	70[3]	42[5]	70[3]	15[3]	70[3]
AT_n (days)	42[6]	3,285[7]	3,650[7]	2,555[7]	730[7]	2,555[7]
AT_c (days)	25,550[7]	25,550[7]	25,550[7]	25,550[7]	25,550[7]	25,550[7]
Incidental Ingestion/Dermal Contact with Soil						
IR (mg/day)	165[8]	50[9]	50[9]	50[9]	100[8]	50[8]
EF-Soil (days/year)	30[9]	219[3]	13[4]	13[4]	234[3]	234[3]
FI (unitless)	1[3]	1[3]	1[3]	1[3]	1[3]	1[3]
SA (cm^2/day)	3,300[10]	3,300[10]	3,100[6]	3,300[10]	2,800[10]	5,700[10]
AF (mg/cm^2)	0.1[10]	0.02[10]	0.04[10]	0.02[10]	0.04[10]	0.01[10]
ABS (unitless)	chemical-specific[10]	chemical-specific[10]	chemical-specific[10]	chemical-specific[10]	chemical-specific[10]	chemical-specific[10]
CF (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Inhalation Fugitive Dust/Volatile Emissions from Soil						
C_{air} (mg/m^3)	calculated[11]	calculated[11]	calculated[11]	calculated[11]	calculated[11]	calculated[11]
InhR (m^3/hour)	2.5[5]	1.5[6]	1.2[6]	1.5[6]	10 m^3/day[5]	20 m^3/day[11]
ET (hours/day)	4[8]	4[9]	1[9]	1[9]	24[5]	24[11]
EF-Soil (days/year)	30[9]	219[3]	13[4]	13[4]	234[3]	234[3]
PEF (m^3/kg)	1.27E+06[12]	1.36E+09[11]	1.36E+9[11]	1.36E+9[11]	1.36E+09[11]	1.36E+09[11]

Notes:

A	Skin surface area available for contact	EF	Exposure frequency
ABS	Absorption factor	ET	Exposure time
AF	Soil-to-skin adherence factor	EV	Event frequency
AT_c	Averaging time for carcinogenic effects	FI	Fraction ingested from contaminated source
AT_n	Averaging time for non-carcinogenic effects	InhR	Inhalation rate

TABLE 4

SUMMARY OF EXPOSURE INPUT PARAMETERS, CENTRAL TENDENCY EXPOSURES
SITE 12 - HARBOR DREDGE SPOIL AREA
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

B	Bunge Model partitioning coefficient	IR	Ingestion rate (soil or groundwater)
BW	Body weight	K_p	Permeability coefficient from water through skin
CF	Conversion factor	SA	Skin surface area available for contact
IR	Ingestion rate	PEF	Particulate emission factor
$C_{soil/sed}$	Exposure concentration for soil/sediment	τ	Lag time
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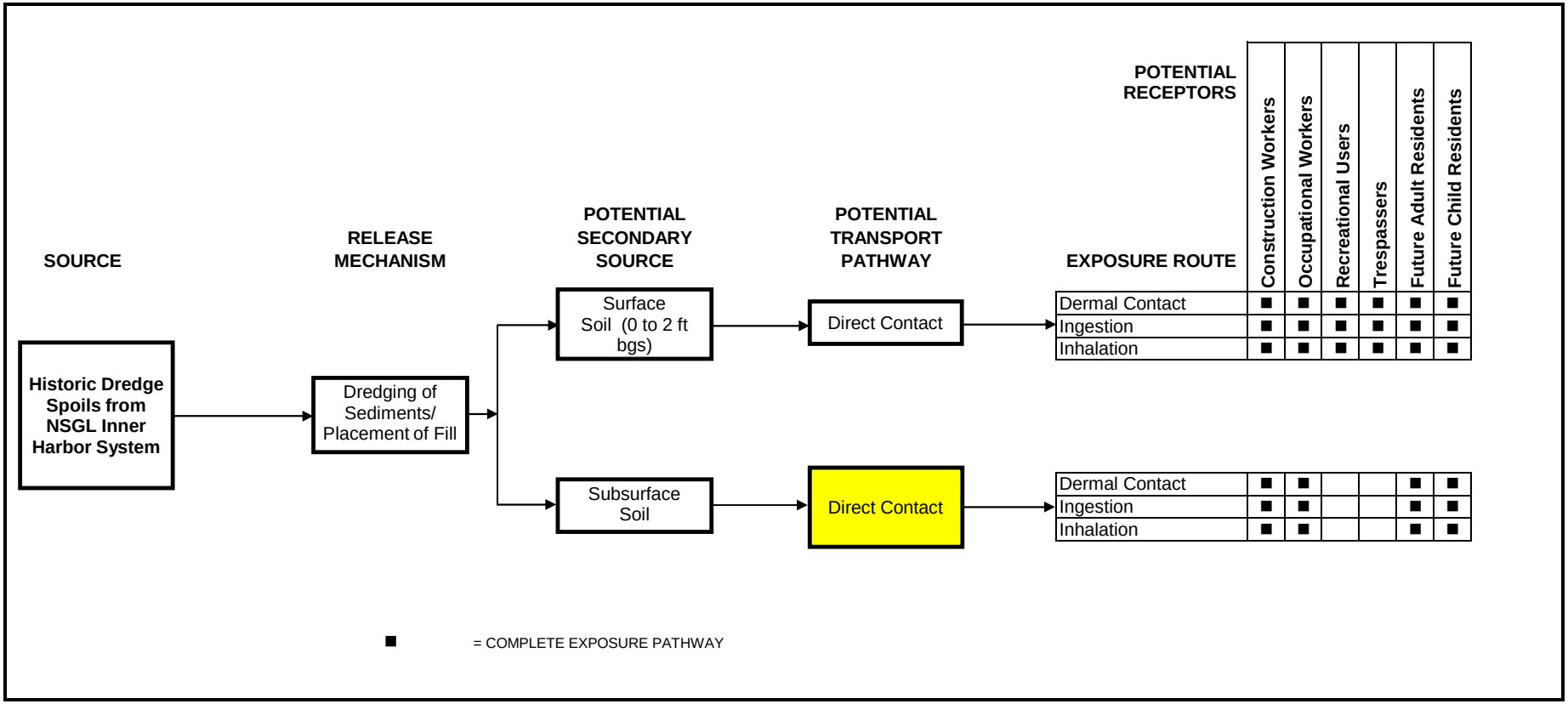
C_{air}	Exposure concentration for air	t_{event}	Duration of event
ED	Exposure duration		

1 - U.S. EPA, 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.
2 - Professional judgment.
3 - U.S. EPA, 1993: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
4 - Adolescents ages 7 to 16 years old.
5 - U.S. EPA, 1997: Exposure Factors Handbook. EPA/600/8-95/002FA.
6 - IEPA, Janaury 2003.
7 - U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A.
8 - Central tendency exposure is assumed to be one-half the reasonable maximum exposure value.
9 - IEPA, April 2004.
10 - U.S. EPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. PA/540/R/99/005.
11 - U.S. EPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9365.4-24.
12 - The PEF for construction workers is calculated using the equations presented in the Supplemental Guidance For Developing Soil Screening Levels For Superfund Site

Note: The exposure factors for future civilian and military residents are the same, except for exposure duration (ED) for adult military residents.
Exposure duration for adult military residents is assumed to be the typical enlistment times of 6 years, for the RME and CTE.

FIGURE 6-1

HUMAN HEALTH CONCEPTUAL SITE MODEL
SITE 12 - HARBOR DREDGE SPOIL AREA
NAVAL STATION GREAT LAKES, ILLINOIS



Blank space indicates incomplete exposure pathway or relatively insignificant or not applicable potential exposure.
A complete exposure pathway requires a source, a route of contaminant transport, and an exposure or contact point for a human receptor. If one of these is lacking, the exposure pathway is considered incomplete and is not quantitatively in the risk assessment under current land use. However, the situation at the site might change in the future (e.g., residential dwellings could be built), and the exposure pathway for future residents would be complete and would then be evaluated in the risk assessment under future land use.

APPENDIX D

LABORATORY STANDARD OPERATING PROCEDURES

METALS DIGESTION/PREPARATION

METHODS

USEPA SW846

3005A, 3010A, 3030C, 3031, 3050B

USEPA CLPILM 04.1 Aqueous & Soil/Sediment (NJDEP does not accept CLPILM 04.1 after June, 2003)

Addendum for USEPA CLPILM 05.2 Aqueous & Soil/Sediment

USEPA Methods for Chemical Analysis of Water and Wastes

200.7, Standard Methods 3030C

SOP NUMBER: **SOP-100**

REVISION NUMBER: **19**

APPROVED BY:

Betty DeVille

SECTION MANAGER

Randy D. Ward

QUALITY ASSURANCE OFFICER

07/25/06

EFFECTIVE DATE

04/20/09

DATE OF LAST REVIEW

METALS DIGESTION/PREPARATION

References:
Methods 3005A/USEPA CLPILM0 4.1 Aqueous, 3010A, 3030C, 3031, 3050B
USEPA CLPILM0 4.1 (Soil/Sediment), 200.7, Standard Methods 3030C
See Addendum for USEPA CLPILM 05.2 (Aqueous & Soil/Sediment)

I. SCOPE AND APPLICATION

A. AQUEOUS

1. Method 3005A and USEPA CLP ILM0 4.1, "Acid Digestion of Waters for Total Recoverable or Dissolved Metals for Analysis by ICP Spectroscopy".

   a. This method is used to prepare surface water, ground water, drinking water and wastewater samples for analysis by inductively coupled argon plasma spectroscopy (ICP).

2. Method 200.7, "Determination of Metals and Trace Metals in Water and Wastes by Inductively Coupled Plasma-Atomic Emission Spectrometry"

   a. This method is used to prepare surface water, ground water, drinking water and wastewater samples for analysis by inductively coupled argon plasma spectroscopy (ICP).

3. Method 3010A, "Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by ICP Spectroscopy".

   a. This method is used to prepare aqueous samples, EP and mobility-procedure extracts, and wastes that contain suspended solids for analysis by ICP. The procedure is used to determine total metals.

4. Method 3030C (Standard methods), "Preliminary Treatment for Acid-Extractable Metals".

   a. This method is used to prepare ground water samples from North Carolina for analysis by ICP.

B. SOLIDS

1. Method 3050B, "Acid Digestion of Sediments, Sludges and Soils".

   a. This method is used to prepare sediments, sludges and soil samples for analysis by ICP. Since certain matrices may result in poor recovery, the method of standard additions may be used when analyzed.

   b. It should be noted that some metals could be biased high with the soil digestion when dilution is necessary. Take necessary measures to ensure that dilutions are made as accurately as possible.

2. USEPA CLP ILM0 4.1, “Acid Digestion of Soil/Sediment”

   a. This method is used to prepare sediments and soil samples for analysis by ICP. Since certain matrices may result in poor recovery, the method of standard additions may be used when analyzed.

C. OILS

1. Method 3031, "Digestion Procedure for Oils".

   a. This method is used to prepare samples containing oils, greases or waxes for analysis by inductively coupled argon plasma emission spectroscopy (ICP).

D. **NOTES:**

1. "Total Metals" includes all metals, inorganically and organically bound and both dissolved and particulate.

2. "Dissolved metals" includes all metals present in a sample after filtration through a 0.45 micron filter followed by digestion.

II. SUMMARY OF METHODS

A. A representative sample of water, soil or oil is put into an acid medium and exposed to heat for a certain amount of time. This allows for reduction of interferences by organic matter and converts metals bound to particulates to form the free metal that can be determined by ICP-Atomic Emission Spectrometry.

NOTE: When a reporting limit is required for a project lower then is customary, a four times concentration must be used in order to reach that lower level. Care

must be taken to matrix match this concentrated aliquot. A blank and laboratory control sample (at a reduced concentration) are required with this concentration. A matrix spike (not at reduced concentration) and duplicate or matrix spike and matrix spike duplicate is needed per 20 samples or per batch.

III. SAMPLE HANDLING AND PRESERVATION

A. AQUEOUS

1. Samples are taken in high density polyethylene, one liter bottles. Samples should be preserved with concentrated HNO_3 to a pH <2 immediately once sampled. If dissolved metals are to be analyzed the sample should be filtered before the HNO_3 is added. The samples should be maintained at 4°C until analysis. The holding time for metals samples is 180 days or approximately 6 months.

B. SOLIDS

1. Samples are taken in high density polyethylene(CLP only) or glass bottles. The samples should be maintained at 4°C until analysis. The holding time for metals samples is 180 days or approximately 6 months.

C. OILS

1. Samples are taken in high density polyethylene bottles. The samples should be maintained at 4°C until analysis. The holding time for metals samples is 180 days or approximately 6 months.

IV. INTERFERENCES

A. AQUEOUS

1. Method 3005A and USEPA CLPILM0 4.1, "Acid Digestion of Waters for Total Recoverable or Dissolved Metals for Analysis by ICP Spectroscopy", SW846, July, 1992.

   a. This digestion procedure may not be sufficiently vigorous to destroy some metal complexes.

2. Method 200.7

3. Method 3010A

   a. See method 6010B.

B. SOLIDS

1. Method 3050B

   a. Sludge samples can contain diverse matrix types, each of which may present its own analytical challenge. Spiked samples and any relevant standard reference material should be processed to aid in determining whether this method is applicable to a given waste.

2. USEPA CLP ILM0 4.1

   a. Sludge samples can contain diverse matrix types, each of which may present its own analytical challenge. Spiked samples and any relevant standard reference material should be processed to aid in determining whether this method is applicable to a given waste.

C. OILS

1. Method 3031

   a. These digestates can have very high dissolved solids, which may necessitate the use of internal standards, dilutions, or the method of standard addition.

V. SAFETY

A. Normal accepted laboratory safety practices should be followed while performing this analysis.

B. Be certain the exhaust hood is functioning before you begin the digestion procedure.

C. Hot acids can be extremely corrosive. Avoid inhalation or contact with skin.

VI. EQUIPMENT/APPARATUS

A. Fume hood, Labconco or equivalent.

B. Hot plate, Thermolyne cimarec-3 or equivalent source for use at 95°C. The temperature of the hot plate must be monitored via the use of a temperature blank.

C. Thermometer capable of reading 80 to 120 degrees C – ERTCO cat# 611-3-SC or equivalent.

D. Vacuum pump for filtering dissolved metals- Gast or equivalent.

E. Analytical balance capable of weighing to 0.01 gram. Mettler model BB300 or equivalent.

F. Beckman CS-6R centrifuge.

G. Various class A volumetric glassware and ribbed watchglasses, Pyrex or equivalent.

H. Whatman No. 41 filter paper or equivalent.

I. Whatman No. 42 filter paper or equivalent.

J. Whatman 0.45 micron filter paper or equivalent.

K. 250 mL beaker or other appropriate vessel such as polypropylene block digester tubes, watch glasses and caps.

L. Stirring device, e.g. magnetic stirrer, glass rod or equivalent.

M. Manual Sample Mill

N. Wiley Sample Mill

O. Clippers for cutting vegetation

NOTE: All glassware should be acid washed.

VII. REAGENTS AND STANDARD PREPARATION

A. REAGENTS

1. Metals grade Nitric acid (HNO_3). Reagent should be analyzed to determine level of impurities. If method blank is <MDL, then the reagent can be used.

2. Metals grade Hydrochloric acid (HCl). Reagent should be analyzed to determine level of impurities. If method blank is <MDL, then the reagent can be used.

3. 30% hydrogen peroxide reagent, ACS Grade. Reagent should be analyzed to determine level of impurities. If method blank is <MDL, then the reagent can be used.

4. Metals grade Sulfuric acid (H_2SO_4). Reagent should be analyzed to determine level of impurities. If method blank is <MDL, then the reagent can be used.

5. Reagent water (Deionized water).

6. Potassium Permanganate - Ultra pure grade. Reagent should be analyzed to determine level of impurities. If method blank is <MDL, then the reagent can be used.

7. Ammonium hydroxide, concentrated, reagent grade. Reagent should be analyzed to determine level of impurities. If method blank is <MDL, then the reagent can be used.

8. Ammonium phosphate, reagent grade- Reagent should be analyzed to determine level of impurities. If method blank is <MDL, then the reagent can be used.

9. Base oil, analyte-free. Oil should be analyzed to determine level of impurities. If method blank is < MDL, then the reagent can be used.

B. STANDARDS

1. Traceability

a. A bound logbook record shall be maintained on all reference materials. The record shall include date of receipt, source, purity, all compositional information, storage conditions and expiration date. These materials/solutions are to be identified by a unique number in the logbook as well as on the container's label.

b. All working standards made from reference materials shall be labeled with a unique ID number with complete information on preparation date, concentration of each compound, solvent, preparer's name, expiration date and the logbook where information is recorded. Reagents shall be labeled with date received and expiration date, if applicable. All of the information described above shall also be recorded in a bound logbook. Measurements made during standards preparation (e.g., from weighing operations, volume diluted to, etc.) shall also be recorded. There should be no container with sample, sample extract, standard solution, etc. that is not correctly labeled and properly stored.

c. The analyst must initial and date each entry made in a logbook. Each analyst must be sure to "Z" out the unused area of each logbook page.

2. PREPARATION

A. Laboratory control sample

1. Aqueous

a. This solution is prepared as follows: 50 mL concentrated HCl, 20 mL concentrated HNO_3, 1 mL of CLP-CAL-1, Solution A, 1 mL of CLP-CAL-1 Solution B, 0.25 mL of CLP-CAL-2, and 0.25 mL of CLP-CAL-3 diluted to 1 L in a volumetric flask. Use 50 mL (100 mL for strict CLPIlM0 4.1) for digestion. This solution is given a unique identifier and recorded in sample digestion logbook.

b. For four times concentrated samples: The solution is prepared as follows: 50 mL concentrated HCl, 20 mL concentrated HNO_3, 1mL CLPP-SPK-4 (Inorganic Ventures) (This solution contains 10 mg/L Selenium, 100 mg/L Antimony, 50 mg/L Cadmium and Thallium, 40 mg/L Arsenic and 20 mg/L Lead) to 1 L in a volumetric flask. This solution is given a unique identifier. Use 12.5 mLs to 50 mLs and prepare two aliquots. Heat at 90 to 95°C to reduce the volume in each vessel to ten mLs and then combine each 10 mL aliquot into one vessel and take to a final volume of 25 mLs. Take care to matrix match acids so that the final 25 mL portion will contain 2% HNO_3 and 5% HCl. Use 0.125 mLs HNO_3 and 0.3125 mLs HCl to each 50 mL vessel.

2. Solids

a. A 1.0 ±0.02 gram aliquot of teflon chips is weighed and spiked using the same spiking solution used for matrix spikes. This sample is given a unique identifier according to the Lot# for the teflon chips used and when digested is given the descriptor. i.e. LCSS(date)A and then B etc. plus the unique identifier number assigned. Alternatively a solid matrix standard reference material is obtained from the manufacturer. This sample is given a unique identifier and recorded in the sample digestion logbook.

3. Oils

a. **An analyte free oil MUST be used or explosive reactions can occur.** An analyte free oil (wesson oil which has been analyzed previously to prove that it is < MDL.) is spiked using the same spiking solution used for matrix spikes. This sample is given a unique identifier. i.e. LCSO(date)A and then B etc.

B. Spiking solution

1. Sample is spiked using 0.1 mL of CLP-CAL-1, Solution A, 0.1 mL of CLP-CAL-1 Solution B, 0.025 mL of CLP-CAL-2 and 0.025 mL of CLP-CAL-3 for a final volume of 100 mL. If only 50 mL is used, decrease amount used appropriately. These solutions are given unique identifiers. Record the amount spiked and the unique identifier of the standard.

2. CLP sample is spiked using 0.1 mL CLPP-SPK-1 and 0.1 mL CLPP-SPK-4 for a final volume of 100 mL. If only 50 mL is used, decrease amount used appropriately. These solutions are given unique identifiers.

3. For samples that require four times concentration, the sample is spiked using 0.0125 mLs of CLPP-SPK-4 to each of two vessels with 50 mLs of sample in each. The volume of each of the vessels is lowered to less then 10 mLs and combined and the final volume of this concentrated sample is 25mLs.

VIII. CALIBRATION

A. The temperature of the samples must be maintained at 95°C and monitored via a temperature blank. 85° for oil samples. Record in digestion logbook.

IX. PROCEDURE

A. Glassware preparation for oil digestion or when the hot-block can not be used:

1. Wash glassware with hot soapy water and rinse thoroughly. (Beakers must be washed as soon as possible after being used, dirty beakers must not be allowed to sit overnight.)

2. Rinse glassware with reagent water that contains 5% HNO_3 and 5% HCl followed by a rinse with reagent water.

3. Prior to use, all glassware must be confirmed clean via a glassware check. Otherwise, repeat step "2" until the glassware check passes.

B. Aqueous sample filtration (for dissolved metals):

1. Thoroughly clean a flask and funnel with hot soapy water. Next, rinse the flask and funnel with 1:5 HNO_3 followed by a thorough D.I. water rinsing. This step is very important because the filters contain some metals (namely Zn) which could contaminate the samples.

2. Rinse a 0.45 micron filter with 1:5 HNO_3 thoroughly, followed by D.I. water.

3. Filter the unpreserved sample. If dissolved Hg analysis is requested for the sample, filter at least 200 mL.

4. Discard the first 50 to 100 mL.

5. A preparation blank must be taken through the filtration step and analyzed with the sample.

6. Preserve the sample with HNO_3 to pH<2.

7. Soluble samples that are clean and clear do not have to be digested. Use 100 mL sample, add 5 mL of concentrated HCl and 2 mL of concentrated HNO_3. **Samples must be digested unless approval for analysis without digestion is received from the project manager.**

C. Aqueous sample preparation

1. Method 3005A and USEPA CLP ILM0 4.1, "**Acid digestion procedure for total recoverable or dissolved metals for analysis by ICP ".**

   a. Shake sample thoroughly and pour 50 mL of the well-mixed sample into a digestion vessel. For samples which require concentration pour 50 mLs of the well-mixed sample into two digestion vessels.

   b. Add 0.50 mL (1 mL of (1+1) when strict CLP ILM0 4.1 is required) concentrated HNO_3 to the sample. For samples which require concentration, add 0.125 mL (0.25 mL of (1+1) when strict CLP ILM0 4.1 is required) concentrated HNO_3 to the sample.

   c. Add 2.5 mL (5 mL of 1+1) when strict CLP ILM0 4.1 is required) concentrated HCl to the sample. For samples which require concentration, add 0.3125 mL (0.625 mL of (1+1) when strict CLP ILM0 4.1 is required) concentrated HCl to the sample.

   d. Cover the sample with a ribbed watch glass or equivalent source.

   e. Transfer the digestion vessel to a pre-heated hot plate or hot block at 90 to 95°C. A temperature blank will assure correct temperature. The temperature must be recorded in the digestion log book. Take the volume down to between 5 to 10 mL, (12 to 25 mLs when strict CLP ILM0 4.1 is required) **making certain that the sample does not boil**. **This is extremely important. Boiling may lead to vaporization of certain analytes.** Remove the sample from the hot plate and cool

   f. When necessary, filter or centrifuge the sample to remove insoluble material that could clog the nebulizer. The filtering apparatus must be thoroughly cleaned with dilute nitric acid prior to filtration.

   g. Bring sample to its predigestion volume (or when samples require concentration, to a volume four times lower then what was started with) with DI water in the digestion vessel. The final volume must be recorded in the digestion log book.

   h. The sample is now ready for analysis.

   i. The digestion log must contain the date, analyst, sample number, client, sample mass/volume, final volume of digestate, lot # of acids used and the preparation and ID of standards plus identification #'s for standards used for spiking and the volume spiked into the sample.

2 Method 200.7, "**Acid digestion procedure for total recoverable metals**".

a. Shake sample thoroughly and pour 50 mL of the well-mixed sample into the digestion vessel. If sample contains undissolved solids >1% refer to Section 11.3 of Method 200.7 for subsequent procedures.

b. Add 1.0 mL concentrated HNO_3 to the sample.

c. Add 2.50 mL concentrated HCl to the sample.

d. Cover the sample with a ribbed watch glass or equivalent source.

e. Transfer the digestion vessel to a pre-heated hot plate or equivalent source at 85°C. Take the volume down to between 10 to 15 mL, **making certain that the sample does not boil**. **This is extremely important. Boiling may lead to vaporization of certain analytes.**

f. Leave sample on hot plate and gently reflux for 30 minutes. Remove from hot plate and cool.

g. Bring sample to its predigestion volume with DI water in the digestion vessel.

h. When necessary, filter or centrifuge the sample to remove insoluble material that could clog the nebulizer. The filtering apparatus must be thoroughly cleaned with dilute nitric acid prior to filtration.

i. The sample is now ready for analysis.

j. The digestion log must contain the date, analyst, sample number, client, sample mass/volume, final volume of digestate, lot # of acids used and the preparation and ID of standards.

3. Method 3010A, "**Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by ICP Spectroscopy**".

a. Shake sample thoroughly and pour 50 mL of the well-mixed sample into the digestion vessel.

b. Add 1.5 mL concentrated HNO_3 to the sample.

c. Cover the sample with a ribbed watch glass.

d. Transfer the digestion vessel to a pre-heated hot plate or hot block at 90 to 95°C. A temperature blank must be used, with the temperature

being recorded in the log book. Take the volume down to a low volume (~5 mL), **making certain that the sample does not boil**. **This is extremely important. Boiling may lead to vaporization of certain analytes. Also make certain that no portion of the bottom of the digestion vessel is allowed to go dry. This may lead to low recoveries.** Remove the sample from the hot plate and cool.

e. Add another 1.5 mL portion of concentrated HNO_3 to the sample.

f. Cover the sample with a ribbed watch glass.

g. Transfer the vessel to the hotblock or equivalent source. Increase the temperature so a gentle reflux occurs. Continue heating, adding additional acid as necessary, until the digestion is complete (generally indicated when the digestate is light in color or does not change in appearance with continued refluxing).

h. Uncover the vessel and evaporate to a low volume (~3 mL) **making certain that no portion of the bottom of the digestion vessel is allowed to go dry.** Remove and cool.

i. Add 2.5 ml of 1:1 HCl (10 mL/100 mL of final solution).

j. Cover the digestion vessel and reflux for an additional 15 minutes.

k. Bring sample to its predigestion volume in digestion vessel.

l. When necessary, filter or centrifuge the sample to remove insoluble material that could clog the nebulizer. The filtering apparatus must be thoroughly cleaned with dilute nitric acid prior to filtration.

Note: When preparing USACE project samples, if any sample in a digestion batch requires filtration, all samples (including QC samples) must be treated in the same manner.

m. The sample is now ready for analysis.

n. The digestion log must contain the date, analyst, sample number, client, sample mass/volume, final volume of digestate, lot # of acids used and the preparation and ID of standards.

4 Method 3030C (Standard Methods), "**Preliminary treatment for Acid-Extractable Metals"**

a. Shake sample thoroughly and pour 50 mL of the well-mixed sample into a 50 mL digestion vessel.

b. Add 2.5 mL 1:1 HCl to the sample.

c. Heat 15 minutes in a hot bath.

d. Filter through a membrane filter.

e. Adjust filtrate volume to 50 mL with DI water.

f. Transfer to ICP analyst.

D. Solid sample preparation

It is extremely important that waste (when appropriate), soil and sediment samples be mixed thoroughly to ensure that the sample is as representative as possible of the sample media. The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

- *The material in the sample pan(inorganic-plastic/organic-aluminum) should be divided into quarters and each quarter should be mixed individually.*
- *Two quarters should then be mixed to form halves.*
- *The two halves should be mixed to form a homogenous matrix.*

This procedure should be repeated several times until the sample is adequately mixed.

NOTE: Samples that are clay type materials should be handled in a different manner. Due to these type sample matrices having an affinity to stick to most anything that touches it, another approach must be followed. Obtain a representative sub-sample aliquot from the center or middle section of the sample container.

Grinding of Vegetation Samples

Remove sample from shipping container and brush off dirt particles. Chop sample into about half inch pieces with clippers or other cutting tool. Place the sample in an aluminum pan and air-dry in an exhaust hood to the appropriate dryness for grinding. It should be dry enough where it won't stick to the inside of the mill. Grind the dried sample to fineness in either the manual sample mill

or the Wiley mill or both if needed. Place the ground sample in a container and label immediately.

1. USEPA CLP ILM0 4.1, **"Acid digestion of Soil/Sediment"**

   a. Mix the sample thoroughly to achieve homogenity. For each digestion procedure, weigh (to the nearest 0.01 g) a 1.0 to 1.5 g portion of sample and transfer to a digestion vessel.

   b. Add 10 mL of 1:1 nitric acid (HNO_3), mix the slurry, and cover with a watch glass or equivalent source. Heat the sample to 92 to 95°C and reflux for 10 minutes without boiling. Allow the sample to cool, add 5.0 mL of concentrated HNO_3, replace with watch glass or equivalent source, as appropriate, and reflux for 30 minutes. Do not allow the volume to be reduced to less than 5 mL while maintaining a covering of solution over the bottom of the heating vessel.

   c. After the second reflux step has been completed and the sample has cooled, add 2 mL of Type II water and 3.0 mL of 30% hydrogen peroxide (H_2O_2). Return the heating vessel to the hot plate or equivalent heating source for warming to start the peroxide reaction. Care must be taken to ensure that losses do not occur due to excessively vigorous effervescence. Heat until effervescence subsides, and cool the heating vessel.

   d. Continue to add 30% H_2O_2 in 1 mL aliquots with warming until the effervescence is minimal or until the general sample appearance is unchanged. (NOTE: Do not add more than a total of 10 mL 30% H_2O_2.)

   e. If the sample is being prepared for ICP analysis of Al, As, Sb, Ba, Be, Ca, Cd, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, K, Se, Ag, Na, Tl, V, and Zn, add 5 mL of 1:1 HCl and 10 mL of Type II water, return the covered heating vessel to the hot plate or equivelent heating source, and heat for an additional 10 minutes. After cooling, filter through Whatman No. 42 filter paper (or equivalent) and dilute to 50 mL with Type II water. NOTE: In place of filtering, the sample (after dilution and mixing) may be centrifuged or allowed to settle by gravity overnight to remove insoluble material. Dilute the digestate to 144 mL with DI water, add 5 mLs concentrated HCl and 1 mL of concentrated HNO_3, mix well and place into the appropriate container. The diluted sample has an approximate acid concentration of 2.5% (v/v) HCl and 5% (v/v) HNO_3. The sample is now ready for analysis.

f. The digestion log must contain the date, analyst, sample number, client, sample mass/volume, final volume of digestate, lot # of acids used and the preparation and ID of standards and ID of matrix spikes and the amounts used for spiking.

2. Method 3050B, **"Acid digestion of Sediments, Sludges and Soils"**

a. Mix the sample thoroughly for 5 minutes using a plastic spatula or Teflon coated spatula in a glass or plastic weigh boat to achieve homogeneity.

b. Weigh approximately (to the nearest 0.01 g) a 1 to 1.5 g portion of the sample directly into a digestion vessel. For samples with low percent solids a larger sample size may be used as long as digestion is completed. Record the exact mass in the digestion log.

NOTE: To achieve the lowest reporting limit possible, use a 2.0 g portion of sample with an ending volume of 100 mLs.

c. Add 5 mL D.I. water and 5 mL concentrated HNO_3(1:1), mix the slurry and cover with a watch glass. Place the sample in a preheated hot block and reflux at 95°C for 10 to 15 minutes being certain that the sample does not boil. Record temperature in digestion log book

d. Allow the sample to cool. Add 5 mL concentrated HNO_3, replace the watch glass and heat/reflux again for 30 minutes. If brown fumes are generated, indicating oxidation of the sample by HNO_3, repeat this step (addition of 5 mL of concentrated HNO_3) over and over until <u>no</u> brown fumes are given off by the sample indicating the complete reaction with HNO_3. Using a watch glass or equivalent allow the solution to evaporate to approximately 5 mL without boiling at 95°C $\pm$ 5°C for approximately two hours. Maintain a covering of solution over the bottom of the vessel at all times. Do not allow the volume to be reduced to less than 5 mL while maintaining a covering of solution over the bottom of the beaker. If the volume does get low, add 2.5 mL of D.I. water to bring volume back up.

e. Take the sample off the hot block and allow it to cool. Next, add 2 mL of D.I. water and 3 mL of 30% Hydrogen Peroxide. (The sample will bubble upon the addition of H_2O_2 if it is still warm.) Cover the vessel with a watch glass and return the sample to the hot block or equivalent source and heat until the bubbling subsides. Care must be taken to

ensure that losses do not occur due to excessively vigorous effervescence. Heat until effervescence subsides and cool the beaker. Add two more 3 mL portions of H_2O_2 to the sample in the same manner as before. (NOTE: Do not add more than a total of 10 mL 30% H_2O_2.)

f. Cover the sample with a ribbed watch glass and continue heating the acid-peroxide digestate at 95°C $\pm$ 5°C without boiling for approximately two hours until the volume has been reduced to approximately 2.5 mL. Maintain covering of solution over the bottom of the vessel at all times.

g. Add 2.5 mL of DI water and 2.5 mL of concentrated HCl and 10 mL of DI water, cover the sample with a ribbed watch glass and continue refluxing for an additional 10 minutes without boiling

h. When necessary, filter or centrifuge the sample to remove insoluble material that could clog the nebulizer. The filtering apparatus must be thoroughly cleaned with dilute nitric acid prior to filtration.

i. Bring sample up to 50 mL with D.I. water in the vessel. Add 150 ml of DI water to a 250 ml sample bottle. Invert the 50 ml sample digestion vessel several times to mix the sample and pour sample into the 150 ml of the sample bottle. Pour some sample back into the 50 ml sample digestion vessel to rinse and pour back into the 250 ml sample bottle and cap and mix.

NOTE1: When preparing USACE project samples, if any sample in a digestion batch requires filtration , all samples (including QC samples) must be treated in the same manner.

NOTE2: To achieve the lowest reporting limit possible use 2.0 grams of sample with an ending volume of 100 mLs.

j. The sample is now ready for analysis.

k. The digestion log must contain the date, analyst, sample number, client, sample mass/volume, final volume of digestate, lot # of acids used and the preparation and ID of standards.

E. Oils

1. Method 3031, "**Digestion Procedure for Oils**"

NOTE: THIS METHOD IS VERY TIME CONSUMING--DISCUSS SUB-CONTRACTING SAMPLES WITH YOUR SUPERVISOR AS SOON AS THEY COME IN THE DOOR.

a. Homogenize sample and Weigh approximately (to the nearest 0.01 g) a 0.5 g representative portion of the sample into a 250 mL beaker. Separate and weigh proportional aliquots of the phases if more than one phase is present. Record the exact mass in the digestion log. Larger or smaller sample sizes can be used if needed.

g. Add 0.5 g of potassium permanganate powder. If larger sample sizes are used, increase the amount of potassium permanganate so that the ratio of oil to postassium permanganate is still 1:1. Mix the oil and permanganate thoroughly until homogenous. Thick oils and tars that cannot be mixed should be heated to achieve mixing (the oil may react mildly). It is important to record the amount of potassium permanganate used for each sample if analysis is by ICP-AES and correction is to be made for the amount of manganese. If more than 10% of the sample is aromatic material, such as xylene, then the reaction will be incomplete. If this is the case, increase the amount of potassium permanganate. If the sample is a mixture of oil and other non-organic materials, reduce the amount of potassium permanganate.

<u>NOTE</u>: All steps requiring the use of acids should be conducted under a fume hood by properly trained personnel using appropriate laboratory safety equipment. This should include face shields and latex gloves.

h. Cautiously add 1.0 mL concentrated H_2SO_4, and stir with an appropriate stirring device. If larger sample sizes are used, increase the volume of the sulfuric acid so that the ratio of oil to sulfuric acid is 1 g to 2 mL. The H_2SO_4 can be added dropwise or all at once, depending on analytical needs. (Generally, dropwise is preferred when low reporting limits are needed.)

<u>NOTE</u>: To prevent a strong exothermic reaction, H_2SO_4 should be added dropwise to all samples unfamiliar to the analyst and to all samples that are known to be highly reactive.

The reaction can take several seconds to begin, but when it occurs it will be very quick, vigorous, and exothermic. Generally larger sample sizes will react faster than smaller. Likewise, lower average molecular weight materials will react faster than heavier. Do not be mislead by an initial lack of reactivity. A grey-white vapor will be ejected from the beaker (SO_3) and splattering and bubbling can occur. The beaker will become very hot. This step is complete when no more gases are given off and the sample would be a thick black lumpy paste. Allow the beaker to cool as needed.

NOTE: Care must be taken when working with very light organic materials, such as diesel fuels, as they may flash. Generally, the lower the average molecular weight of the meterial correlates to a greater danger of flashing. The danger of flashing is reduced by adding the sulfuric acid dropwise.

NOTE: If more than 10% of the sample is aromatic material, such as xylene, only a little grey-white vapor will form. This will reduce accuracy and complicate nebulization. If there is a signigicant amount of non-hydrocarbon material, a sputtering recation will occur and black MnO_2 particulates will be given off. See section (b.) above under procedure.

i. Add 2 mL of concentrated HNO_3 and stir. This reaction will be slightly exothermic. If larger sample sizes are used, it is not always necessary to increase the volume of HNO_3 proportionately, depending on analytical needs. Some reddish-brown vapor (NO_2) may be given off. Allow the reaction to continue until complete, that is when the digestate no longer gives off fumes. Allow the beaker to cool as needed.

j. Add 10 mL of concentrated HCl and stir. If larger sample sizes are used, it is not always necessary to increase the volume of HCl proportionately, depending on analytical needs. This reaction will be slightly exothermic and gas formation and foaming will occur. Lighter oils will foam more than will heavier oils. If excess foaming occurs, add water to prevent sample loss. Allow the beaker to cool as needed.

k. Heat the beaker until there is no further gas evolution. (temperature should not exceed 150 °C to prevent volatilization). There may be additional foaming or other milder reactions which may result in overflow from the beaker. If excess foaming occurs, either remove the beaker from the heating source until foaming subsides or add

sufficient water to prevent overflow. The final digestate should be a clear yellow liquid with black or dark reddish-brown particulates.

l. Filter the digestate through Whatman 41 filter paper and collect filtrate in a volumetric flask or beaker.

m. Wash the digestion beaker and filter paper, while still in the funnel, with no more than 5 mL of hot HCl.

   NOTE: The purpose of this next step is to recover antimony, barium, and silver that may not have been completely solubilized. If the sample is not being prepared for these analytes, the next step may be skipped.

n. (Optional) After having washed the filter paper, remove the filter and residue from the funnel and place it back in the beaker. Add 5 mL of conc. HCl and place the beaker back on the heating source until the filter paper dissolves (temperature should not exceed 150 °C ±5 °C to prevent volatilization). Remove the beaker from the heating source and wash the cover and sides with reagent grade water and then filter the residue and collect the filtrate in the same flask or beaker as in sections f. and g. above. Allow the filtrate to cool and quantitatively transfer to a volumetric flask. Bring to volume.

o. (Optional) If the filtrate is collected in a beaker, the filtrate can be heated again to drive off excess HC1. This can reduce matrix effects in sample introduction (temperature should not exceed 150 °C ± 5 °C to prevent volatilization). When sufficient HCl has been removed, remove the beaker from the heating source, allow to cool, and then transfer the contents to a volumetric flask and bring to volume. However, if too much HCl is removed, barium, silver and antimony can be lost.

p. Analyze the flitrate by ICP-AES. Depending on the final volume selected, the total solids in the digestate may be high enough to cause nebulization problems. Problems due to high dissolved solids may be corrected by 1) following optional Section i., 2) using internal standards, 3) using flow injection analysis, or 4) using other matrix correction procedures.

   Manganese Removal Steps

   NOTE: The purpose of these next steps is to remove the manganese in the digest by precipitating it as manganese ammonium phosphate

under alkaline conditions. Elements that do not form insoluble phosphates, such as arsenic, are filtered out and can be analyzed at lower concentrations.

q. Take the digestate, or portion of digestate and reduce the volume to remove as much HCl as possible without going below 10 mL. Then add conc. NH_4OH until pH is 7 or greater. For most matrices, the digestate will change colors (often from yellow to brown) at pH 7. A mild exothermic reaction will occur immediately.

r. Add at least 2 g ammonium phosphate for each 1 g of potassium permanganate used in the digestion and stir. An excess of phosphate is needed for good analyte recovery. Then add enough water and mix to ensure maxium precipitation. A pink or yellow silky amorphous precipitate, manganese ammounium phosphate, will form. If too much NH_4OH is used some of the manganese ammonium phosphate can be solubilized. Stir until precipitation is complete. Some ammonium phosphate may remain unreacted at the bottom of the beaker.

s. Filter the digestate through Whatman 41 filter paper (or equivalent) and collect filtrate in a volumetric flask or beaker.

t. Heat the filtrate to volatilize the ammonia (temperature should not exceed 150 °C ± 5 °C to prevent volatilization). The volume of filtrate can be reduced by heating to no less thatn 10 mL. If too much water is removed ay ammonium chloride formed will solidify. If this occurs, either add enough water to dissolve the solids or filter out the solids and wash the residue with deionized water. The filtrate can be analyzed by ICP-AES.

u. The digestion log must contain the date, analyst, sample number, client, sample mass/volume, final volume of digestate, lot # of acids used and the preparation and ID of standards.

X. CALCULATIONS

A. The analyst must be supplied with both beginning sample masses/volumes and final digestate volumes. This information must be recorded in the digestion log.

XI. QUALITY CONTROL

A. Digestion

1. Temperature blank

   a. The temperature of the hot plate/hot block must be monitored for temperature during the digestion process.

   b. The thermometer must be tagged with annual calibration information. Record the thermometer reading, correction factor and the corrected temperature in the digestion log.

2. Blanks

   a. Digest a blank with every batch of samples digested (20 sample maximum). The blank is prepared by adding all the same reagents added to the samples to a clean dry beaker and taking it through the same process as the samples. **NOTE: The blank for OILs MUST include an analyte-free oil or explosive reactions can occur.**

   b. Also, there must be a blank for every different method of digestion that is set up that day, every 20 samples.

   c. There must also be a blank for every different matrix of samples that is to be digested, every 20 samples.

   d. Sample is given a unique identifier in the digestion log.

3. Laboratory Control Samples

   a. For water samples, one LCS is digested with every batch of samples digested (20 sample maximum).

   b. For water samples, a LCS is digested every day for each type of digestion, every 20 samples.

   c. For soil/sediment samples, a soil matrix standard reference material (SRM) must be digested per batch (20 samples maximum) or alternatively a spiked teflon chip sample.

   d. Sample is given a unique identifier in the digestion log.

   e. Recoveries of standard reference materials or laboratory control samples spiked with organo-metallic standards recoveries should be **±25% of their true values for OILS.**

4. Duplicates

   a. A duplicate is prepared every 20 samples. This usually takes the form of a matrix spike duplicate.

      NOTE: Certain projects require a sample duplicate and a matrix spike duplicate with each set of twenty samples.

5. Blank Spike

   a. This is required for certain projects.

B. Sample Matrix

NOTE: Field blanks/duplicates, trip blanks, or equipment blanks are not to be used for sample matrix QC samples.

1. Matrix spike

   a. Digest a spike and spike duplicate every 20 samples where sample volume is adequate to do so. Choose a sample (if possible) that has a lot of metals requested to be analyzed.

      NOTE: For some projects, a sample duplicate and sample spike may be required instead of a spike and spike duplicate. Your supervisor should make you aware of these projects.

   b. The following metals do not get digested spikes when using CLP spike.

      Calcium
      Magnesium
      Sodium
      Potassium

   v. For TCLP samples, a spike must be digested for every matrix. You should inspect the sample (original sample prior to extraction) or check the log book to determine matrix type. (Also the matrix spike aliquot must be added to the extract after filtration but before preservation.)

d. The CLH project requires that a high and a low spike be prepared and analyzed. Spikes shoud be prepared at 40 mg/Kg and 400 mg/Kg for soil samples and 200 ug/L and 2000 ug/L for aqueous samples.

XII. CORRECTIVE ACTIONS

A. Sample boils during digestion.

1. Redigest another sample aliquot.

B. Sample goes dry or portion of beaker bottom is exposed due to excess evaporation during digestion.

1. Redigest another sample aliquot.
2. Glass beaker dry for an extended period of time? Discard beaker.

XIII. SPECIAL NOTES

A. **Never** take for granted how a sample should be digested. If the sample looks strange or unusual, or if you are not sure what metals the sample gets, what detection limits are required, whether the sample is total or dissolved, or even what method of digestion should be used, always ask your supervisor or the person who is to analyze the sample. How metals need to be digested changes too often to take it for granted.

B. **Antimony (Sb) soils** should be analyzed within 48 hours of digestion whenever possible. When a soil requesting Antimony analysis is received, you must coordinate with the person who will be analyzing it to be sure that they can analyze it on the same day that it is digested.

C. Labels for the digested sample must be written in a neat and legible manner. The labels must include such information as sample number, client name, the date digested, and the volume or mass digested.

D. There are several precautions that must be taken to minimize the possibility of contamination.

1. All metals glassware must be kept separate from all other laboratory glassware.

2. Metals glassware must be washed as soon as possible after being used. **Dirty metals beakers must not be left overnight.**

3. Acid to be used for metals digestions must be kept separate from all other laboratory acid.

E. Samples must be digested in a timely manner to ensure ICP analysis remains on schedule for data generation. Samples received on or before Wednesday of week X must be prepared for ICP digestion by the end of week X. Your supervisor must be consulted if this schedule can not be met at a particular time.

F. Please consult Waste Disposal SOP-405, for information concerning disposal of waste generated from this area. Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

Addendum for USEPA CLPILM 05.2 AQUEOUS &SOIL/SEDIMENT

The following is a list of changes for sample preparation when the 5.2 statement of work is required:

1. Soluble samples are required to be digested unless the chain of custody specifically states that digestion is not required. An MDL study must be done on the unprepared MDL solution in order to provide MDL levels for samples that are not digested. When digestion is not required an LCSW and post digestion spike are not required.

2. Digestates must be stored until 365 days after delivery of a complete, reconciled data package.

3. Preparation codes are used on form 13's. They are found in the 5.2 statement of work page B-39 3.4.12.2.4.

DEFINITIONS – Refer to SOP-431 for common environmental laboratory definitions.

MERCURY ANALYSIS IN WATER BY MANUAL COLD VAPOR TECHNIQUE

METHODS USEPA SW846 7470A and 245.1 CLP-M 4.1 (NJDEP does not accept CLPILM 04.1 after June, 2003), Addendum for USEPA CLP ILM 05.2

SOP NUMBER: SOP-103

REVISION NUMBER: 16

APPROVED BY: Betty DeVille
SECTION MANAGER

Randy D. Ward
TECHNICAL DIRECTOR

EFFECTIVE DATE: 01/28/09
DATE OF LAST REVIEW 01/28/09

MERCURY ANALYSIS IN WATER BY MANUAL COLD VAPOR
References:
SW846 Method 7470A
USEPA Method 245.1
USEPA SOW ILM04.1
See Addendum for SOW ILM05.2

I. SCOPE AND APPLICATION

A. This method is a cold-vapor atomic absorption procedure for determining the concentration of mercury in mobility-procedure extracts, aqueous wastes, and ground waters. This method can also be used for sludge-type wastes. All samples must be subjected to an appropriate dissolution procedure prior to analysis.

B. In addition to inorganic forms of mercury, organic materials may also be present. These organo-mercury compounds will not respond to the cold vapor atomic absorption technique unless they are first broken down and converted to mercuric ions. Potassium permanganate oxidizes many of these compounds, but recent studies have shown that a number of organic mercurials, including phenol mercuric acetate and methyl mercuric chloride, are only partially oxidized by this reagent. Potassium persulfate has been found to give approximately 100% recovery when used as the oxidant step following the addition of the permanganate has been included to insure that organo-mercury compounds, if present, will be oxidized to the mercuric ion before measurement. A heat step is required for methyl mercuric chloride when present in or spiked to a natural system. For distilled water the heat step is not necessary.

C. The range of the method may be varied through instrument and/or recorder expansion. Using a 30 mL sample, a detection limit of 0.2 µg Hg/L can be achieved.

II. SUMMARY OF METHOD

A. The flameless AA procedure is a physical method based on the absorption of radiation at 253.7 nm by mercury vapor. Organic mercury compounds are oxidized and the mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of a flow injection Mercury system. Absorbance (peak height) is measured as a function of mercury concentration and recorded in the usual manner.

III. SAMPLE HANDLING AND PRESERVATION

A. Samples are preserved by acidification with nitric acid to a pH of 2 or lower immediately at the time of collection, and refrigeration to 4°C.

B. The holding time for the mercury digestion is 28 days from time of sampling.

IV. INTERFERENCES

A. Possible interference from sulfide is eliminated by the addition of potassium permanganate. Concentrations as high as 20 mg/L of sulfide as sodium sulfide do not interfere with the recovery of added inorganic mercury from distilled water.

B. Copper has also been reported to interfere; however, copper concentrations as high as 10 mg/L had no effect on recovery of mercury from spiked samples.

C. Sea waters, brines and industrial effluents high in chlorides require additional permanganate (as much as 6.25 mL in 30 mL of sample). During the oxidation step, chlorides are converted to free chlorine which will also absorb radiation at 253 nm. Care must be taken to assure that free chlorine is absent before the mercury is reduced and swept into the cell. This is accomplished by using an excess of hydroxylamine sulfate reagent (6.25 mL to 30 mL of sample).

D. Samples containing high concentrations of oxidizable organic materials, as evidenced by high chemical oxygen demand values, may not be completely oxidized of organic mercury will be low. The problem can be eliminated by reducing the sample volume or by increasing the amount of potassium persulfate (and consequently stannous chloride) used in the digestion.

V. Safety

A. Normal accepted laboratory practices should be followed while performing this procedure.

B. The toxicity and carcinogenicity of each reagent in this method have not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be minimized by good laboratory practices. Normal accepted laboratory practices should be followed during reagent preparation and instrument operation. Always wear safety glasses or full-face shield for eye protection when working with these reagents. Each laboratory is responsible for maintaining a current safety plan, a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method.

C. Mercury compounds are highly toxic if swallowed, inhaled, or absorbed through the skin. The analyst should use chemical resistant gloves when handling concentrated mercury standards.

D. The analyst should make sure that the system is vented to fresh permanganate in a bottle located at the back. Otherwise Hg vapors could be vented to the room.

VI. EQUIPMENT/APPARATUS

A. Perken Elmer Flow injection Mercury system

B. Mod Block Digester set to maintain 95±2°C for 2 hours.

C. Polypropylene sample digestion vessels with snap or screw caps or equivalent.
Five vessels of each lot of digestion vessels must be taken through analysis to check for mercury.

VII. REAGENTS AND STANDARD PREPARATION

A. REAGENTS

1. Concentrated sulfuric acid suitable for Hg determination.

2. Concentrated nitric acid suitable for Hg determination.

3. Stannous chloride: in a 1000 mL volumetric flask add approximately 500 mL D.I. water, 30 mL concentrated HCl, add 11 grams stannous chloride crystals swirl to mix and dilute to 1000 mLs. Prepare fresh daily.

4. 3% HCl Carrier Solution: Dilute 30 mL of concentrated metals grade HCl to one liter. Prepare fresh daily.

5. Sodium chloride-hydroxylamine chloride solution: dissolve 120 grams of sodium chloride and 120 grams of hydroxylamine hydrochloride (very high grade --Do not get from Tennessee Reagents) in D.I. water and dilute to 1 liter. Note: this is normally made up 2 Liters at a time.

5. Potassium permanganate: 5% solution, w/v: dissolve 200 grams of potassium permanganate in 4000 mL of D.I. water. Should have "suitable for mercury determination" written on the side of the potassium permanganate bottle. This reagent takes overnight stirring (minimum of 3 hours if absolutely necessary). Use stirring bar already in the reagent bottle for this purpose. It is very easy to contaminate with mercury.

6. Potassium persulfate: 5% solution, w/v: dissolve 100 grams of potassium persulfate in 2000 mL D.I. water. Slight heating with stirring may be necessary to completely dissolve. The formation of crystals in this solution is not a problem.

B. STANDARDS

1. Traceability

a. A bound logbook record shall be maintained on all reference materials. The record shall include date of receipt, source, purity, all compositional information, storage conditions and expiration date. These materials/solutions are to be identified by a unique number in the logbook as well as on the container's label.

b. All working standards made from reference materials shall be labeled with a unique ID number with complete information on preparation date, concentration of each compound, solvent, preparer's name, and expiration date. Reagents shall be labeled with date received and expiration date, if applicable. All of the information described above shall also be recorded in a bound logbook. Measurements made during standards preparation (e.g., from weighing operations, volume diluted to, etc.) shall also be recorded. There should be no container with sample, sample extract, standard solution, etc. that is not correctly labeled and properly stored.

c. The analyst must initial and date each entry made in a logbook. Each analyst must be sure to "Z" out the unused area of each logbook page.

NOTE: All standard solutions should be prepared using class A volumetric flasks, class A volumetric pipettes (or calibrated Eppendorfs). All standards, blanks, and samples are taken through the digestion process.

a. Stock mercury solution: (100 µg/mL). Order from manufacturer already prepared. This solution is given a unique identifier.

b. Primary source and secondary source mercury standard solutions at 200 ug/L: dilute 2 mL of stock solution to 1000 mL in a 1000 mL volumetric flask, with 1.5 mL concentrated HNO_3.

c. Calibration standards

i. Prepared from the primary source working standard. The preparation of the calibration standards, etc. is described below.

a. Dilute the volumes below to 30 mLs in a 70 mL polypropylene vessel. (Note: The standards are diluted to 10 mLs for the initial step of the digestion. From that point when 25 mLs of DI water are added to samples, 15 mLs of DI water is added to the standards.

ug/L Hg	mLs of 200 ug/L standard in 30 mLs
0.20	0.03
0.50	0.075
1.0	0.15
2.0	0.30
4.0	0.60
6.0	0.90
10.0	1.5

iii. Appropriate reagents are added as below in the sample preparation section.

iv. Prepare one vessel for each.

v. It is necessary to digest the calibration standards.

e. Calibration verification standards

i. Initial calibration verification (ICV) solution – 4.0 ug/L

a. Prepared by diluting 0.6 mL of the second source standard to 30 mL with reagent water in a 70 mL polypropylene vessel. (TV = 4.0 ug/L)

b. Appropriate reagents are added as below in the sample preparation section.

c. It is necessary to digest the ICV standards for Method 7470A, Method 245.1 does not require digestion of standards.

ii. Continuing calibration verification (CCV) solution

a. Prepared from the primary source standard.

b. Prepared by diluting 0.3 mL of the primary standard at 200 ug/L to 30 mLs with reagent water in a 70 mL polypropylene vessel for 2.0 ug/L or 0.6 ml to 30 mls for 4.0 ug/L.

c. Appropriate reagents are added as below in the sample preparation section.

d. It is necessary to digest the CCV standards for Method 7470A, Method 245.1 does not require digestion of standards.

f. Digestion standards

i. Laboratory control sample

a. Prepared from the secondary source standard.

b. Prepared by diluting 0.3 mL of the second source standard to 30 mL with reagent water in a 70 mL polypropylene vessel.

c. Appropriate reagents are added as below in the sample preparation section.

d. This solution should be given a unique identifier in the digestion log.

ii.. Matrix Spikes

a. Prepared from the secondary source working standard.

b. Prepared by diluting 0.3 mL of the second source standard to 30 mL with sample in a 70 mL polypropylene vessel. Project specific or method specific requirements may over-ride the spiking level.

c. Appropriate reagents are added as below in the sample preparation section.

VIII. CALIBRATION

A. Set up the instrument with proper operating parameters.

1. Perkin Elmer Flow Injection Mercury System (FIMS).

i. Replace any old tubing that is around the pump cylinder. The sample transfer tubing connected to the seperator cover must not have any moisture in it. If it does replace it. **(Perkin-Elmer tygon tubing, waste and carrier 1.52mm I.D., waste only 3.17mm I.D., stannous chloride 1.14mm I.D.)**

ii. Also replace the filter membrane with the rough side up. (for instructions refer to page 1-22 in maintenance manual.)

iii. Turn on PE 100 spectrophotmeter; (Note: this must be on in order to start up the software on the computer.)

iv. Turn on computer and go to icon "AA Win LAB Analyst".

v. Go to method; select "Hg CAL 2" then OK.

vi. Wavelength = 253.7; smoothing points =9; measurement = peak height; read time =18sec.; BCC time = 2 sec.

vii. Go to "Sample Info" and enter the order of the samples and other information that may be needed.

viii. Save entered sample list under "Save ….sample info file" Note: description and batch ID are normally the date of analysis.

ix. Go to "auto"; then to set-up. Select Browse in both spaces. One is to bring up your saved "Sample Information" File. The other is to select a results library. Double click on heading and choose.

x. Turn the printer on.

xi. Connect all tubing to the pump and blocks.

xii. Start the pump by going to "FIAS" and click the pump 1 Icon (120).

xiii. The pump will start, then lock down and tighten the tubes onto the pump.

xiv. Turn on the nitrogen tank, it should be above 500 psi on the guage. Replace the nitrogen tank when it is at 500 psi.

xv. The pressure gauge on the PE100 should be just below 100.

xvi. Use the tension adjuster to press down the tubing magazine to the pump head on the top and bottom. Start the pump and then lock

them down. This technique needs to be demonstrated so that a new user will be able to understand what is needed here and how to do it.

xvii. Adjust the spring tension tubing until there is a constant "bubble of low rate" coming out to the waste tube.

xviii. Place carrier tubes into carrier and stannous chloride tube into SnCl2. (click valve fill inject and make sure flow is correct and the line is rinsed).

xix. Make sure the permanganate waste bottle is bubbling in order to absorb any Hg vapors which could be vented into the room.

xx. Allow a few minutes for reagents to flow through the system before starting analysis.

xxi. Calibrate: Go to "Auto" click on "Analyze", click on "calibrate".

xxii. "Select Location" enter #'s to be ran, and then press "OK". Samples are done in increments of 10 samples

B. Analyze the calibration standards as below.

1. New calibration points must be analyzed when the ICV analysis is not within ± 5%. **A curve must be analyzed daily for all projects especially USACE and CLP projects.**

2. The curve should be linear with a calculated intercept with a minimum correlation coefficient (r) of $\geq$0.995 (USACE) or 0.998 (other). If not, a new curve must be analyzed.

IX. PROCEDURE

A. Glassware preparation

1. After use, samples are nuetralized and disposed down an acid sink with running water and rinsed with tap water. Or the sample may be discarded into the Mercury waste drum.

2. Acid clean the glassware used for mercury prep as follows:

a. Rinse with low Hg content 1:1 HCl.

b. Rinse with D.I. water.

B. Label the vessels indicating which sample will be in each..

C. Prepare calibration standards as detailed above. Add all reagents to the standards which are added to the samples as outlined below. Record the standard preparation in the digestion log.

D. Sample preparation

1. Transfer 30 mL, or an aliquot diluted to 30 mL of sample to the 30 mL mark on a 50 mL digestion vessel previously marked for this sample.

   NOTE: Normally, **a**n automatic dilution of 10X to 100X is performed for all TCLP extracts. All TCLP samples get one matrix spike unless several come in at one time from the same client with the same matrix. Then one in ten of the same matrix get spiked. Check with your manager.

2. Add 1.5 mL of concentrated sulfuric acid to each vessel and mix.

3. Add 0.75 mL of concentrated nitric acid to each bottle and mix.

4. Add 4.5 mL potassium permanganate solution to each vessel and mix. For sewage samples additional permanganate may be required. Shake and add additional portions of potassium permanganate to the solution if necessary, until the purple color persists for at least 15 minutes (not more than 7.5 mL). If the purple color does not persist after the addition of 7.5 mL $KMnO_4$ the sample must be diluted prior to digestion. Inform your manager that the minimum detection limit cannot be reached for that particular matrix.

   NOTE: The same amount of $KMnO_4$ added to the samples should be present in the standards and blanks.

5. Add 2.4 mL of potassium persulfate to each vessel and mix. Cover.

6. Heat for 2 hours in the block digester at 95$\pm$2°C (the block temperature must be monitored and documented. Record observed temperature, correction factor, and the corrected temperature), cool.

6. Samples may be saved at this point if there is not time to run the whole set that day.

NOTE: Stannous Chloride (VII. A 5.) and 3% HCl (VII. A 8.) are added by the instrument during analysis.

E. Sample analysis

1. Set up the instrument as described in the calibration section above.

2. When ready to run samples, add 1.8 mL of sodium chloride-hydroxylamine chloride to reduce the excess permanganate. Sample analysis must be preceded by the analysis of an ICV with control limits of ±10% for SW846-7470 and ±5 % for 245.1. Followed by the ICB (< ±MDL for USACE or ±RL/CRDL for others and CLP).

3. Each set of ten samples and at the end of the analytical run must be followed by a CCV with control limits of ±20% for SW846-7470 and ±10% for 245.1

4. CCB must always follow the CCV. Control limits are (<±MDL for USACE or ±RL/CRDL for others and CLP). CCB must be run at the beginning and end of a sequence and after every 10 samples. **No analyte must be detected >2xMDL for DOD QSM Ver. 3.**

5. The autosampler log is set up to analyze 106 samples at a time.

Instrument Run Log example:

AS LOC	**Sample ID**
0	Wash
1	0.0
2	0.02
3	0.05
4	0.1
5	0.2
6	0.4
7	0.6
8	1.0
9	ICV
10	ICB
11	LCSW
AS LOC	**Sample ID**
12	PBW
13	Sample
14	Sample
15	Sample
16	Sample
17	Sample
18	Sample
19	Sample
20	Sample
21	CCV

22	CCB
23	Sample
24	Sample
25	Sample
26	Sample
27	Sample
28	Sample
29	Sample
30	Sample
31	MS
32	MSD
33	FCV
34	FCB

F. Data reporting

1. Reduce data to result which will be reported.

2. Complete the data review checklist (attached). Must be completed and attached to each set of USACE data.

X. CALCULATIONS

A. Apply a least squares fit to the calibration standards plotting µg Hg/L versus the absorbance. For the concentration of the standards, assume 30 mL of solution volume (the 0.1 µg Hg standard will be input as 1.0 µg Hg/L) (0.1µg Hg / 0.030 L solution).

B. Input the sample absorbance into the mercury spreadsheet making sure that you are using the correct spreadsheet for the matrix of the sample.

C. Also make sure that the appropriate dilution factor is inputted in the correct space on the spreadsheet.

D. Report the data as µg Hg/L of sample.

XI. QUALITY CONTROL (Reference SW-846, 7470A Update III, USEPA CLP ILMO 4.1 or 245.1, Rev 3.0, 5/94 for further clarification)

A. Daily

1. **The instrument must be calibrated daily for all projects.**

2. Begin each analysis with an ICV(QCS) second source. The control limits are ±10% and IPC(CCV) for 245.1, limits are ± 5% and subsequent analyses are ± 10%.

3. Analyze ICB. Control limits (<±MDL for USACE or ±RL/CRDL for others and CLP)., depending on method. **No analyte detected >2xMDL for DOD QSM Ver. 3.**

4. If the ICV(QCS) is not in control a new curve must be analyzed prior to sample analysis.

5. If the IPC(initial CCV) for 245.1 is not within the limits of ±5%, try preparing another undigested CCV and reanalyzing before recalibrating. If this fails then a recalibration is necessary.

6. Follow each set of 10 samples with a CCV and also must end up with a CCV after the last sample. The control limits are ±20% for SW846-7470 and ± 10% for 245.1.

7. A CCB must always follow a CCV, the control limit is (<±MDL for USACE or ±RL/CRDL for others and CLP). CCB must be run at the beginning and end of a sequence and after every 10 samples. **No analyte detected >2xMDL for DOD QSM Ver. 3.**

B. Quarterly or as needed when doing straight CLP work.

1. IDL's for CLP 4.1.

C. Digestion

1. LCS data should be maintained and available for easy reference or inspection.

2. Preparation blank (<1/2 ±RL or ±RL/CRDL for common contaminates (DOD) and ±RL/CRDL for others and CLP).

   a. Employ a minimum of one preparation blank per sample batch to determine if contamination or any memory effects are occurring. The preparation blank is taken through the same digestion/preparation steps as the samples being tested. The result for the preparation blank must be below the method detection limit. If not, the analyst must use good judgment to evaluate the impact upon the associated samples. There is no impact if an associated sample is below the method detection limit nor if the level in the sample is greater than 10X the level found in the preparation blank. If the level of mercury in a

sample is above the method detection limit but less than 10X the level found in the preparation blank, the sample must be redigested and reanalyzed or the data must be qualified on the final report. The project manager or QA manager will make this determination.

3. Laboratory control sample (LCS)

   a. Employ a minimum of one laboratory control sample (LCS) per sample batch to verify the digestion procedure. The LCS is taken through the same digestion/preparation steps as the samples being tested. The minimum control limits are ±20% for SW846-7470 and ±15% for 245.1. If the LCS is not in control, the impact upon the client data should be evaluated and the associated sample(s) should be either redigested or the data should be qualified. The project manager or QA Officer will make this determination.

D. Sample matrix

1. Analyze one replicate sample for every twenty samples. A replicate sample is a sample brought through the whole sample preparation and analytical process in duplicate. It is acceptable to substitute a matrix spike duplicate for the sample replicate. CLP does not allow this. Project specific requirements will take precedence in these situations.

2. Analyze one spiked sample and spiked sample duplicate for every twenty samples. A replicate sample is a sample brought through the whole sample preparation and analytical process in duplicate. Project specific requirements will take precedence in these situations. CLP requires 1 duplicate and 1 spike per batch. If the analyte level in the sample is not greater than four times the spiking level, the spike recoveries should be within ±25% of the true value (**± 20% for DOD projects**). If not, check with supervisor to determine appropriate action. The final analytical report must document this situation.

   NOTE: For TCLP extracts, a matrix spike must be performed for each different matrix. The method of standard additions must be used if the sample spike recovery is not at least 50% and the concentration of Hg does not exceed the regulatory level and if the concentration of Hg measured in the extract is within 20% of the regulatory level.

3. The relative percent difference (RPD) between replicate determinations is to be calculated as referenced in the laboratory QA manual. (A control limit of ± 20% RPD shall be used for sample values greater than ten times the instrument detection limit.) Supervisor must be notified if the control

limit is not met. Supervisor will determine corrective action if required. The final analytical report must document this situation.

4. For 245.1 analyze one serial dilution (1 to 5 dilution) for every 20 samples or per analytical batch, whichever is more frequent. Percent recovery should be ±10%. The concentration of the original sample should be a minimum of 50X the IDL in order to apply the recovery criterion; if not, the serial dilution approach is not used.

5. When the sample matrix is so complex that viscosity, surface tension, and components can not be accurately matched with standards, the method of standard addition (MSA) is recommended. Section 8.6 of SW846-7000A provides tests to evaluate the need for using the MSA.

E. Method Detection Limit (MDL), Empirical Laboratories' Reporting Limit (ERL), Contract Required Quantitation Limit (CRQL) and Analyte Wavelength:

TABLE I

Aqueous Method Detection Limits(MDL), Empirical Laboratories' Reporting Limits(ERL), CLP OLM04.1 & OLM05.2 Contract Required Quantitation Limits (CRQL)				
Mercury by EPA 245.1, 7470A, SOW 4.1 & 5.2	**AQUEOUS MDL(ug/L)**	**AQUEOUS ERL(ug/L)**	**AQUEOUS CRQL ILMO 4.1 (ug/L)**	**AQUEOUS CRQL ILMO 5.2 (ug/L)**
Mercury	0.08	0.20	0.2	0.2

TABLE 2

ANALYTE	**WAVELENGTH**
Mercury	**253.7**

XII. CORRECTIVE ACTIONS

A. INSTRUMENT RELATED

1. ICV(**QCS for 245.1**)- second source not within ± 10%.
   a. If the problem is with the solution.
      i. Reprepare, obtain new stock if necessary.
   b. If the problem is with the calibration.
      i. Recalibrate through analysis of appropriate standards and recheck ICV.
2. CCV not within ± 20% for SW846 and ±10% for (**245.1, ± 5% for initial IPC and + 10% for subsequent IPCs**)
   a. If the problem is with the solution.
      i. Reprepare, obtain new stock if necessary.
   b. If the problem is with the calibration.
      i. Recalibrate through analysis of appropriate standards and reprepare/reanalyze the previous ten sample according the following guidelines.
         a. If the CCV was biased high, any of the previous ten samples which were below the detection limit do not require reanalysis.
         b. If the CCV was biased low, the previous ten samples must be reanalyzed.

B. DIGESTION RELATED

1. The preparation blank less than <1/2 RL or ±RL/CRDL for common contaminates (DOD) and ±RL/CRDL for others and CLP.

   a. If the problem is with the instrument or stannous chloride.
      i. Analyze a reagent blank to determine the stannous chloride and the instrument are behaving properly. If this check has detectable mercury, reprepare the stannous chloride or determine if there are any problems with the instrument. Contact supervisor immediately.

   b. If the problem is with the digestion.
      i. All associated samples which are below the RL, CRDL or have a level of mercury greater than 5X the level found in the preparation

blank can be reported. If the level of mercury in an associated sample is not BMDL nor greater than 5X the level found in the preparation blank, the sample must be redigested/reanalyzed or reported as qualified. The project manager or QA manager will make this determination.

2. LCS not within control limits (or ±20%, ± 15% for **245.1**).
   a. If the problem is with the instrument.
      i. Reanalyze when instrument is in control if further sample bottles are available.
   b. Is the problem is with the digestion.
      i. If biased low, associated samples must be redigested.
      ii. If biased high, the impact upon the data user must be evaluated. The samples will be redigested or the data will be qualified on the final report.

C. SAMPLE MATRIX RELATED

1. Replicate analysis RPD not within ±20%
   i. The associated sample data must be qualified on the final report.

2. Spike analysis recovery not within ±25%(**± 20% for DOD projects**)
   i. If the analyte level in the sample is greater than 4X the spiking level, the %recovery can not be evaluated and no action is taken.
   ii. If the analyte level in the sample is not greater than 4X the spiking level, the associated sample data must be qualified on the final report. TCLP extracts must be evaluated as in section XI.D.2 above. The associated sample data must be qualified on the final report.

3. When the sample matrix is so complex that viscosity, surface tension, and components can not be accurately matched with standards, the method of standard addition (MSA) is recommended. Section 8.6 of SW846-7000A provides tests to evaluate the need for using the MSA.

XIII. WASTE DISPOSAL and POLLUTION PREVENTION

Please see Waste Disposal SOP-405, for instruction of proper disposal of waste generated from this area.
Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

XIV. REFERENCES

1. *Test Methods for Evaluating Solid Waste Physical/Chemical Methods, SW-846; Third Edition (Update III)*; Method 7470A

2. USEPA *Code of Federal Requlations, 40, CH 1,PT 136;* Method 245.1; APX-B

3. USEPA *Contract Laboratory Program(CLP) for Inorganics ILM04.1; ILM05.2*

XV. DEFINITIONS

1. Refer to SOP-431 for common definitions.

ADDENDUM FOR USEPA SOW ILM05.2

1. The CCV concentration must be different from the ICV.

2. The same CCV shall be used throughout analysis for an SDG.

3. Calibration standards must be within 5% of the standard concentration.

4. A CRA must be analyzed after the ICV/ICB and after each batch of 20 samples, but before the final CCV/CCB. The control limit is ±30%.

5. Spike samples at 1 ug/L for water.

ANALYST DATA REVIEW CHECKLIST

Sample Number(s):	
Batch Number(s):	
Method:	**7470A (Mercury)**

QA/QC Item	Yes	No	NA	Second Level Review
1. Were samples analyzed within USACE holding times?				
2. Was initial calibration curve QC criteria met?				
3. Was all continuing calibration criteria in control?				
4. Did any sample exceed the highest calibration standard? (If yes, were appropriate dilutions made to generate samples concentration within calibration range?)				
5. Did LCS or blank spike meet control limits?				
6. Did MS/MSD meet control limits?				
7. Was the preparation (Method) Blank below the project required detection limits?				
8. Did you return samples back to cold storage immediately after use?				
9. Was water bath temperature monitored/documented and did you apply the thermometer correction factor?				
10. Sample preparation information is correct and complete.				
11. Analytical results are correct and complete.				
12. The appropriate SOP's have been used and followed.				
14. "Raw data" including all manual integration's have been correctly interpreted.				

15. "Special" sample preparation and analytical requirements have been met. _____ _____ _____ _____

16. Documentation complete (e.g., all anomalies in the analytical sequence have been documented, corrective action forms are complete. _____ _____ _____ _____

Comments on any "No" response:

_____
_____
_____
_____
_____
_____

Analyst: _____ Date: _____

Second-Level Review: _____ Date: _____

MERCURY ANALYSIS IN SOIL/SEDIMENT BY MANUAL COLD VAPOR TECHNIQUE

METHODS SW846 7471A 7471B, EPA 245.5 and CLPILM 04.1 (NJDEP does not accept CLPILM 04.1 after June, 2003), Addendum for USEPA CLP ILM 05.2

SOP NUMBER: SOP-104

REVISION NUMBER: 17

APPROVED BY:

Betty DeVille
SECTION MANAGER

Randy D. Ward
TECHNICAL DIRECTOR

EFFECTIVE DATE: 01/29/09

DATE OF LAST REVIEW 01/29/09

MERCURY ANALYSIS IN SOIL/SEDIMENT BY MANUAL COLD VAPOR TECHNIQUE
References:
SW846 Method 7471A, 7471B
USEPA Method 245.5, CLP SOW ILM04.1
See Addendum for CLP SOW ILM05.2

I. SCOPE AND APPLICATION:

A This procedure measures total mercury (organic and inorganic) in soils, sediments, bottom deposits and sludge type materials.

B. The range of the method is 0.2 to 2 µg/g. The range may be extended above or below the normal range by increasing or decreasing sample size or through instrument and recorder control.

II. SUMMARY OF METHOD:

A. A weighed portion of the sample is acid digested for 2 minutes at 95±2°C, followed by oxidation with potassium permanganate and with a secondary digestion at 95°C for 30 minutes. Mercury in the digested sample is then measured by the conventional cold vapor technique.

III. SAMPLE HANDLING AND PRESERVATION:

A. Because of the extreme sensitivity of the analytical procedure and the omnipresence of mercury, care must be taken to avoid extraneous contamination. Sampling devices and sample containers should be ascertained to be free of mercury; the sample should not be exposed to any condition in the lab that may result in contact with solid, liquid or airborne mercury.

B. Refrigerate solid samples at 4°C (±2°C) upon receipt until digestion and analysis.

C. The sample should be analyzed without drying. A separate percent solids determination is required

D. The holding time for digestion of mercury samples is 28 days.

IV. INTERFERENCES:

A. Potassium permanganate is added to eliminate possible interference from sulfide. Concentrations as high as 20 mg/Kg of sulfide, as sodium sulfide, do not interfere with the recovery of added inorganic mercury in reagent water.

B. Copper has also been reported to interfere; however, copper concentrations as high as 10 mg/Kg had no effect on recovery of mercury from spiked samples.

C. Samples high in chlorides require additional permanganate (as much as 12.5 mLs) because, during the oxidation step, chlorides are converted to free chlorine, which also absorbs radiation of 253 nm. Care must therefore be taken to ensure that free chlorine is absent before the mercury is reduced and swept into the cell.

D. Certain volatile organic materials that absorb at this wavelength may also cause interference. A preliminary run without reagents should determine if this type of interference is present.

V. SAFETY

A. Normal accepted laboratory practices should be followed while performing this procedure.

B. The toxicity and carcinogenicity of each reagent used in this method has not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be minimized by good laboratory practices. Normal accepted laboratory safety practices should be followed during reagent preparation and instrument operation. Always wear safety glasses or full-face shield for eye protection when working with these reagents. Each laboratory is responsible for maintaining a current safety plan, a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method.

C. Mercury compounds are highly toxic if swallowed, inhaled, or absorbed through the skin. Analyses should be conducted in a laboratory exhaust hood. The analyst should use chemical resistant gloves when handling concentrated mercury standards.

VI. EQUIPMENT/APPARATUS:

A. Perkin Elmer Flow Injection Mercury System (FIMS)

B. Perkin Elmer AS 90

C. Mercury lamp

D. Environmental Express Mod-Block digestion block capable of holding 95±2°C for 2 hours

E. A scale or balance capable of weighing to 0.01 ± 0.02 gram.

F. Snap cap digestion polypropylene vessels for use with the mod block digester. **Five vessels of each lot must be taken through analysis to check for mercury**

G. Polypropylene watch glasses suitable for use with the above vessels in F above.

H. Manual Sample Mill

I. Wiley Sample Mill

J. Clippers for cutting vegetation

VII. REAGENTS AND STANDARD PREPARATION:

A. REAGENTS

1. Reagent Water: Reagent water will be interference free. All references to water in this method refer to reagent water unless otherwise specified.

2. Aqua Regia: Prepare immediately before use by carefully adding three volumes of concentrated HCl to one volume of concentrated HNO_3. Both HNO_3 and HCl must be of the reagent grade suitable for mercury determinations.

   NOTE: This reagent is required for use when USACE project samples are being digested.

3. Concentrated HCl.

4. Concentrated HNO_3.

5. Stannous chloride in a one liter volumetric flask add ~500 mL D.I. H_2O, 30 mL concentrated HCl, and 11g stannous chloride crystals. Swirl to mix and dilute to 1 L.

6. Sodium chloride-hydroxylamine chloride solution: Dissolve 120 g of sodium chloride and 120 g of hydroxylamine sulfate in reagent water and dilute to 1 L. Note : this is normally made up 2 liters at a time.

7. Potassium permanganate, mercury-free, 5% solution (w/v): Dissolve 200 g of potassium permanganate in 4 L of reagent water.

8. 3 % HCl carrier solution: 30 mL HCl – 1 L DI H20; Prepare fresh daily.

9. Potassium persulfate 5% solution: Dissolve 100g in 2 liters of D.I. water. Used with digestion of CLP soils.

B. STANDARDS

1. Traceability

a. A bound logbook record shall be maintained on all reference materials. The record shall include date of receipt, source, purity, all compositional information, storage conditions and expiration date. These materials/solutions are to be identified by a unique number in the logbook as well as on the container's label.

b. All working standards made from reference materials shall be labeled with a unique ID number with complete information on preparation date, concentration of each compound, solvent, preparer's name, expiration date. Reagents shall be labeled with date received and expiration date, if applicable. All of the information described above shall also be recorded in a bound logbook. Measurements made during standards preparation (e.g., from weighing operations, volume diluted to, etc.) shall also be recorded. There should be no container with sample, sample extract, standard solution, etc. that is not correctly labeled and properly stored.

c. The analyst must initial and date each entry made in a logbook. Each analyst must be sure to "Z" out the unused area of each logbook page.

2. Preparation

NOTE: All standard solutions should be prepared using class A volumetric flasks, class A volumetric pipettes (or calibrated Eppendorfs). All Standards, blanks, and samples are taken through the digestion process.

a. Stock mercury solution: (100 µg/mL). Order from manufacturer already prepared. This solution is given a unique identifier.

b. Primary source and secondary source mercury standard solutions: dilute 2 mL of stock solution to 1000 mL in a 1000 mL volumetric flask, with 1.5 mL concentrated HNO_3 (200 ug/L).

c. Calibration standards

   i. Prepared from the primary source standard. The preparation of the calibration standards, etc. is described below.

      a. Dilute the volumes below to 5 mLs in a 70 mL polypropylene vessel. (Note: The standards are diluted to 5 mLs for the initial step of the digestion.)

ug/L Hg	mLs of 200 ug/L standard in 50 mL
0.20	0.050
0.50	0.125
1.0	0.25
2.0	0.50
4.0	1.0
6.0	1.5
10.0	2.5

   ii. Appropriate reagents are added as below in the sample preparation section.

   iii. Prepare one vessel of each.

   iv. It is necessary to digest the calibration standards when following all mercury methods.

e. Calibration verification standards

   i. Initial calibration verification (ICV) solution – 4.0 ug/L

      a. Prepared from the secondary source mercury standard (200 ug/L).

      b. Prepared by diluting 1.0 mL of the second source mercury standard to 5 mLs in a polypropylene digestion vessel.

      c. Appropriate reagents are added as below in the sample preparation section.

d. It is necessary to digest the ICV standards when using all mercury methods for soil.

ii. Continuing calibration verification (CCV) solution

a. Prepared from the primary or secondary source mercury standard. The concentration is alternated from 2.0 ug/L to 4.0 ug/L every 20 samples.

b. Prepared by diluting 0.50 for a 2.0 ug/L and 1.0 mL for a 4.0 ug/L of the secondary 200 ug/L standard to 5.0 mL with reagent water in a polypropylene digestion vessel.

c. Appropriate reagents are added as below in the sample preparation section.

d. It is necessary to digest the CCV standards when following all mercury methods for soil.

f. Digestion standards

1. Laboratory control sample

a. The Laboratory Control Sample (LCS) is prepared from the secondary source mercury standard (200 ug/L) and added to ~ 0.3 grams of teflon chips.

b. Prepared by diluting 0.50 mL of the secondary mercury standard (200 ug/L) to 5 mLs in a polypropylene digestion vessel with 0.30 grams of teflon chips.

c. Appropriate reagents are added as below in the sample preparation section.

d. This solution is given a unique identifier in the digestion log.

2. Matrix Spikes

a. Prepared from the primary or secondary source mercury standard (200 ug/L).

b. Prepared by adding 0.50 mL of the mercury standard (200 ug/L) to the sample in a polypropylene digestion vessel. Project specific requirements may over-ride the spiking level.

c. Appropriate reagents are added as below in the sample preparation section.

VIII. CALIBRATION:

A. Set up the instrument with proper operating parameters.

1. Perkin Elmer Flow Injection Mercury System (FIMS)

a. Prepare the instrument for calibration by the following steps:

i. Replace any old tubing that is around the pump cylinder. The sample transfer tubing connected to the seperator cover must not have any moisture in it. If it does replace it. **(Perkin-Elmer tygon tubing, waste and carrier 1.52mm I.D.,waste only 3.17mm I.D., stannous chloride 1.14mm I.D.)**

ii. Also replace the filter membrane with the rough side up. (for instructions refer to page 1-22 in maintenance manual.)

iii. Turn on PE 100 spectrophotometer; (Note: this must be on in order to start up the software on the computer.)

iv. Turn on computer and go to icon "AA Win LAB Analyst"

v. Go to method; select "Hg CAL 2" then OK.

vi. Wavelength = 253.7; smoothing points =9; measurement = peak height; read time = 18 sec.; BCC time = 2 sec.

vii. Go to "Sample Info" and enter the order of the samples and other information that may be needed.

viii. Save entered sample list under "Save …sample info file" Note: description and batch ID are normally the date of analysis.

ix. Go to "auto"; then to set-up. Select Browse in both spaces. One is to bring up your saved "Sample Information." File. The other is to select a results library. Double click on heading and choose.

x. Turn the printer on.

xi. Connect all tubing to the pump and blocks.

xii. Start the pump by going to "FIAS" and click the pump 1 Icon (120).

xiii. The pump witll start, then lock down and tighten the tubes onto the pump.

xiv. Turn on the nitrogen tank, it should be >500 psi on the guage. Replace the nitrogen tank when it is at 500 psi.

xv. The pressure gauge on the PE100 should be just below 100.

xvi. Use the tension adjuster to press down the tubing magazine to the pump head on the top and bottom. Start the pump and then lock them down. This technique needs to be demonstrated so that a new user will be able to understand what is needed here and how to do it.

xvii. Adjust the spring tension tubing until there is a constant "bubble of low rate" coming out to the waste tube.

xviii. Place carrier tubes into carrier and stannous chloride tube into SnCl2. (click valve fill inject and make sure flow is correct and the line is rinsed)

xix. Make sure the permanganate waste bottle is bubbling in order to absorb any Hg vapors which could be vented into the room.

xx. Allow a few minutes for reagents to flow through the system before starting analysis.

xxi. Calibrate: Go to "Auto" click on "Analyze", click on "calibrate".

xxii. "Select location" enter the #'s of the samples to be analyzed, then "OK".

B. Analyze the calibration standards as below.

1. A curve must be analyzed daily for all projects. A new curve must be analyzed when the ICV analysis is not within ±10% for SW846 7471A and 245.5 methods, or ±20% for 7471B.

2. The curve should be linear with a calculated intercept with a minimum correlation coefficient(r) of ≥0.995 (USACE) or 0.998 (other). If not, a new curve must be analyzed.

3. **CLP requires a blank + 5 calibration standards (0, .02, .05, .1, .5 and 1.0 µg). (One standard must be at CRDL or IDL whichever is greater.)**

IX. PROCEDURE:

A. Prepare calibration standards as detailed above. Add all reagents to the standards which are added to the samples as outlined below. Record the standard preparation in the standard log.

B. Sample preparation

It is extremely important that waste (when appropriate), soil and sediment samples be mixed thoroughly to ensure that the sample is as representative as possible of the sample media. The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

- The material in the sample pan(inorganic-plastic/organic-aluminum) should be divided into quarters and each quarter should be mixed individually.
- Two quarters should then be mixed to form halves.
- The two halves should be mixed to form a homogenous matrix.

This procedure should be repeated several times until the sample is adequately mixed.

NOTE: Samples that are clay type materials must be handled in a different manner. Due to these type sample matrices having an affinity to stick to most anything that touches it, another approach must be followed. Obtain a representative sub-sample aliquot from the center or middle section of the sample container.

Grinding of Vegetation Samples

Remove sample from shipping container and brush off dirt particles. Chop sample into about half inch pieces with clippers or other cutting tool. Place the sample in an aluminum pan and air-dry in an exhaust hood to the appropriate dryness for grinding. It should be dry enough where it won't stick to the inside of the mill. Grind the dried sample to fineness in either the manual sample mill or the Wiley mill or both if needed. Place the ground sample in a container and label immediately.

1. Transfer 0.30 g (for USACE work use anywhere from 0.20 to 1.0 g and record the weight in the digestion log) of sample to a polypropylene digestion vessel previously marked for this sample. Record the exact sample mass on the bottle and in the digestion log. (Note: the balance must be calibrated for the specific task. Calibrate by weighing a 0.5 and a 0.1g weight on the balance along with a digestion vessel. Record in specific balance calibration log.)

2. Add 2.5 mL of reagent water, and 2.5 mL of aqua regia and mix for samples. Add 2.5 mL of aqua regia to standards and mix.

3. Cover samples and standards with watch glasses and heat for 2 minutes in the hot block at 95±2°C (The hot block temperature must be monitored and documented. Record observed temperature, correction factor, and the corrected temperature).

4. Cool, bring to 30 ml with D.I. water

5. Add 7.5 mL potassium permanganate solution to each vessel and mix. For sewage samples additional permanganate may be required. Shake and add additional portions of potassium permanganate to the solution if necessary, until the purple color persists for at least 15 minutes (not more than 12.5 mL).
   NOTE: The same amount of $KMnO_4$ added to the samples should be present in the standards and blanks.

6. Heat for 30 minutes on the hot block at 95±2°C (The temperature must be monitored and documented. Record observed temperature, correction

factor, and the corrected temperature), cool. Samples may be saved at this point if there is not time to run the whole set that day.

7. Add 3 mLs of sodium chloride-hydroxylamine chloride solution to each vessel.

8. Bring to 50 ml with D.I. water both standards and samples. Cap mix and vent to decolor and release Cl gas. The samples are now ready for analysis.

NOTE: Stannous Chloride (VII. A 5.) and 3% HCl (VII. A 8.) are added by the instrument during analysis.

C. Sample analysis

1. Set up the instrument as described in the calibration section above.

2. When ready to run samples, transfer samples and standards to autosampler tubes and load the auto sampler according to the sample information sheet set up previously. If chlorides are suspected, purge the head space in the polyethylene tube for at least 1 minute to get rid of any chlorine gas collected there. After a delay of at least 30 seconds the sample is ready for step "3". **NOTE:** When aqua-regia is added assume that all samples and standards have chlorine and treat accordingly. Purging the samples of chlorine is accomplished by putting a pasteur pipette on the end of some air tubing hooked to a fish pump. The pasteur pipette is then placed at an angle into the top of the polyethylene vessel without breaking the surface of the sample. It takes about one minute to purge the air above the sample of chlorine.

3. Analysis must be preceded by the analysis of an ICV (concentration at or near mid range) with control limits of ±10% for SW846-7471A or ±20% for 7471B and ±5% for 245.5 methods.

4. The ICB must follow the calibration standards (<±MDL (USACE) or ±RL/CRDL for other or CLP), but not before the ICV. **No analyte must be detected > 2xMDL for DOD QSM Ver. 3.**

5. Each set of ten samples must be followed by a CCV with control limits of ±20% for SW846-7471A and B and ±10% for 245.5 method. The run must also end with a CCV, then CCB.

6. Analyze CCB after calibration and each CCV. The CCB frequency is 10% or every 2 hours whichever is more frequent. (control limit is < ±MDL or ±RL/CRDL for other or CLP). **For DOD QSM Ver.3 CCB at**

beginning and end of sequence and after every 10 samples. No analyte detected > 2xMDL.

7. Instrument Run Log example:

AS LOC	Sample ID
0	Wash
1	0.0
2	0.O2
3	0.05
4	0.1
AS LOC	**Sample ID**
5	0.2
6	0.4
7	0.6
8	1.0
9	ICV
10	ICB
11	LCSW
12	PBW
13	Sample
14	Sample
15	Sample
16	Sample
17	Sample
18	Sample
19	Sample
20	Sample
21	CCV
22	CCB
23	Sample
24	Sample
25	Sample
26	Sample
27	Sample
28	Sample
29	Sample
30	Sample
31	MS
32	MSD
33	FCV
34	FCB

8. Sample analysis:

i. Go to "Analyze", "select location" and type in the range of numbers needed to complete analysis. (ie. 9-54). Press enter and the autosampler will proceed to enter the selected range. NOTE: Check standards are loaded as part of the tray.

ii. Make sure that the sample wash beaker is filled with 3% HCl.

iii. Dilute and reanalyze samples that are more concentrated than within 10% of the high standard. Soil sample dilutions are made from the digested aliquot. Sample concentration results that are below the calibration curve but above the MDL are reported flagged as estimated, ("B" flag).

D. Data reporting

1. Reduce data to result which will be reported using the soil spreadsheet found on the network..

2. Complete the data review checklist (attached). Must be completed and attached to each set of USACE data.

X. CALCULATIONS:

A. Pull up the blank spreadsheet at K:\wcm\tests\mercury and fill in all the information pertinent to the current analysis. Save as the date of analysis. This information can be obtained from your mercury digestion log.

B. Input the sample absorbance into the excel spreadsheet in the appropriate cell. The spreadsheet uses the current calibration to calculate the Hg results.

C. Make sure that the appropriate dilution factors are entered into the spreadsheet in the correct cells.

D. The spreadsheet should divide the result which is the µg Hg obtained from the sample mass by the sample mass in grams. This will yield a result of µg Hg/g sample on a wet weight basis. Calculations in the spreadsheet should be checked occassionally to make sure that they are working correctly.

E. If available, divide the result by the %solids to obtain the result on a dry weight basis.

F. Report the data as µg Hg/g of sample (mg/kg wet or mg/kg dry when % solids are available).

XI. QUALITY CONTROL (Reference SW-846, 7471A Update III, 7471B Revision 2 February 2007, USEPA CLP ILMO 4.1 or EPA 245.5 for further clarification)

A. Daily

1. **The instrument must be calibrated daily for all projects.**

2. Begin each analysis with an ICV. The control limits are ±10% for 7471A and 245.5, ±20% for 7471B.

3. Analyze ICB. Control limit is <± **MDL** or ±RL/CRDL for other or CLP. **For DOD QSM Ver. 3, no analyte detected > 2x MDL.**

4. If the ICV is not in control a new curve must be analyzed prior to sample analysis.

5. Follow each set of 10 samples with a CCV and also must end up with CCV after last sample. The control limits are ±20% for SW846-7471A, SW846 7471B and for 245.5. If an exceedance occurs, analyze another CCV, if the second CCV fails, then a new calibration curve should be generated and all affected samples should be reanalyzed.

6. Follow each CCV with a CCB. Control limit is **< ±MDL** or ±RL/CRDL for others or CLP. **For DOD QSM Ver. 3, no analyte detected > 2x MDL.**

B. Quarterly

1. IDLs for CLP (Follow SOP - 414).

C. Annually

1. MDLs must be analyzed for all matrixes (Follow SOP - 414).

D. Digestion

1. LCS data should be maintained and available for easy reference or inspection.

2. Preparation blank (< ±½ RL or ±RL for common contaminates or ±RL/CRDL for others or CLP)

   a. Employ a minimum of one preparation blank per sample batch to determine if contamination or any memory effects are occurring. The preparation blank is taken through the same digestion/preparation steps as the samples being tested. The result for the preparation blank must be < ± ½ RL for USACE or ±RL/CRDL for others or CLP. If not, the analyst must use good judgment to evaluate the impact upon

the associated samples. There is no impact if an associated sample is below the method detection limit or if the level in the sample is greater than 10X the level found in the preparation blank. If the level of mercury in a sample is above the method detection limit, but less than 10X the level found in the preparation blank, the sample must be redigested and reanalyzed or the data must be qualified on the final report. The project manager or QA officer will make this determination.

3. Laboratory control sample (LCS).

   a. Employ a minimum of one LCS per sample batch to verify the digestion procedure.. The LCS is taken through the same digestion/preparation steps as the samples being tested. The minimum control limits are ±20% for SW846-7471A, 7471B and 245.5 solid samples. An LCS will accompany each batch of soil samples. If the LCS is not in control, the Inorganic Manager and QA Officer must be notified immediately. Several possibilities exist at this point and a thorough investigation and data evaluation is essential. The first question is to evaluate the impact upon the data. All samples may need to be retested or flagged with the appropriate qualifier. The next question is to find out why it occurred and to proceed with a corrective action plan to prevent reoccurrence. This corrective action is documented in a CAR.

E. Sample matrix

1. Analyze one replicate sample for every twenty samples or per analytical batch, whichever is more frequent. A replicate sample is a sample brought through the whole sample preparation and analytical process in duplicate. It is acceptable to substitute a matrix spike duplicate for the sample replicate. Project specific requirements will take precedence in these situations.

2. Analyze one spiked sample and spiked sample duplicate for every twenty samples or per analytical batch, whichever is more frequent. A replicate sample is a sample brought through the whole sample preparation and analytical process in duplicate. Project specific requirements will take precedence in these situations. CLP requires 1 duplicate and 1 spike per batch. If the analyte level in the sample is not greater than four times the spiking level, the spike recoveries should be within ±25% for 7471A and ±20% for 7471B of the true value**(±20% for DOD projects**). If results do not fall within the control limit-redigestion/reanalysis may be required. If reanalysis is not required, the associated batch of samples will be flagged accordingly. Discuss the situation with your supervisor. A Corrective Action Report (CAR) must be filled out and attached to the

data as well as emailed or sent to the supervisor when the control limits are exceeded.

3. The relative percent difference (RPD) between replicate determinations is to be calculated as referenced in the laboratory QA manual. (A control limit of ± 20% RPD (non-aqueous samples may routinely exceed this amount) shall be used for sample values greater than ten times the instrument detection limit.) Supervisor must be notified if the control limit is not met. Supervisor will determine corrective action if required. The final analytical report must document this situation. A Corrective Action Report (CAR) must be filled out and attached to the data as well as emailed or sent to the supervisor when the control limits are exceeded.

4. For 245.5 analyze one serial dilution (1 to 5 dilution) for every 20 samples or per analytical batch, whichever is more frequent. Percent recovery should be 10%. The concentration of the original sample should be a minimum of 50X the IDL in order to apply the recovery criterion; if not, the serial dilution approach is not used.

5. When the sample matrix is so complex that viscosity, surface tension, and components can not be accurately matched with standards, the method of standard addition (MSA) is recommended. Section 8.6 of SW846-7000A provides tests to evaluate the need for using the MSA.

F. Method Detection Limit (MDL), Empirical Laboratories' Reporting Limit (ERL), Contract Required Quantitation Limit (CRQL) and Analyte Wavelength:

TABLE I

Solid/Soil Method Detection Limits(MDL), Empirical Laboratories' Reporting Limits(ERL), CLP OLM04.1 & OLM05.2 Contract Required Quantitation Limits (CRQL)				
Mercury by EPA 245.1, 245.5, 7471A, SOW 4.1 & 5.2	**SOLID/SOIL MDL (mg/Kg)**	**SOLID/SOIL ERL (mg/Kg)**	**SOLID/SOIL CRQL ILMO 4.1 (mg/Kg)**	**SOLID/SOIL CRQL ILMO** 5.2 (mg/Kg)
Mercury	0.0157	0.033	0.1	0.1

TABLE 2

ANALYTE	WAVELENGTH
Mercury	253.7

XII. CORRECTIVE ACTIONS

A. INSTRUMENT RELATED

1. ICV not within ± 10% (SW846) and (245.5)
   a. If the problem is with the solution.
      i. Reprepare, obtain new stock if necessary.
   b. If the problem is with the calibration.
      i. Recalibrate thru analysis of appropriate standards and recheck ICV.

2. CCV not within ± 20% (SW846) and (245.5)
   a. If the problem is with the solution.
      i. Reprepare, obtain new stock if necessary.
   b. If the problem is with the calibration.
      i. Recalibrate thru analysis of appropriate standards and reprepare/reanalyze the previous ten sample according the following guidelines.
         a. If the CCV was biased high, any of the previous ten samples which were below the minimum detection limit do not require reanalysis.
         b. If the CCV was biased low, the previous ten samples must be reanalysed.

B. DIGESTION RELATED

1. The preparation blank less than ± ½ RL for DOD or ±RL/CRDL for others or CLP.
   a. If the problem is with the instrument or stannous chloride.
      i. Analyze a reagent blank to determine the stannous chloride and the instrument are behaving properly. If this check has detectable mercury, reprepare the stannous chloride or determine if there are any problems with the instrument.
      ii. If the problem was with the instrument or the stannous chloride and the situation is corrected continue analysis with a second aliquot of the preparation blank.
   b. If the problem is with the digestion.
      i. All associated samples which are below the method detection limit (MDL) or have a level of mercury greater than 10X the level found in the preparation blank can be reported. If the level of mercury in an associated sample is not <MDL nor greater than 10X the level found in the preparation blank, the sample must be redigested/reanalyzed or reported as qualified. The project manager or QA manager will make this determination.

2. LCS not within control limits.
   a. If the problem is with the instrument.
      i. Reanalyze when instrument is in control with another aliquot of the sample.
   b. If the problem is with the digestion.
      i. If biased low, associated samples must be redigested.
      ii. If biased high, the impact upon the data user must be evaluated. The samples will be redigested or the data will be qualified on the final report.

C. SAMPLE MATRIX RELATED

1. Replicate analysis RPD not within ±20%
   i. The associated sample data must be qualified on the final report.
2. Spike analysis recovery not within ±25% 7471A and ±20% 7471B **(±20% for DOD projects**)
   i. If the analyte level in the sample is greater than 4X the spiking level, the %recovery can not be evaluated and no action is taken.
   ii. If the analyte level in the sample is not greater than 4X the spiking level, the associated sample data must be qualified on the final report. A corrective action report must accompany the data and be emailed or given to the superviser.

XIII. WASTE DISPOSAL and POLLUTION PREVENTION

Please see Waste Disposal SOP-405, for instruction of proper disposal of waste generated from this area.

Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

XIV. REFERENCES

1. *Test Methods for Evaluating Solid Waste Physical/Chemical Methods, SW-846; Third Edition (Update III/IV)*; Method 7471A, 7471B

2. USEPA *Code of Federal Requlations, 40, CH 1,PT 136;* Method 245.1; APX-B

3. USEPA *Contract Laboratory Program(CLP) for Inorganics ILM04.1; ILM05.2*

XV. DEFINITIONS

1. Refer to SOP-431 for common definitions.

Addendum for USEPA CLP ILM 05.2

1. CCV concentration must be different from ICV.

2. The same CCV shall be used throughout analysis for a sample delivery group.

3. Calibration standards must be within 5% of the standard concentration.

4. 0.2 grams of sample must be used for the sample aliquot, add enough reagent water to each sample to make a total volume of 10 mL. Proceed with method as in the water method SOP 103.0 Revision 9.

5. The ICV and CCV must be at ±20% recovery.

6. A CRA must be analyzed at the beginning and end of each batch of 20 samples. Right after the ICV/ICB and right before the final CCV/CCB. The control limit is ±30%.

7. The matrix spike must be analyzed at the concentration of 0.5 mg/Kg.

ANALYST DATA REVIEW CHECKLIST

Sample Number(s):	
Batch Number(s):	
Method:	**7471A (Mercury)**

QA/QC Item	Yes	No	NA	Second Level Review
1. Were samples analyzed within USACE holding times?				
2. Was initial calibration curve QC criteria met?				
3. Was all continuing calibration criteria in control?				
4. Did any sample exceed the highest calibration standard? (If yes, were appropriate dilutions made to generate samples concentration within calibration range?)				
5. Did LCS or blank spike meet control limits?				
6. Did MS/MSD meet control limits?				
7. Was the preparation (Method) Blank below the project required detection limits?				
8. Did you return samples back to cold storage immediately after use?				
9. Was water bath temperature monitored/documented and did you apply the thermometer correction factor?				
10. Sample preparation information is correct and complete.				
11. Analytical results are correct and complete.				
12. The appropriate SOP's have been used and followed.				
14. "Raw data" including all manual integration's have been correctly interpreted.				
15. "Special" sample preparation and analytical requirements have been met.				
16. Documentation complete (e.g., all anomalies in the analytical sequence have been documented, corrective action forms are complete.				

ANALYST DATA REVIEW CHECKLIST
7471A (Mercury)

Comments on any "No" response:

_____
_____
_____
_____
_____
_____

Analyst: _____ Date: _____

Second-Level Review: _____ Date: _____

METALS ANALYSIS

BY INDUCTIVELY COUPLED PLASMA-ATOMIC EMISSION SPECTROMETRY (ICP-AES) TECHNIQUE

METHODS 200.7, (SW846) 6010B, (SW846) 6010C, (SM 19th Edition 2340B) Hardness Calculation, (USEPA CLP) ILMO 4.1 (NJDEP does not accept CLPILM 04.1 after June, 2003) Addendum for USEPA CLPILM 05.2

SOP NUMBER: SOP-105

REVISION NUMBER: 15

APPROVED BY:

Betty DeWitt
SECTION MANAGER

Randy D. Ward
TECHNICAL DIRECTOR

EFFECTIVE DATE: 02/22/09
DATE OF LAST REVIEW: 05/08/09

ICP METHOD
SOP
References: SW-846, Method 6010B, December 1996; SW-846, Method 6010C, Revision 3 February 2007; USEPA, Method 200.7, June 1991; Standard Methods 19th Edition 2340B; 1995 USEPA CLP, ILM 04.1. See Addendum for USEPA CLPILM 05.2

I. SCOPE AND APPLICATION

A. Inductively Coupled Argon Plasma (ICAP) determines trace elements in solution. **We use the ICP to determine the concentration of the following metals: Ag, Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Sn, Sr, Ti, Tl, V and Zn.** All matrices, including ground water, aqueous samples, TCLP, SPLP and EP extracts, industrial and organic wastes, soils, sludges, sediments, and other solid wastes, require digestion prior to analysis.

B. **Detection limits, sensitivity, and optimum ranges of the metals may be found in the ICP method file.** Use of this method is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences.

II. SUMMARY OF METHOD

A. Prior to analysis, samples must be solubilized or digested using appropriate Sample Preparation Methods (e.g., Methods 3005-3050 and SOW ILM 04.1/05.2). When analyzing for dissolved constituents, acid digestion is not always necessary if the samples are filtered and acid preserved prior to analysis. If particulates form after filtration and preservation the sample must be digested prior to analysis.

NOTE: When selenium is required soluble samples must always be digested.

B. This method describes the simultaneous multi-elemental determination of elements by ICP. The method measures element-emitted light by optical spectrometry. Samples are nebulized and the large droplets are removed by a spray chamber and the small droplets then pass through to the plasma. The solvent is evaporated. The residual sample decomposed to atoms and ions that become excited and emit characteristic light which is measured, giving a measurement of the concentration of each element type in the the original sample. Background correction is required for trace element determination. Background must be measured adjacent to analyte lines on samples during analysis. The position selected for the background-intensity measurement, on either or both sides of the analytical line, will be determined by the complexity of the spectrum adjacent to the analyte line. The position used must be free of spectral interference and reflect the same change in background intensity as occurs at the analytic wavelength measured.

Background correction is not required in cases of line broadening where a background correction measurement would actually degrade the analytical result. Control of the spectrometer is provided by PC based iTEVA software.

C. ICP's primary advantage is that it allows simultaneous determination of any elements in a short time. The primary disadvantage of ICP is background radiation from other elements and the plasma gases. Although all ICP instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Examples would be traces of metals in an alloy or traces of metals in a limed (high calcium) waste. ICP and Flame AA have comparable detection limits (within a factor of 4) except that ICP exhibits greater sensitivity for refractories (Al, Ba, etc.). Furnace AA, in general, will exhibit lower detection limits than either ICP or FAA.

D. It is standard procedure to use an internal standard (scandium) with samples to increase the stability of the instrument as recommended by the manufacturer (Thermo Fisher). (When samples are suspected of containing scandium internal standard cannot be used.)

III. SAMPLE HANDLING AND PRESERVATION

A. Preliminary treatment of most matrices is necessary because of the complexity and variability of sample matrices. Water samples which have been prefiltered and acidified will not need acid digestion as long as the samples and standards are matrix matched and particulates do not form after the filtration and preservation take place. Solubilization and digestion procedures are presented in Sample Preparation Methods (Methods 3005A-3050A).

B. Sample digestates are stored at room temperature for at least 2 months unless a longer time is requested by the client. The samples contain an acid matrix of 3:1. Since the most concentrated acid matrix allowed for direct disposal down an acid sink is a ratio of 20:1, the samples must be diluted with 1 part water to 2 parts sample prior to pouring down the sink while the tap water is running.

C. **The appropriate SOPs should be consulted regarding sample preparation.** The following is a brief summary of the methods we use for metals preparation.

- <u>Method 3005A</u> prepares groundwater and surface water samples for total recoverable and dissolved metals determination by ICP. The unfiltered or filtered sample is heated with dilute HCl and HNO_3 prior to metal determination.

- Method 3010A prepares waste samples for total metal determination by ICP. The samples are vigorously digested with a mixture of nitric acid and hydrochloric acid followed by dilution with laboratory water. The method is applicable to aqueous samples, TCLP and mobility-procedure extracts.

- Standard Methods 19th Edition Method 3030C prepares groundwaters and suface water samples for acid extractable metals: (lead and chromium.) This preparation has a holding time of 72 hours. The samples are preserved at collection with 5mL/L of HNO3, in the laboratory 5 mL/100mL of 1+1 HCl is added and the sample is heated for 15 minutes in a block digester. The sample is filtered through a membrane filter and the filtrate is carefully transferred to a volumetric flask and brought back to 100 mLs.

- Method 3050B prepares wastes samples for total metals determination by ICP. The samples are vigorously digested in nitric acid and hydrogen peroxide followed by dilution with either laboratory water or hydrochloric acid and laboratory water. The method is applicable to soils, sludges, and solid waste samples.

IV. INTERFERENCES

A. Spectral interferences are caused by background contribution from continuum or recombination phenomena, stray light from the line emission of high-concentration elements, overlap of a spectral line from another element, or unresolved overlap of molecular band spectra.

1. Background emission and stray light can usually be compensated for by subtracting the background emission determined by measurements adjacent to the analyte wavelength peak. Spectral scans of samples or single element solutions in the analyte regions may indicate when alternate wavelengths are desirable because of severe spectral interference. These scans will also show whether the most appropriate estimate of the background emission is provided by an interpolation from measurements on both sides of the wavelength peak or by measured emission on only one side. The locations selected for the measurement of background intensity will be determined by the complexity of the spectrum adjacent to the wavelength peak. The locations used for routine measurement must be free of off-line spectral interference (interelement or molecular) or adequately corrected to reflect the same change in background intensity as occurs at the wavelength peak. For multivariate methods using whole spectral regions, background scans should be included in the correction algorithm. Off-line interferences are handled by including spectra on interfering species in the algorithm.

2. To determine the appropriate location for off-line background correction, the user must scan the area on either side adjacent to the wavelength and record the apparent emission intensity from all other method analytes. This spectral information must be documented and kept on file. The location selected for background correction must be either free of off-line interelement spectral interference or a computer routine must be used for automatic correction on all determinations. If a wavelength other than the recommended wavelength is used, the analyst must determine and document both the overlapping and nearby spectral intereference effects from all method analytes and common elements and provide for their automatic correction on all analyses. Tests to determine spectral interference must be done using analyte concentrations that will adequtetely describe the interference. Normally, 100 mg/L single element solutions are sufficient; however, for analytes such as iron that may be found at high concentration, a more appropriate test would be to use a concentration near the upper analytical range limit.

3. Spectral overlaps may be avoided by using an alternate wavelength or can be compensated by equations that correct for interelement contributions. Instruments that use equations for interelement correction require the interfering elements be analyzed at the same time as the element of interest. When operative and uncorrected, interferences will produce false positive determinations and be reported as analyte concentrations. More extensive information on interferant effects at various wavelengths and resolutions is available in reference wavelength tables and books. Users may apply interelement correction equations determined on their instruments with tested concentration ranges to compensate (off line or on line) for the effects of interfering elements. Some potential spectral interferences observed for the recommended wavelength are listed in the method in table 2. For multivariate methods using whole spectral regions, spectral interferences are handled by including spectra of the interfering elements in the algorithm. The interferences listed are only those that occur between method analytes. Only interferences of a direct overlap nature are listed. These overlaps were observed with a single instrument having a working resolution of 0.035 nm.

4. When using interelement correction equations, the interference may be expressed as analyte concentration equivalents (i.e. false analyte concentrations) arising from 100 mg/L of the interference element. For example, assume that As is to be determined (at 193.696 nm) in a sample containing approximately 10 mg/L of Al. According to Table 2 from the method, 100 mg/L of Al would yield a false signal for As equivalent to approximately 1.3 mg/L. Therefore, the presence of 10 mg/L of Al would result in a false signal for As equivalent to approximatley 0.13 mg/L. The user is cautioned that other instruments

may exhibit somewhat different levels of interferences than that shown in Table 2 from the method. The interference effects must be evaluated for each individual instrument since the intensities will vary.

5. Interelement corrections will vary for the same emission line among instruments because of differences in resolution, as determined by the grating, the entrance and exit slit widths, and by the order of dispersion. Interelement corrections will also vary depending upon the choice of background correction points. Selecting a background correction point where an intefering emission line may appear should be avoided when practical. Interelement corrections that constitute a major portion of an emission signal may not yield accurate data. Users should not forget that some samples may contain uncommon elements that could contribute spectral interferences.

6. The interference effects must be evaluated for each individual instrument whether configured as a sequential or simultaneous instrument. For each instrument, intensities will vary not only with optical resolution but also with operating conditions (such as power, viewing height and agron flow rate). When using the recommended wavelengths, the anlaylst is required to determine and document for each wavelength the effect from referenced interferences as well as any other suspected interferences that may be specific to the instrument of matrix. The analyst is encouraged to utilize a computer routine for automatic correction on all analyses.

7. If the correction routine is operating properly, the determined, apparent analyte(s) concentration from analysis of each interference solution should fall within a specific concentration range around the calibration blank. The concentration range is calculated by multiplying the concentration of the interfering element by the value of the correction factor being tested and divided by 10. If after the subtraction of the calibration blank the apparent analyte concentration falls outside of this range in either a positive or negative direction, a change in the correction factor of more than 10% should be suspected. The cause of the change should be determined and corrected and the correction factor updated. The interference check solutions should be analyzed more than once to confirm a change has occurred. Adequate rinse time between solutions and before analysis of the calibration blank will assist in the confirmation.

8. When interelement corrections are applied, their accuracy should be verified, daily, by analyzing spectral interference check solutions. If the correction factors or multivariate correction matrices tested on a daily basis are found to be within 20% criteria for 5 consecutive days, the required verification frequency of those factors in compliance may be extended to a weekly basis. Also, if the nature of the samples

analyzed is such they do not contain concentrations of the interfering elements at ± one reporting limit from zero, daily verification is not required. All interelement spectral correction factors or multivariate correction matrices must be verified and updated every six months or when an instrumentation change, such as in the torch, nebulizer, injector, or plasma conditions occurs. Standard solution should be inspected to ensure that there is no contamination that may be perceived as a spectral interference.

B. Physical interferences are effects associated with the sample nebulization and transport processes. Changes in viscosity and surface tension can cause significant inaccuracies, especially in samples containing high dissolved solids or high acid concentrations. If physical interferences are present, they must be reduced by diluting the sample or by using a peristaltic pump, by using an internal standard or by using a high solids nebulizer. Another problem that can occur with high dissolved solids is salt buildup at the tip of the nebulizer, affecting aerosol flow rate and causing instrumental drift. The problem can be controlled by wetting the argon prior to nebulization, using a tip washer, using a high solids nebulizer or diluting the sample. Also it is has been reported that better control of the argon flow rate, especially to the nebulizer, improves instrument performance: this may be accomplished with the use of mass flow controllers.

C. Memory interferences result when analytes in a previous sample contribute to the signals measured in a new sample. Memory effects can result from sample deposition on the uptake tubing to the nebulizer and from the build up of sample material in the plasma torch and spray chamber. The site where these effects occur is dependent on the elements and can be minimized by flushing the system with a rinse blank between samples. The possibility of memory interferences should be recognized within an analytical run and suitable rinse times should be used to reduce them. The rinse times necessary for a particular element must be estimated prior to analysis. This may be achieved by aspirating a standard containing elements at a concentration ten times the usual amount or at the top of the linear dynamic range. The aspiration time for this sample should be the same as a normal sample analysis period, followed by analysis of the rinse blank at designated intervals. The length of time required to reduce analyte signals to within a factor of two of the method detection limit should be noted. Until the required rinse time is established, this method suggests a rinse period of at least 60 seconds between samples and standards. If a memory interference is suspected, the sample must be reanalyzed after a rinse period of sufficient length. Alternate rinse times may be established by the analyst based upon their DQOs.

D. Users are advised that high salt concentrations can cause analyte signal suppressions and confuse interference tests. If the instrument does not display negative values, fortify the interference check solution with the elements of interest at 0.5 to 1 mg/L and measure the added standard concentration

accordingly. Concentrations should be within 20% of the true spiked concentration or dilution of the samples will be necessary. In the absence of measurable analyte, overcorrection could go undetected if a negative value is reported as zero.

V. SAFETY

A. Normal accepted laboratory safety practices should be followed while performing this analysis.

1. Care should be used in handling all samples. Safety glasses must be worn in the lab at all times. The use of appropriate safety gloves and lab coats is highly recommended.
2. Research into expected sample content and concentration should be done in order to be prepared for additional safety considerations. Generally, any samples that need special consideration have applicable notes on the sample logs.
3. MSDS sheets are available for all reagents and standards that have been purchased. These are located in the bookshelves in the Quality Assurance Officers office.

VI. EQUIPMENT/APPARATUS

A. Inductively coupled argon plasma emission spectrometer: Thermo Scientific 6500 DUO.

B. Computer-controlled emission spectrometer with background correction: Thermo Scientific 6500 DUO or equivalent.

C. Radio frequency generator compliant with FCC regulations: Thermo Scientific or equivalent.

D. Argon gas supply – Liquid Argon

E. Class A volumetric flasks

F. Class A volumetric pipettes

G. Analytical balance - capable of accurate measurement to a minimum of three significant figures (.001gm): Mettler model AE100

H. Variable Eppendorf Pipettes 1000µL; 5000µL

VII. REAGENTS AND STANDARD PREPARATION

A. Notes

1. Reagent Water. All references to water in the method refer to reagent grade water unless otherwise specified. Reagent water will be interference free.

2. Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination. If the purity of a reagent is in question analyze for contamination. If the concentration is less than the MDL then the reagent is acceptable.

B. REAGENTS

1. Hydrochloric acid (concentrated), HCl.
2. Nitric acid (concentrated), HNO_3.

C. STANDARDS

1. Matrix

a. All standards contain 2% HNO_3 and 5% HCl.

2. Storage

a. The standards are stored at room temperature in 500 mL Teflon bottles.

3. Traceability

a. All records shall be maintained on all reference materials within Element. The record shall include date of receipt, source, purity, all compositional information, storage conditions and expiration date. These materials/solutions are to be identified by a unique Element number that is recorded on the container's label.

b. All working standards made from reference materials shall be labeled with a unique Element ID number with complete information on preparation date, concentration of each compound, solvent, preparer's name, expiration date in Element. Reagents shall be labeled with date received and expiration date, if applicable. All of the information described above shall also be recorded in Element. Measurements made during standards preparation (e.g., from weighing operations,

volume diluted to, etc.) shall also be recorded. There should be no container with sample, sample extract, standard solution, etc. that is not correctly labeled and properly stored.

4. Calibration standards

a. All standards have an acid matrix of 2% HNO_3 and 5% HCl and should be prepared using class A volumetric flasks, class A volumetric pipettes (or calibrated Eppendorfs).

b. STD-1 is the calibration blank: Reagent grade water **matrix matched as in (a) above. Note: when this standard is analyzed the intensities should be compared to a previous run to make sure that no contamination has occurred. Prepare this solution fresh daily.**

c. Stock QC21 solution: (100 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element and includes the following metals - Sb, As, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mg, Mn, Mo, Ni, Se, Sr, Tl, Ti, V, and Zn.

e. Stock QC7 solution: Order from the manufacturer already prepared. This solution is given a unique identifier within Element and includes the following metals- (50 ug/mL)- silver; (100 ug/mL)- aluminum, boron, barium and sodium; (1000 ug/mL)- potassium; (500 ug/mL or 100 ug/mL note we use two sources of this standard and each have different concentrations for Si) –Silica.

f. Boron solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

g. Stock Tin solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

h. Stock Silver solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

i. Stock Aluminum solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

j. Stock Calcium solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier.

k Stock Magnesium solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

l. Stock Iron solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

m. Stock Potassium solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

n Stock Barium solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

o Stock Sodium solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

p. Stock Arsenic solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

q. Stock Cobalt solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

r. Stock Chromium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

s Stock Copper solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

t. Stock Manganese solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

u Stock Nickel solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

v. Stock Lead solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

w. Stock Selenium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

x. Stock Thallium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

y. Stock Beryllium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

z. Stock Cadmium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

aa. Stock Antimony solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

bb. Stock Molybdenum solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

cc. Stock Strontium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifie within Element.

dd. Stock Titanium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifie Element.

ee. Stock Vanadium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

ff. Stock Zinc solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

gg. Stock Scandium solution (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

5. Calibration and Calibration Verification standards

a. The calibration standards and calibration verification standards preparations are recorded in Element. Please find method of preparation in Appendix I.

b. The CRI solution is analyzed to check the accuracy of the instrument down near the contract required detection limits (CRDL). It is analyzed in conjunction with the interference check sample. The sample is prepared from a purchased solution which contains 120 µg/mL Sb, 100 µg/mL Co and V, 80 µg/mL Ni, 50 µg/mL Cu, 40 µg/mL Zn, 30 µg/mL Mn, 20 µg/mL As, Cr, Ag and Tl, 10 µg/mL Be, Cd and Se along with 6 µg/mL Pb. 500 µ/L of the solution is diluted to 500 mL. This solution is stable for 6 months.

hh. The interference check solutions (ICSA and ICSAB) are prepared to contain known concentrations of interfering elements that will provide an adequate test of the IECs. A solution containing 500 ug/mL Al, Ca, Mg and 200 ug/mL Fe is diluted 10x to prepare the ICSA. The ICSAB is prepared by diluting 100x a solution containing 10 ug/mL of As and Tl; 20 ug/mL Ag; 50 ug/mL Ba, Be, Cr, Co, Cu, Mn, and V; 100 ug/mL Cd, Ni and Zn; 5 ug/mL Pb and Se; and 60 ug/L Sb. Add to this a solution containing 500 ug/mL Al, Ca, Mg and 200 ug/mL Fe diluted 10x. These solutions are prepared as needed or monthly.

d. Reporting Limit Standard- Prepared 1.0 ml of RL Stock solution A and 1.0 ml of RL Stock Solution B diluted to 100 ml with 2% HNO3 and 5% HCL matrix , mix well. Solution stable for 3 months

6. Digestion standards

a. The Laboratory control sample (LCS) is prepared from High Purity solutions CLP-CAL-1 solution A and B; CLP-CAL-2 and CLP-CAL-3. 0.50 mL of CLP-CAL-1 A and B is diluted to 500 mL with 0.125 mL of CLP-CAL-2 and CLP-CAL-3. 25 mL of HCl and 10 mL of HNO3 are added for preservation. This solution is stored in a Teflon bottle. A portion is reserved in case of a problem with digestion. When there is a problem with the analysis of the LCS the solution is checked first before action is taken to make sure that it was made properly and has not deteriorated since it was made up. This solution is given a unique identifier. The LCS is prepared from a source independent from that used in the calibration standards. This solution is prepared daily or as needed. Note: The analysis of Molybdenum is not a routine procedure but a project-specific requirement. A customized LCSW mix must be prepared to contain this target analyte.

b. The solid Laboratory Control Sample (Soil) (LCSS) is prepared by weighing up 1.0 g of teflon chips and spiking using the same spiking

solutions used to spike the sample matrix. This standard is given a unique identifier i.e. LCSS(date prepared)A,B,C etc.

c. The spiking solutions are prepared as follows:

1. Stock Multi-element Spiking Solutions: High Purity CLP-CAL-1 solution A: 2000 ug/mL Al and Ba; 50 ug/mL Be; 200 ug/mL Cr; 500 ug/mL Co, Mn, Ni, V and Zn; 250 ug/mL Cu; 1000 ug/mL Fe; 5000 ug/mL Ca, Mg, K and Na; solution B: 250 ug/mL Ag; CLP-CAL-2: 1000 ug/L Sb; CLP-CAL-3: 1000 ug/mL As, Pb, Se, Tl; 500 ug/mL Cd. Order from the manufacturer already prepared. These solutions are given a unique identifier. Add 0.050 mL (0.20 mL for soil samples) of CLP-CAL-1 solutions A and B, and 0.0125 mL (0.05 mL for soil samples) of CLP-CAL-2 and 3 to 50 mL of sample (1gram of sample for soils) for the following spike values: 2000 ug/L Al and Ba; 50 ug/L Be; 200 ug/L Cr; 500 ug/L Co, Mn, Ni, V and Zn; 250 ug/L Cu; 1000 ug/L Fe; 5.0 mg/L Ca, Mg, K and Na, 250 ug/L Ag, Sb, As, Pb, Se and Tl; 125 ug/L Cd. A blank spike should be prepared at the time the samples are spiked to check the actual spike value and accuracy.

2. TCLP Spiking Solution: Use 0.50 mL diluted to 50 mL for digestion:
2.5 mL 10000 mg/L Ba stock standard diluted to 100 mL; 2.5 mL Cr, Pb and As 1000 mg/L stock standard diluted to 100 mL; 0.50 mL Cd and Se diluted to 100 mL . Store in a Teflon bottle. A blank spike should always be prepared at the same time a sample is being spiked. This solution should produce a spike value of 2500 ug/L Ba; 250 ug/L Cr, Pb and As; and 50 ug/L of Cd and Se. Note: Since the samples are diluted 10x when digested the spike value will appear to be 10x greater when analyzed.

3. TCLP Silver Spiking Solution: Use 5.0 mL diluted to 50 mL for digestion:
0.40 mL of 1000 mg/L stock Ag solution diluted to 200 mL. Store in a Teflon bottle. A blank spike should always be prepared at the same time a sample is being spiked. This solution should produce a spike value of 200 ug/L. . Note: Since the samples are diluted 10x when digested the spike value will appear to be 10x greater when analyzed. Also this solution is not very stable and may require fresh preparation at least weekly.

VIII. CALIBRATION AND ASSOCIATED QA/QC

A. Set up the instrument with proper operating parameters. The instrument must be allowed to become thermally stable before beginning (usually requiring at least 30 minutes of operation prior to calibration).

B. Operating conditions - **The instrument settings can be found in method file.** For operation with organic solvents, use of the auxiliary argon inlet is recommended, as are solvent-resistant tubing, increased plasma (coolant) argon flow, decreased nebulizer flow, and increased RF power to obtain stable operation and precise measurements. Sensitivity, instrumental detection limit, precision, linear dynamic range, and interference effects must be established for each individual analyte line on that particular instrument. The analyst must (1) verify that the instrument configuration and operating conditions satisfy the analytical requirements and (2) maintain quality control data confirming instrument performance and analytical results.

C. Autopeak when some change has been made to the introductory system and calibrate the instrument according to the instrument manufacturer's recommended procedures, using the typical mixed calibration standard solutions. **(See SOP-106, *ICP Instrument Operation*)** Flush the system with 2% HNO_3 / 5% HCl between each standard or as the manufacturer recommends. (Use the average intensity of multiple exposures for both standardization and sample analysis to reduce random error.) The calibration curve consists of a blank and three standards ($r \geq 0.998$). If a three point calibration curve is not required for the client samples being analyzed Empirical Laboratories may use a blank and one standard as referenced in USEPA - CLP protocols.

D. Before beginning the sample run, analyze the Iron and Aluminum standards at their linear range to check for IEC drifts. Analyze these standards first as QC samples with an IEC check table and action taken should be to calculate IECs using the iTEVA software. Make sure to rinse thoroughly after running these linear range standards, they can cause carry over into the initial QC samples which are analyzed next. The analysis order follows as: ICV ($\pm$ 10%) for 200.7 ($\pm$ 5%) and ICB (< ±MDL or ±RL/CRDL for others or CLP, **for CCB, DOD QSM Ver. 3 no analytes detected >2xMDL**) first, then analyze a reporting limit standard (a standard at the concentration of the reporting limit). This standard should be within ±20% for DOD projects and ±30% for samples analyzed for 6010C. Then reanalyze the highest mixed calibration standard(s) as if it were a sample. Concentration values obtained should not deviate from the actual values by more than 5%. If they do, follow the recommendations of the instrument manufacturer to correct for this condition.

E. For CLP projects, verify the validity of the curve in the region of 2x the contract required detection limit (CRDL) before and after each batch of 20 samples in the specific order of CRI, ICSA, ICSAB, CCV and CCB(CCB

criteria: < ±MDL or ±RL/CRDL for others or CLP, **for CCB, DOD QSM Ver. 3 no analytes detected >2xMDL, beginning and end of sequence and after every 10 samples**) or twice during every 8-hour work shift, whichever is more frequent. Results should be within ±20%. Supervisor must be notified if the control limit is not met. Supervisor will dictate corrective action if required. The final analytical report must document this situation. (For Internal QC)

F. Verify the interelement and background correction factors at the beginning and after each batch of 20 samples in the specific order of CRI, ICSA, ICSAB, CCV and CCB(CCB criteria: < ±MDL or ±RL/CRDL for others or CLP, **for CCB, DOD QSM Ver. 3 no analytes detected >2xMDL, beginning and end of sequence and after every 10 samples**) or twice during every 8-hour work shift, whichever is more frequent. Do this by analyzing the interference check solution A and AB. Results should be within ±20% of the true value for ICSAB. **For ICSA DOD QSM Ver 3. , absolute value of concentration for all non-spiked analytes < 2xMDL**.(CRI, ICSA and ICSAB required at the end for CLP projects only).

G. *When analyzing samples associated with North Carolina or with DOD QSM Ver. 3 work, a solution containing analytes at their reporting limit must be analyzed prior to sample analysis. The concentrations must be within 20% DOD(20 or 30% depending on project) of their true values to be acceptable.*

Note: Supervisor must be notified if the control limit is not met. Supervisor will dictate corrective action if required. The final analytical report must document this situation.

H. The instrument must be calibrated once every 24 hours if performing straight CLP work.

I. Instrument Autosampler Report example:

Calibration Rack(used by instrument software to insert QC)

1) STD 1-blank
2) Low Cal
3) Mid Cal
4) Ba @ 5000 ppb
5) QC5
6) QC 21
7) NAK 100
8) QC3

Sample Sequence RACK 1

1) Al IEC-(readback)

2) Fe IEC-(readback)
3) ICV
4) ICB-initial
5) RL-reporting limit standard
6) Ba@ 5000 ppb (readback)
7) QC5
8) NAK High-(readback)
9) QC 21 High-(readback)
10) Salt Cal at 500 ppm (readback)
11) Rinse
12) CRI-0
13) ICAS-0
14) ICASB-0
15) Rinse
16) CCV 1A
17) CCB 1A
18) Preparation Blank (*Batch #* BLK-1)
19) Laboratory Control Sample (*Batch #* BS-1)
20) Sample 1
21) Sample 2
22) Sample 3
23) Sample 4
24) Sample 5
25) Sample 6
26) Sample 7
27) Sample 8
28) CCV 1B
29) CCB 1B
30) Sample 9
31) Sample 10
32) Sample 11
33) Sample 12
34) Sample 13
35) Sample 14
36) Sample 15
37) Sample 16
38) Sample 17
39) Sample 18
40) CCV 2A
41) CCB 2A
42) Sample 19
43) Sample 20
44) Sample matrix spike (*batch#* MS-1)
45) Sample matrix spike duplicate (*batch#* MSD-1)
46) Sample post digestion spike (*batch#* PS-1)
47) Sample serial dilution (*batch#* SRD-1)
48) CRI-1

49) ICSA-1
50) ICSAB-1
51) Rinse
52) CCV 2B
53) CCB 2B
54) Preparation Blank (*batch#* BLK-1)
55) Laboratory Control Sample (*batch#* BS-1)
56) Sample 1
57) Sample 2
58) Sample 3
59) Sample 4
60) Sample 5

RACK 2

1) Sample 6
2) Sample 7

Etcetera…

Each rack holds 60 samples and there are 4 racks that are used for samples, CCVs and CCBs and run QC.

IX. PROCEDURE

A. Once the instrument has been calibrated, begin the analysis of samples.

B. If particulates are visible in the digestate, the sample must be filtered prior to analysis. If filtration is required, a filter blank must be prepared by filtering reagent grade water which has been properly acidified. **In the event USACE samples are filtered, all USACE samples and the QC samples in that QC batch must be filtered. All USACE solid samples and their associated batch QC samples must be filtered prior to analysis.**

C. Flush the system with 2% HNO_3 / 5% HCl for at least 1 minute before the analysis of each sample.

D. Dilute and reanalyze samples that are more concentrated than the linear calibration limit or, for 200.7, $\pm$ 10% of the linear range standard. **In the case of USACE samples, the criterion changes and requires dilution and reanalysis of all samples which produce a concentration that exceeds the highest calibration standard. Sample results detected between the MDL and RL are flagged as estimated with a ”B” flag.**

E. Verify calibration every 10 samples or every 2 hours, whichever is more frequent and at the end of the analytical run, using a continuing calibration verification (CCV) sample and a continuing calibration blank (CCB) sample.

- The results of the CCV are to agree within 10% for 6010 (5% for 200.7) on initial verification of the expected value, with relative standard deviation (RSD) < 5% from replicate (minimum of two integrations). If not, terminate the analysis, correct the problem, and reanalyze the previous ten samples. The analyst may continue the analytical run, and after conferring with the section manager it may be necessary to reanalyze a group of samples. The analyst must notify the section manager within 24 hours.

- The results of the calibration blank (this is not the method/preparation blank) are to agree within < ±MDL(SW-846 Method 6010B), and 3 x IDL or CRDL for CLP, for **DOD QSM Ver. 3 no analytes detected >2xMDL**. If the calibration blank is not in control, evaluate the impact upon the previous 10 samples. Reanalysis may be required after an evaluation of the data. If the blank < 1/10 the concentration of the action level of interest, and no sample is within 10% of the action limit, samples need not be reanalyzed. One must also evaluate the reporting limit (RL) as it relates to 3X the IDL/MDL. If the RL is significantly above 3X IDL or MDL then reanalysis may not be required (Na, K, Mg and Ca are good examples of this situation).

- Total hardness is reported from HNO_3 preserved sample. The final concentration is calculated from the calcium and magnesium results as follows:

$$\text{Ca mg/L} \times 2.5 + \text{Mg mg/L} \times 4.1 = \text{total Hardness in mg/L as } CaCO_3$$

F. Documentation of Capability (DOC) – Each analyst must perform a DOC to demonstrate proficiency with this method. Refer to SOP-413 for guidance.

X. CALCULATIONS

A. The instrument will generate data results in mg/L or µg/L (labeled appropriately). Each result represents an average of three individual readings per metal channel.

B. For aqueous samples, if a post/predigestion dilution is performed, the result must be multiplied by this factor or the dilution factor must be entered into the instrument data table in which case the instrument will generate data corrected for the dilution.

C. For solid samples, if a postdigestion dilution is performed , the result must be multiplied by this factor or the dilution factor must be entered into the instrument data table in which case the instrument will generate data corrected for the dilution. Also, the result must be converted to reporting units which are usually mg/kg.

SR (ug/g or mg/kg) = IR*DF*FED/SM

SR = Sample result
IR = Instrument result (µg/L)
DF = Dilution factor (post digestion)
FED = Final volume of digestate (L)
SM = Sample mass digested(g)

XI. QUALITY CONTROL

A. Daily

1. See sections VIII and IX above.

B. Quarterly

1. Linear range standards must be analyzed at a frequency no less than once every three months. The linear range standard represents the second standard required for verification that samples are actually linear to the degree claimed. The analyst is responsible for completing this task in a timely manner. The linear range standard must be within +/-5% of true value.

2. The interelement correction factors (IEC) should be verified at the time the linear range standards are analyzed.

3. IDL's if CLP work required.

C. Digestion

1. All quality control data should be maintained and available for easy reference or inspection.

2. Employ a minimum of one method blank per sample batch to determine if contamination or any memory effects are occurring. A method blank, sometimes referred to as the preparation blank is a volume of reagent water acidified with the same amounts of acids as were the standards and samples. These blanks are taken through the same digestion/preparation steps as the sample being tested. The result for the method blank should not indicate contamination greater than ± ½ RL (USACE) or ±RL/CRDL for other or CLP. If exceeded, the impact upon the data should be evaluated and the associated sample(s) should be either redigested or the data should be qualified.

3. Employ a minimum of one laboratory control sample (LCS) for aqueous samples or one teflon chip spiked sample per sample batch to verify the digestion procedure. These LCSs are taken through the same digestion/preparation steps as the sample being tested. The control limits

are ±15% method 200.7 - aqueous and soil samples or ±20% for all other methods aqueous and soil samples. If the LCS is not in control, the impact upon the client data should be evaluated and the associated sample(s) should be redigested. Consult your supervisor for further action. Qualifying the associated data may not be permissable for some clients.

D. Sample

1. Analyze one replicate sample for every twenty samples or per analytical batch, whichever is more frequent. A replicate sample is a sample brought through the whole sample preparation and analytical process in duplicate. It is acceptable to substitute a matrix spike duplicate for the sample replicate. Project specific requirements will take precedence in these situations. NJDEP demands that this requirement be met with a client specific duplicate rather than a spike duplicate. The control limits are 20% RPD (if both are >5x CRDL) or ± the CRDL (if either are <5X CRDL).

2. Analyze one spiked sample and spiked sample duplicate for every twenty samples or per analytical batch, whichever is more frequent. A replicate sample is a sample brought through the whole sample preparation and analytical process in duplicate. Project specific requirements will take precedence in these situations. If the analyte level in the sample is not greater than 4X the spiking level, the spike recoveries should be within ±25% of the true value (**± 20% for DOD projects**). If not, a post digestion spike should be analyzed.

3. The relative percent difference (RPD) between replicate determinations is to be calculated as referenced in the laboratory QA manual. (A control limit of ± 20% RPD (non-aqueous samples may routinely exceed this amount) shall be used for sample values greater than five times the contract required detection limit.) Supervisor must be notified if the control limit is not met. Supervisor will dictate corrective action if required. The final analytical report must document this situation.

4. *The following should be analyzed with each preparation batch containing a matrix spike.*

   - Serial dilution: If the analyte concentration is sufficiently high (minimally, a factor of 50 above the instrumental detection limit after dilution), an analysis of a 1:4 dilution (volumetric glassware must be used) should agree within ±10% of the original determination. If not, a chemical or physical interference effect should be suspected. The analyst and or section manager must note this situation on the final analytical report.

   - Post digestion spike addition: An analyte spike added to a portion of a prepared sample, or its dilution, should be recovered to within 85% to 115% of the known value and is required if the pre-digestion matrix

spike (low-level only for CLH) is outside of control limits. The spike addition should produce a minimum level of 10 times and a maximum of 100 times the instrumental detection limit. If the spike is not recovered within the specified limits, a matrix effect should be suspected. The analyst and or section manager must note this situation on the final analytical report.

E. Method Detection Limit (MDL), Empirical Laboratories Reporting Limit (ERL), Contract Required Quantitation Limit (CRQL) and Analyte Wavelength:

TABLE I

Aqueous and Soil Method Detection Limits(MDL), Empirical Laboratories Reporting Limits(ERL), CLP OLM04.1 & OLM05.2 Contract Required Quantitation Limits (CRQL)

Analytes by EPA 200.7,3005A/3050A- 6010B SOW 4.1 & 5.2	AQUEOUS MDL (ug/L)	AQUEOUS ERL (ug/L)	AQUEOUS CRQL ILMO 4.1 (ug/L)	AQUEOUS CRQL ILMO 5.2 (ug/L)	SOLID/SOIL MDL (mg/Kg)	SOLID/SOIL ERL (mg/Kg)	SOLID/SOIL CRQL ILMO 4.1 (mg/Kg)	SOLID/SOIL CRQL ILMO 5.2 (mg/Kg
Silver	**1.0**	**10**	**10**	**10**	**0.20**	**2.0**	**2**	**2**
Aluminum	**50**	**200**	**200**	**200**	**10**	**40**	**40**	**40**
Arsenic	**3.0**	**10**	**10**	**15**	**0.6**	**2.0**	**2**	**3**
Barium	**5.0**	**200**	**200**	**200**	**1.0**	**40**	**40**	**40**
Beryllium	**1.0**	**5.0**	**5**	**5**	**0.20**	**1.0**	**1**	**1**
Calcium	**1000**	**5000**	**5000**	**5000**	**20**	**1000**	**1000**	**1000**
Cadmium	**1.0**	**5.0**	**5**	**5**	**0.20**	**1.0**	**1**	**1**
Cobalt	**5.0**	**50**	**50**	**50**	**1.0**	**10**	**10**	**10**
Chromium	**2.0**	**10**	**10**	**10**	**0.40**	**2.0**	**2**	**2**
Copper	**4.0**	**25**	**25**	**25**	**0.40**	**5.0**	**5**	**5**
Iron	**30**	**100**	**100**	**100**	**1.0**	**20**	**20**	**20**
Potassium	**1000**	**5000**	**5000**	**5000**	**40**	**1000**	**1000**	**1000**
Magnesium	**1000**	**5000**	**5000**	**5000**	**40**	**1000**	**1000**	**1000**
Manganese	**1.0**	**15**	**15**	**15**	**0.20**	**3.0**	**3**	**3**
Sodium	**1000**	**5000**	**5000**	**5000**	**40**	**1000**	**1000**	**1000**
Nickel	**3.0**	**40**	**40**	**40**	**1.0**	**8.0**	**8**	**8**
Lead	**1.5**	**5.0**	**3**	**10**	**0.60**	**2.0**	**0.6**	**2**
Selenium	**3.0**	**10**	**5**	**35**	**0.60**	**2.0**	**1**	**7**
Antimony	**5.0**	**60**	**60**	**60**	**1.0**	**12**	**12**	**12**
Thallium	**3.0**	**10**	**10**	**25**	**0.60**	**2.0**	**2**	**5**
Vanadium	**5.0**	**50**	**50**	**50**	**1.0**	**10**	**10**	**10**
Zinc	**5.0**	**20**	**20**	**60**	**1.0**	**4.0**	**4**	**12**

TABLE 2

METAL	WAVELENGTH
Aluminum	**396.1**
Antimony	**206.8**
Arsenic	**189.0**
Barium	**233.5**
Beryllium	**313.0**
Cadmium	**228.8**
Calcium	**317.9**
Chromium	**267.7**
Cobalt	**228.6**
Copper	**324.7**
Iron	**261.1**
Lead	**220.3**
Magnesium	**279.0**
Manganese	**257.6**
Molybdenum	**202.0**
Nickel	**231.6**
Potassium	**766.4**
Selenium	**196.0**
Silver	**328.0**
Sodium	**589.5**
Thallium	**190.8**
Tin	**189.9**
Titanium	**334.9**
Vanadium	**292.4**
Zinc	**206.2**

XII. CORRECTIVE ACTIONS

A. INSTRUMENT RELATED

1. ICV not within ± 10% or ± 5% for 200.7
   a. Is the problem with the solution?
      i. Reprepare or obtain new stock.
   b. Is the problem with the calibration?
      i. Recalibrate through analysis of appropriate standards and recheck ICV.

2. ICB not ±MDL or within ± 3X IDL or CRDL for CLP, **DOD QSM Ver. 3 no analytes detected >2xMDL**

   a. Is the problem with the solution?
      i. Reprepare
   b. Is the problem with the calibration?
      i. Recalibrate with the blank solution or the low level standard. Restart analysis with the ICV.

3. Check standards not within ± 5%
   a. Is the problem with the solution?
      i. Repour, reprepare or obtain new stock.
   b. Is the problem with the calibration?
      i. Recalibrate thru analysis of appropriate standards. Restart analysis with the ICV.

4. CRI not within ± 20% (Internal QC, only required for CLP work).
   a. Is the problem with the solution?
      i. Reprepare or obtain new stock.
   b. Is the problem with the calibration?
      i. Recalibrate thru analysis of appropriate standards. Restart analysis with the ICV.
5. ICSA metals not present are not less than the CRDL for that metal, **for ICSA DOD QSM Ver 3. , absolute value of concentration for all non-spiked analytes < 2xMDL.**
   a. Is the problem with the solution?
      i. Reprepare or obtain new stock.
   b. Is the problem with the calibration?
      i. Recalibrate thru analysis of appropriate standards. Restart analysis with the ICV.

6. ICSAB not within ± 20%
   a. Is the problem with the solution?
      i. Reprepare or obtain new stock.
   b. Is the problem with the calibration?
      i. Recalibrate thru analysis of appropriate standards. Restart analysis with the ICV.

7. CCV not within ± 10%
   a. Is the problem with the solution?
      i. Reprepare or obtain new stock.
   b. Is the problem with the calibration?
      i. If appropriate, continue the analysis. Discuss effect of the out of control situation with your supervisor. The samples will be reanalyzed or the data will be qualified. Note: CLH data must

always be reanalyzed back to the last compliant CCV and not qualified.

8. CCB not ±MDL or within ± 3X IDL or CRDL for CLP, **DOD QSM Ver. 3 no analytes detected >2xMDL**
   a. Is the problem with the solution?
      i. Reprepare
   b. Is the problem with the calibration?
      i. Apply SW846 guidance. (See Section IX-E for additional guidance). Note: CLH data must always be reanalyzed back to the last compliant CCB and not qualified.

B. DIGESTION RELATED

1. Preparation blank not within ± ½ RL and ± RL for common contaminants USACE or RL/CRDL for other or CLP
   a. Is the problem with the instrument?
      i. Evaluate with respect to instrumental bias or reanalyze when instrument is in control.
   b. Is the problem with the digestion?
      i. If associated samples are less than 10X the level of the preparation blank but above the RL, the sample must be redigested or the data must be qualified on the final report.

2. LCS not within control limits
   a. Is the problem with the instrument?
      i. Evaluate with respect to instrumental bias or reanalyze when instrument is in control.
   b. Is the problem with the digestion?
      i. If biased low, associated samples must be redigested.
      ii. If biased high, the impact upon the data user must be evaluated. The samples will be redigested or the data will be qualified on the final report.

C. SAMPLE MATRIX RELATED

1. Replicate analysis RPD not within ±20% (if both are >5X CRDL) or ± the CRDL (if either are <5X CRDL).
   a. The associated sample data must be qualified on the final report.

2. Spike analysis recovery not within ±25%(**± 20% for DOD projects**)
   a. Is the analyte level in the sample greater than 4X the spiking level?
      i. If yes, the spike recovery is not evaluated.
      ii. If no, a post digestion spike must be analyzed and the associated sample data must be qualified on the final report.

3. When required, post digestion spike analysis recovery not within ±15%.

a. The associated sample data must be qualified on the final report.
b. For USACE analysis by MSA is required.

4. Serial dilution analysis percent difference not within ±10%
   a. Is the analyte concentration a factor of 50 above the instrumental detection limit after dilution?
      i. If no, the serial dilution data can not be evaluated.
      iii. If yes, a chemical or physical interference effect should be suspected. The analyst and or section manager must note this situation on the final analytical report.

XIII. WASTE DISPOSAL and POLLUTION PREVENTION

Please see Waste Disposal SOP-405 fot instruction of proper disposal of waste generated from this area.

Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

XIV. REFERENCES

1. *Test Methods for Evaluating Solid Waste Physical/Chemical Methods, SW-846; Third Edition (Update III)*; Method 6010B and Method 6010C

2. USEPA *Code of Federal Requlations, 40, CH 1,PT 136;* Method 200.7; APX-B

3. USEPA *Contract Laboratory Program(CLP) for Inorganics ILM04.1; ILM05.2*

Refer to SOP-431 for common environmental laboratory definitions.

Addendum for USEPA CLPILM 05.2

1. The control limit for the ICSA is at 20% or ±CRQL whichever is greater.
2. Preparation codes are required in the digestion log See SOW Exhibit B for a listing of these codes with definitions.
3. The CRQL check standard is run at the concentration of the respective CRQLs. For a listing of CRQL for this SOW see Exhibit C. Several of the metals concentration levels have changed.
4. The spiking level for CLP ILM 05.2 is at 50 ug/L for selenium. All other spike levels remain the same as in SOW ILM 04.1.
5. The CCV shall be analyzed at a different concentration then the ICV (at or near one-half of the calibration standard concentration.
6. The post digestion spike must be analyzed at 2x the indigenous level of the sample or two times the CRQL whichever is greater.
7. A Non-prepared MDL study must be analyzed and the results of this study used for MDL reporting when sample volumes are not digested.

CHANGES TO FORMS for SOWCLPILM 05.2

1. Forms must be double-sided
2. A photocopy of the instrument's direct sequential readout shall be included.
3. Undiluted samples must be reported as well as diluted samples.
4. J flags are used in place of B flags when a sample has a concentration less the CRQL but greater then or equal to the MDL.
5. A D flag is used for samples reported from a dilution.
6. All results are reported down to the MDL not the IDL.
7. Preparation codes are used on form 13.

   The form for method of standard additions (MSA) has been removed and all subsequent QC has move up one form number in other words form 8 is now serial dilution when it used to be the MSA form,etcetera.

ANALYST DATA REVIEW CHECKLIST Sample Number(s):

Batch Number(s):

Method: 6010B (ICP)

QA/QC Item	Yes	No	NA	Second Level Review
1. Were samples analyzed within USACE holding times?				
2. Was initial calibration curve QC criteria met?				
3. Was all continuing calibration criteria in control?				
4. Did any sample exceed the highest calibration standard? (If yes, were appropriate dilutions made to generate samples concentration within calibration range?)				
5. Did LCS or blank spike meet control limits?				
6. Did MS/MSD meet control limits?				
7. Was the preparation (Method) Blank below the project required detection limits?				
8. Did you return samples back to cold storage immediately after use?				
9. Was hot plate temperature monitored/documented and did you apply the thermometer correction factor?				
10. Sample preparation information is correct and complete.				
11. Analytical results are correct and complete.				
12. The appropriate SOP's have been used and followed.				
14. "Raw data" including all manual integration's have been correctly interpreted.				
15. "Special" sample preparation and analytical requirements have been met.				
16. Documentation complete (e.g., all anomalies in the analytical sequence have been documented, corrective action forms are complete.				

Comments on any "No" response:

_____

_____

_____

_____

_____

_____

Analyst: _____ Date: _____

Second-Level Review: _____ Date: _____

APPENDIX I

Preparation Method for Calibration Standards

EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE

INORGANICS: SOP 149 REVISION #: 04 EFFECTIVE DATE: 20100830

FLASHPOINT/INGNITABILITY
BY METHOD SW-846 1010A

APPROVALS:

Lab Director: _____ Date: 9/9/10

Data Quality Manager: _____ Date: 9/9/10

Section Supervisor: _____ Date: 9/9/10

Changes Summary

Revision 04, 08/30/2010

- The SOP is an update from Revision 03 dated 12/19/08

FLASHPOINT/IGNITABILITY
SW846 Method 1010A

I. SCOPE AND APPLICATION:

A. The Pensky-Marten closed cup tester is used to determine the Flashpoint of liquids.

II. METHOD SUMMARY:

A. The sample is heated at a slow, constant rate with continual stirring. A small flame is directed into the cup at regular intervals with simultaneous interruption of stirring. The flash point is the lowest temperature at which application of the test flame ingintes the vapor above the sample. Sample results are corrected for ambient barometric pressure after determination.

III. SAMPLING HANDLING AND PRESERVATION:

A. Store samples at 4 ^{o}C. Some samples may require freezing before the test can be accurately measured.

IV. INTERFERENCES:

A. None.

V. EQUIPMENT/APPARATUS:

A. Pensky-Marten closed cup tester with stirring mechanism.

B. Propane.

C. Thermometer capable of reading in 0.5 ^{o}C from -5 to 110 ^{o}C. ASTM 9 C.
Thermometer capable of reading in 2.0° C from 90 to 370° C. ASTM 10 C.

D. Igniter.

VI. REAGENTS:

A. p-Xylene, neat liquid.

VII. PROCEDURE:

A. Fill the test cup with sample up to the line engraved on the inside of the cup.
B. Place the cup in the heater.
C. Heat the sample at a slow, constant rate.
D. Test for a flash by placing the ignition source into the vapor above the sample.
E. Continue to test for a flash every 2 ^{o}C until either the sample flashes or the temperature of the sample reaches 100 ^{o}C.

VIII. CALCULATIONS:

The barometric pressure is read on a digital barometer which measures in inches mercury. Remember to convert to millimeters mercury using the following constant:

1 inch Hg = 25.4 mm Hg

Observe and record the ambient barometric pressure at the time of the test. When the pressure differs from 101.3 kPa (760 mm Hg), correct the flash point as follows:

Corrected flash point = C + 0.033 (760 - P)

Where:

C = observed flash point, °C,
P = ambient barometric pressure, mm Hg

Note: Aneroid barometers, such as those used at weather stations and airports , are precorrected to give sea level readings and would not give the correct reading for this test

IX. QUALITY CONTROL:

A. The Flashpoint of the p-xylene should be determined at the beginning and end of each set of 20 or less samples. The p-xylene should flash at 27.2 ^{o}C with control limits of +/-1.1 ^{o}C.

EMPIRICAL LABS, LLC.
TRAINING ATTENDANCE RECORD

TRAINING TOPIC **SOP149 Rev04 - Flashpoint Ignitability Method SW846-1010A**

Group: **Betty Deville**

ATTENDEES:

	NAMES (print)	SIGNATURE	REMARK	DATE	TIME	INSTRUCTOR
1	Roy Burr	Roy Burr		9-15-10	11:49	BLD
2						
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EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE

ORGANICS: SOP 164 REVISION #: 15 EFFECTIVE DATE: 20100325

DISTILLATION OF AQUEOUS/SOLID SAMPLES FOR CYANIDE, TOTAL AND AMENABLE

REFERENCE:
SW846 METHOD 9012A, USEPA Methods 335.1, 335.4, Standard Methods SM 4500-CN C,G, 18th, 19th ED. / CLP ILMO 4.1
See Addendum for USEPA CLPILM 05.2 (Aqueous, Soil/Sediment)

APPROVALS:

Lab Director: _____ Date: 3/30/10

Data Quality Manager: _____ Date: 3/30/10

Section Supervisor: _____ Date: 3/30/10

Changes Summary:

Revision Date: 03/25/2010

- The SOP has been reviewed for accuracy and completeness. No changes have been made.

DISTILLATION OF CYANIDE, TOTAL AND AMENABLE

REFERENCE:
SW846 METHOD 9012A, USEPA Methods 335.1, 335.4, Standard Methods SM 4500-CN C,G, 18th, 19th ED. / CLP ILMO 4.1
See Addendum for USEPA CLPILM 05.2 (Aqueous, Soil/Sediment)

I. SCOPE AND APPLICATION

A. This method is applicable to the distillation of cyanide from drinking, surface, and saline waters, domestic and industrial wastes, and soil/sediments.

B. The limit of detection for waters is 0.0050 mg/L and the limit of quantitation is 0.010 mg/L. The limit of detection for soils is 0.13 mg/kg and the limit of quantitation is 0.25 mg/kg.

II. SUMMARY OF METHOD

A. The cyanide as hydrocyanic acid is released from cyanide complexes by means of a reflux distillation operation, and absorbed in a scrubber containing sodium hydroxide solution. The cyanide ion in the absorbing solution is then determined colorimetrically.

B. Cyanide is defined as cyanide ion (CN^-) and complex cyanides converted to hydrocyanic acid (HCN) by reaction in a reflux system of a mineral acid in the presence of magnesium ion.

III. SAMPLE HANDLING AND PRESERVATION

A. The sample should be collected in plastic or glass bottles of 100 mLs. All bottles must be thoroughly cleansed and thoroughly rinsed to remove soluble material from containers.

B. Oxidizing agents such as chlorine decompose most of the cyanides. Test a drop of the sample with potassium iodide-starch test paper (KI starch paper); a blue color indicates the need for treatment. Add ascorbic acid, a few crystals at a time, until a drop of sample produces no color on the indicator paper. Then add an additional 0.06 g of ascorbic acid for each liter of sample volume.

C. Samples (not including soils/sediments) must be preserved with 2 mL of ten normal sodium hydroxide per liter of sample (pH $\geq$12) at time of collection.

D. Samples should be analyzed as rapidly as possible after collection. If storage is required, the samples should be stored in a refrigerator to maintain temperature at 4°C.

E. The holding time for cyanide is 14 days counting the day of sampling as the first day. This applies for soils as well as waters. Samples must be distilled and analyzed within 14 days of sampling.

IV. INTERFERENCES

A. Interferences are eliminated or reduced by using the distillation procedure.

B. Sulfides adversely affect the colorimetric procedures. Samples that contain hydrogen sulfide, metal sulfides, or other compounds that may produce hydrogen sulfide during the distillation, must be treated by adding lead acetate, or if the sulfide concentration is too high, add powdered lead carbonate [$Pb(CO_3)_2$] to avoid significantly reducing pH. Repeat test until a drop of treated sample no longer darkens the acidified lead acetate test paper. Filter sample before raising pH for stabilization.

C. High results may be obtained for samples that contain nitrate and/or nitrite. During the distillation, nitrate and nitrite will form nitrous acid, which will react with some organic compounds to form oximes. These compounds once formed will decompose under test conditions to generate HCN. Nitrate and nitrite interference is eliminated by adding 0.5 ml of sulfamic acid solution (VII.A.7) before distillation.

D. The presence of surfactants may cause the sample to foam during refluxing. If this occurs, the addition of an agent such as Dow Corning 544 antifoam agent will prevent the foam from collecting in the condenser.

V. SAFETY

A. **CAUTION: KCN is highly toxic. Avoid contact with standard solutions.**

B. If an alkaline solution containing simple cyanide is acidified, the simple cyanide will be released.

C. The toxicity or carcinogenicity of each reagent used in this method has not been fully established. Each chemical should be regarded as a potential heath hazard and exposure should be as low as reasonably achievable. Cautions are included for known extremely hazardous materials or procedures.

D. Your laboratory manager and/or Safety Officer is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of Material Safety Data Sheets (MSDS) are made available to all personnel involved in the chemical analysis. A formal safety plan is also available. Use proper personal protection equipment, PPE, such as safety glasses, gloves and laboratory coats should be warn when handling samples and chemicals.

VI. EQUIPMENT/APPARATUS

A. Reflux distillation apparatus is a midi-distillation apparatus which uses Hammett Scientific Glassware Note: This glassware is made to fit our specific block digester for cyanide. Glassware orders must be made in advance since they are not made until ordered.

VII. REAGENTS AND STANDARDS PREPARATION

A. Reagents

1. **Sodium Hydroxide, 0.25N**: Dissolve 10 g grams of NaOH in DI water and dilute to 1 liter with DI water. Store in a labeled plastic container at room temperature.

2. **Sulfuric Acid 1:1:** Slowly add 500 mL of concentrated H_2SO_4 to 500 mL DI water. Use caution because solution will become extremely hot!! Allow to cool while continuing to stir. Store in a labeled container at room temperature.

4. **Magnesium Chloride Solution**: Weigh 510 g of $MgCl_2 \cdot 6H_2O$ into a 1 liter flask; dissolve and dilute to 1 liter with DI water. Store in a labeled plastic container at room temperature.

5. **Chlorine Bleach Made with Sodium Hypochlorite**, such as Chlorox.

6. **Rhodanine Indicator**:
   Dissolve 20 mg of p-dimethyl-amino-bensalrhodanine in 100 mL acetone.

7. **Sulfamic Acid:** Dissolve 40 g of sulfamic acid in DI water, dilute to 100 mL (saturated solution). **NOTE:** When making this reagent for use with the maxi-distillation system the 40 g of sulfamic are diluted to one liter with DI water

8. **Phenolphthalein solution:** Commercially prepared.

9. **Lead Acetate Test Paper**: Commercially prepared.

10. **Acetate Buffer Solution, pH 4.0:** Dissolve 146g anhydrous $NaC_2H_3O_2$, or 243 g $NaC_2H_3O_2.3H_2O$, in 400 mL distilled water, add 480 g conc. acetic acid, and dilute to 1 L with chlorine-demand-free water.

11. **Lead Acetate**

12. **Powdered Lead Carbonate [$Pb(CO_3)_2$]**

B. Standards

1. Traceability

a. All reference materials must be recorded in Element and given an element identification number. The record shall include date of receipt, source, purity, all compositional information, storage conditions and expiration date. These materials/solutions are to be identified by a unique number in Element as well as on the container's label.

b. All working standards made from reference materials shall be labeled with a unique ID number from Element with complete information on preparation date, concentration of

each compound, solvent, preparer's name, expiration date. Reagents shall be labeled with date received and expiration date, if applicable. All of the information described above shall also be recorded in Element. Measurements made during standards preparation (e.g., from weighing operations, volume diluted to, etc.) shall also be recorded on the bench sheet. There should be no container with sample, sample extract, standard solution, etc. that is not correctly labeled and properly stored.

2. **Preparation**

   a. Stock Cyanide Solution at 1000 mg/L: Commercially prepared.

   b. Working Standard Cyanide Solution: Prepare fresh daily by diluting 1 mL of stock cyanide solution to 100 mL in a volumetric flask with using 0.25N NaOH as diluent. 1 mL - 10 µg CN. Record the preparation in Element.

   c. Performance Evaluation (PE) samples which we have analyzed and received true values for are used for the Laboratory Control Samples. These PE samples are given a unique identifier and all information such as expiration date (typically one year from the date made), source, concentration and preservation are recorded in Element and the Element # assigned is used to label this PE sample and is used on all data to trace it back to its source and true concentration.

VIII. CALIBRATION

A. Not applicable. See SOP-175 "**POST DISTILLATION ANALYSIS OF CYANIDE BY THE LACHAT"** for analysis.

IX. PROCEDURE

A. Pretreatment for cyanides amenable to chlorination

1. Two sample aliquots are required to determine cyanides amenable to chlorination. Place one 25 mL aliquot or a volume diluted to 25 mL, in a 100 mL beaker, under the hood, add a stirring bar, and place on a magnetic stirrer, and start stirring bar turning.

2. Check pH and adjust to between 11 and 12 units, with 1.25N NaOH. Use NaOH pellets if solution is highly buffered.

3. Add sodium hypochlorite chlorine bleach (Chlorox) solution dropwise until a drop of well-mixed sample turns KI starch paper a distinct blue color. Add about 10 drops excess bleach. (Caution: the initial reaction product of alkaline chlorination is the very toxic gas cyanogen chloride.) Maintain this excess for one hour, continuing agitation. Check periodically during the hour (15 minute intervals) to make sure an excess is maintained. If necessary, add additional hypochlorite bleach solution. Also check the pH and adjust back up to 11 to 12 units if necessary.

4. After one hour, add 0.025 g portions of ascorbic acid until KI starch paper shows no residual chlorine. Add an additional 0.025 g of ascorbic acid to ensure the presence of excess reducing agent.

5. Turn off stirring plate and remove stirring bar. Proceed with distillation as in the procedure.

6. Test for total cyanide in both the chlorinated and unchlorinated aliquots. (The difference of total cyanide in the chlorinated and unchlorinated aliquots is the cyanide amenable to chlorination.)

B. Spikes and high and low check standards

1. **Spikes**: Matrix spikes are prepared by diluting 2.5 mL of the High DCV solution in #3 below, to 25 mL with sample (adding 22.5 mL of sample and 2.5 mL of DCV high to the distillation tube). The concentration of this spike is 0.10 mg/L.

2. **Low Distilled Check standard (low DCV).** Dilute 2.0 mL of the 10 mg/L working standard to 100 mLs in a volumetric flask. Then dilute 6.0 mLs of this solution to 25 mLs with 0.25N NaOH, to make a 0.048 mg/L standard.

3. **High Distilled Check standard (high DCV).** Dilute 10 mLs of the 10 mg/L working standard to 100 mLs in a volumetric flask with DI water. Then dilute 5 mLs of this solution to 25 mLs with 0.25N NaOH, to make a 0.20 mg/L standard.

C. Distillation

1. For Waters: Place 25 mL of sample, or an aliquot diluted to 25 mL, in a sample tube. 0.25 N NaOH must be used for all sample dilutions following the distillation.

2. For Soils or Sludges:

   a.) It is extremely important that waste (when appropriate), soil and sediment samples be mixed thoroughly to ensure that the sample is as representative as possible of the sample media. The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

   - The material in the sample pan(inorganic-plastic/organic-aluminum) should be divided into quarters and each quarter should be mixed individually.
   - Two quarters should then be mixed to form halves.
   - The two halves should be mixed to form a homogenous matrix.

   This procedure should be repeated several times until the sample is adequately mixed.

   NOTE: Samples that are clay type materials should be handled in a different manner. Due to these type sample matrices having an affinity to stick to most anything that touches it, another approach must be followed. Obtain a

representative sub-sample aliquot from the center or middle section of the sample container.

b.) Accurately weigh a representative 1-g minimum (record actual weight) portion of wet-weight sample (unless there are project-specific requirements where a lower detection limit is required) and transfer it to a sample tube. Add 25 mL of 0.25 N NaOH. Shake or stir the sample so that it is dispersed.

3. Add one drop of Phenolphthalein solution to verify preservation. A positive test is indicated by a bright pink color. If not add a small amount of NaOH.

4. To test for sulfide, place a drop of sample on lead acetate paper, previously moistened with acetic acid buffer solution (pH 4). A positive test is indicated by a black color on the paper.

   a.) If positive the sample will need to be filtered through 934AH filter paper. (4.5cm size) The filtrate will be treated and the filter added back to the treated filtrate before distillation.

   b.) Treat filtrate with powdered lead carbonate [$Pb(CO_3)_2$]. Repeat test until a drop of treated sample no longer darkens the acidified lead acetate test paper.

   c.) Filter the resulting precipitate (should form a lead sulfide which will be black in appearance).

   d.) Once the filtrate is treated and filtered, the filter with the original solids from the pretreated sample will be added back to the treated filtrate and then distilled.

5. Add 25 mL of sodium hydroxide solution 0.25N to the absorber and assemble the apparatus as shown in Fig. 1.

6. Start a slow stream of air entering the boiling flask by adjusting the vacuum source. Adjust the vacuum such that air bubbles from the thistle tube in the flask at a rate of 3 to 5 per second.

   Note: The bubble rate will not remain constant after the reagents have been added and while heat is being applied to the flask. It may be necessary to readjust the air rate occasionally to prevent the solution in the sample tube from boiling and spewing out through the thistle tube.

7. Turn on condenser water.

8. Add 0.5 mLs of sulfamic acid through the thistle tube.

9. Slowly add 2 mL 1:1 H_2SO_4 through the thistle tube.

10. Add 2 mL 2.5 <u>M</u> $MgCl_2$ through the thistle and rinse it down with deionized water.

11. Reflux at 100°C for 90 minutes, turn off heat, allow to cool with pump on for 15 minutes.

12. Disconnect absorber and transfer the solution from the absorber into a storage container.

14. Record distillation information in the distillation log. Include date, analyst, sample number, client, matrix, position, sample mass / volume, distillation time, cool down time, when transferred to analyst, when analyzed.

X. CALCULATIONS

A. Sample volumes / masses must be recorded accurately in the distillation log to allow the analyst to correctly calculate the final concentration of cyanide correctly.

XI. DISTILLATION GLASSWARE CLEANING & LABELING

A. The distillation glassware is cleaned thoroughly with hot soapy water between distillations. 1:1 HCl is aerated through the frits on the block to ensure that the frits are clean. Deionized water is forced up through the glassware to rinse it. The cold fingers are dipped in mild acid, rinsed and wiped off.

B. All glassware must be labeled and each position's label must be recorded in the distillation log with the sample that was distilled in that particular vessel.

C. When sample concentrations are at or exceed 1000 mg/L a deionized water blank must be distilled in the exact glassware used for that sample before processing any other client's sample to ensure that the glassware is cleaned and has no residual cyanide to carryover.

XII. QUALITY CONTROL

A. With each distillation batch of samples (maximum of 20 samples) a preparation blank (BLK) must be distilled.

B. Each distillation batch of aqueous samples **requires a laboratory control sample (BS) each day or per 20 samples whichever is more frequent.** Under CLP the BS serves as the distilled ICV.

C. With each distillation batch of soil samples a soil BS (boiling chips are used) **each day or per 20 samples whichever is more frequent.**

D. A high and low check standard (DCV/ICV) must be distilled each day or per 20 samples whichever is more frequent. A non-distilled check standard must be prepared daily. This will be used to verify the preparation of the DCV if the DCV results are outside the specification limits. Under CLP the aqueous BS serves as the ICV.

E. A sample spike (MS) and sample spike duplicate (MSD) are performed with each set of twenty samples. CLP requires 1 duplicate and 1 spike per batch. All QC samples should be taken through the whole procedure including distillation. Spikes are added to the boiling flask in the same manner as standards adding 25 mL of samples or a dilution as used for the unspiked

sample. Spike concentration is listed in the method. The addition of the spiking solution must be witnessed and such must be noted in the digestion log.

XIII. CORRECTIVE ACTION

A. If any problems, such as low or high recovery for check standards or BSs occur, contact the Group Leader. Problems most frequently encountered (for the distillation procedure) are listed below.

B. Recoveries are affected in various ways.

1. If the spiking solution is not prepared properly (e.g., making the proper dilutions), the check standard will be out of control. Caution should be used in calculating the dilution and performing the pipetting.

2. Also, the air flow from the vacuum pumps can cause low recovery. Pay attention to the air flow (it should be in the area of 1 to 2 bubbles per second). If it is too great the HCN does not have an adequate amount of time to be absorbed by the NaOH solution.

3. If the heating block is not heating properly, this will also lead to low recovery. During the distillation, periodically check the sample tubes for the presence of heat (tubes should be very hot to the touch).

4. The addition of all reagents, including the spiking solution, is essential. Without the $MgCl_2$, 1:1 H_2SO_4, or spiking solution, the percent recovery will suffer greatly for complex cyanide. The recovery of simple cyanides will usually be unaffected.

5. If the volume of 0.25 N NaOH and reagent water is not accurate in the NaOH absorber tubes, low recoveries will usually occur.

B. Spike recoveries are affected in similar ways. Refer to the above suggestions. Also, if possible, do not spike a sample that is known to be high in cyanide. This may cause recovery and calculation problems.

XIV. WASTE DISPOSAL and POLLUTION PREVENTION

Please see Waste Disposal SOP-405, for instruction of proper disposal of waste generated from this area. Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

Addendum for USEPA CLPILM 05.2 AQUEOUS &SOIL/SEDIMENT

The following is a list of changes for sample preparation when the 5.2 statement of work is required:

1. The ICV shall be distilled.

2. Boiling chips are to be added to each sample. Midi-Distillation is reflux 1.5 hours then the heat and vacuum is turned off and the samples cool an additional 15 minutes.

3. The QC criteria for both the Distillation Check QC and the distilled ICV is ±15%.

4. A CRI is required at the beginning and end of each run and for every 20 samples. The QC criteria for the CRI is ±30%.

5. Rounding rule for the appropriate level of precision is that the figure following those to be retained is $\geq$ 5, round up: otherwise round down. (examples: 1.5 and 2.5 would be 2 and 3 respectively rounded up; 1.4 and 2.4 would be 1 and 2 respectively rounded down) Please see Exhibit B, Section 3, (3.3.9.1) of SOW ILM0 5.2 for more guidance on rounding significant figures.

XV. DEFINITIONS

See SOP-431 for a list of definitions

EMPIRICAL LABS, LLC.
Record of SOP Review and Implementation

TRAINING TOPIC SOP164 Rev 15 - Distillation of Aqueous/Solid Samples for Total and Non-Amenable Cyanide Analysis Methods 335.1/335.4/ Standard Methods SM 4500-CN C,G 18th, 19th ED./ (SW846) 9012A/USEPA CLP ILMO 4.1

Group: Inorganic

ATTENDEES:

	NAMES (print)	SIGNATURE	REMARK	DATE	TIME	INSTRUCTOR
1	Veronica Mullen	Veronica Mullen		8-3010	1118	
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EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE

INORGANICS: SOP181 REVISION #: 08 EFFECTIVE DATE: 20101130

PHENOL AND PHENOLIC MATERIALSDISTILLED WATER SAMPLES Methods: EPA 420.2/420.4, SW846 9066, LACHAT 10-210-00-1-A

APPROVALS:

Lab Director: _____ Date: 12/2/10

Data Quality Manager: _____ Date: 12/3/10

Section Supervisor: Betty DeVille Date: 12/2/10

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Changes Summary

Revision 08, 11/30/2010

- The SOP is an update from Revision 07 dated 12/19/08.
- Updated to replace change LCS to BS and method blank to BLK.
- References to the laboratories QS SOPs have been added.

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PHENOL AND PHENOLIC MATERIALSDISTILLED WATER SAMPLESMethods: EPA 420.2/420.4, SW846 9066, LACHAT 10-210-00-1-A

I. SCOPE AND APPLICATION

A. The method is applicable to the analysis of drinking, surface and saline waters, domestic and industrial wastes.

B. The method is capable of measuring phenolic materials from 10 to 500 ug phenol/L in the aqueous phase using phenol as a standard. The method detection limit or limit of detection is 10 ug phenol/L and the reporting limit or limit of quantitation is 30 ug phenol/L. Approximately 90 samples per hour can be analyzed.

II. PRINCIPLE

Volatile phenolic compounds are separated from the sample matrix by distillation. The distillate is collected and analyzed. Phenol, ortho- and meta-substituted phenols, and para-substituted phenols where the para- group is carboxyl, a halogen, a methoxyl, or a sulfonic acid group are all determined by reaction with 4-aminoantipyrine. Not determined are para-cresol, and other para- substituted phenol where the para- group is an alkyl, an aryl, a nitro, a bezoyl, a nitroso, or an aldehyde group.

III. SUMMARY OF METHOD

A. The method is based on the distillation of phenol and subsequent reaction of the distillate with alkaline ferricyanide and 4-aminoantipyrine to form a red complex which is measured from 500 to 520nm.

B. Color response of phenolic materials with 4-aminoantipyrine is not the same for all compounds. Because phenolic type wastes usually contain a variety of phenols, it is not possible to duplicate a mixture of phenols to be used as a standard. For this reason, phenol has been selected as a standard and any color produced by the reaction of other phenolic compounds is reported as phenol. This value will represent the minimum concentration of phenolic compounds present in the sample.

C. Reduced volume versions of this method that use the same reagents and molar ratios are acceptable provided they meet the quality control and performance requirements stated in the method.

D. Limited performance based method modifications may be acceptable provided they are fully documented and meet or exceed requirements expressed in section 9.0, Quality Control.

E. Laboratory Quality System SOP QS08 **"**Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures" provides information on calibrations and commonly used definitions.

IV. INTERFERENCES

A. Distillation removes all non-volatile interferences. Interference from sulfur compounds is removed by adding phosphoric acid to the sample to pH less than 4, and then aerating briefly by stirring.

B. Oxidizing agents, such as chlorine, will oxidize phenols. If oxidizing agents are present, remove them immediately after sampling by adding excess iron (II) sulfate ($FeSO_4$).

C. Oils and tars can be removed prior to distillation by extraction with chloroform ($CHCl_3$). Adjust the sample pH to 12 to 12.5 by adding NaOH pellets, and then extract the oil or tar with a 50 mL portion of chloroform. Remove the chloroform layer and evaporate the excess chloroform in the aqueous layer by gently warming the aqueous layer.

V. SAMPLE HANDLING AND PRESERVATION

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A. Biological degradation is inhibited by the addition of concentrated sulfuric acid to a pH of <4. Samples must be collected in 1 liter glass (only) bottles. The sample must be kept at 4°C until distilled and after distillation unless it is to be colored that day.

B. Phenol holding time is 28 days, counting the day it is sampled.

VI. DEFINITIONS

A. ANALYTICAL BATCH-The set of samples extracted /distilled/ or digested at the same time to a maximum of 20 samples.
B. CALIBRATION BLANK (CB)- A volume of reagent water in the same matrix as the calibration standards, but without the analyte.
C. CALIBRATION STANDARD (CAL)- A solution prepared from the primary dilution standard solution or stock standard solutions. The CAL solutions are used to calibrate the instrument response with respect to analyte concentration.
D. FIELD BLANK (FMB)- An aliquot of reagent water or equivalent neutral reference material treated as a sample in all aspects, including exposure to a sample bottle holding time, preservatives, and all preanalysis treatments. The purpose is to determine if the field or sample transporting procedures and environments have contaminated the sample.
E. FIELD DUPLICATE (FD)- Two samples taken at the same time and place under identical circumstances which are treated identically throughout field and laboratory procedures. Analysis of field duplicates indicates the precision associated with sample collection, preservation, and storage, as well as with laboratory procedures.
F. LABORATORY BLANK (LRB)- An aliquot of reagent water or equivalent neutral reference material treated as a sample in all aspects, except that it is not taken to the sampling site. The purpose is to determine if the analytes or interferences are present in the laboratory environment, the reagents, or the apparatus.
G. LABORATORY CONTROL SAMPLE (LCS)- A solution prepared in the laboratory by dissolving a known amount of one or more pure compounds in a known amount of reagent water. It's purpose is to assure that the results produced by the laboratory remain within the acceptable limits for precision and accuracy. (This should not be confused with a calibrating standard, it must be prepared from a source other than the same source as the calibration standards).
H. LABORATORY DUPLICATE (LD)- Two aliquots of the same environmental sample treated identically throughout a laboratory analytical procedure. Analysis of laboratory duplicates indicates precision associated with laboratory procedures but not with sample collection, preservation, or storage procedures.
I. QUALITY CONTROL CHECK SAMPLE (QCS)- A sample containing analytes of interest at known concentrations (true value) of analytes. The QCS is obtained from a source external to the laboratory or is prepared from standards obtained from a different source than the calibration standards. The purpose is to check laboratory performance using test materials that have been prepared independently from the normal preparation process.
J. METHOD DETECTION LIMIT (MDL)- The lowest level at which an analyte can be detected with 99 percent confidence that the analyte concentration is greater than zero.

VII. PREPARATION OF REAGENTS

Use deionized water (10 mega-ohm) for all solutions.

Reagent 1. 1 + 9 Phosphoric Acid Solution

By Volume: In a 100 mL volumetric flask, dilute 10 mL of 85 percent phosphoric acid (H_3PO_4). Stir or shake to mix.

Reagent 2. 10 Percent Copper Sulfate Solution

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Dissolve 100 g copper sulfate pentahydrate ($CuSO_4$-5 H_2O) in 1 L water. Stir or shake to mix.

Reagent 3. 1 M Sodium Hydroxide Solution

To 1 kg or 1 L water, add 40.0 g sodium hydroxide (NaOH). Shake to dissolve. Store in a plastic container.

Reagent 4. 4-Aminoantipyrine Color Reagent

In a 250 mL volumetric flask, or in a tared, 250 mL container, dissolve 0.16 g 4-aminoantipyrine (Aldrich A3, 930-0, Sigma A4382, or equivalent) in 250 mL or g water. Prepare fresh daily.

Reagent 5. Buffered Potassium Ferricyanide, pH 10.3

By Volume: In a 1 L volumetric flask, dissolve 2.0 g potassium ferricyanide [$K_3Fe(CN)_6$], 3.1 g boric acid (H_3BO_3) and 3.75 g potassium chloride (KCl) in about 800 mL water. Add 47 mL 1 M sodium hydroxide (Reagent 3) and dilute to the marker. Invert three times to mix. Prepare fresh every 3 months.

VIII. PREPARATION OF STANDARDS

Because the relative amounts of various phenolic compounds in a given sample are unpredictable, it is not possible to provide a universal standard containing a mixture of phenols. For this reason, phenol (C_6H_5OH) itself has been selected as a standard for this method. Any color produced by the reaction of other phenolic compounds is reported as phenol. Because this substitution generally reduces response, this value represents the minimum concentration of phenolic compounds.

Standard 1. Stock Standard 1,000 mg phenol/L

By Volume: In a 1 L volumetric flask add about 500 mL DI water, 1.0 g anhydrous copper sulfate ($CuSO_4$), 0.5 mL 85 percent phosphoric acid, (H_3PO_4), and 1.0 g phenol (C_6H_5OH). Dilute to the mark with water, dissolving the phenol.

Standard 2. Intermediate Stock Standard 5.00 mg phenol/L

By Volume: In a 1 L volumetric flask, add 5.00 mL Stock Standard (Standard 1) and dilute to the mark with water. Invert to mix. Chill @ 4°C and prepare fresh every 6 months.

Set of Six Working Standards: (see note on next page)

0.50 0.25 0.10 0.050 mg phenol/L

By Volume: To four 100 mL volumetric flasks add, respectively, exactly

10.0 5.00 2.00 1.00 mL of 5.0 mg/L

By Volume: To two 100 mL volumetric flasks add, respectively, exactly

10.0 0.00 mL of 0.10 mg/L

of the Intermediate Stock Standard (Standard 2). Dilute each to the mark with DI water and invert three times.

If samples always fall within a narrower range, more standards within this narrower range can be added and standards outside this narrower range can be dropped.

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The standards can be made up differently from the suggested volumes. For example:

10 mls of 5.0 mg/L working standard → 100 mls = 0.50 mg/L standard

2 mls of 5.0 mg/L working standard → 100 mls = 0.20 mg/L standard

10 mls of 0.50 mg/L working standard → 100 mls = 0.05 mg/L standard

10 mls of 0.10 mg/L working standard → 100 mls = 0.01 mg/L standard

10 mls of 0.05 mg/L working standard → 100 mls = 0.005 mg/L standard

These standards should be made up fresh daily.

IX. TIMING

Sample throughput: 90 samples/h; 40 s/sample
Pump speed: 35

Cycle period: 40 s
Inject to start of peak period: 14 s

X. SYSTEM NOTES

System IV Gain: 210 x 10

Presentation, Data Window

Top scale response: 0.05 abs
Bottom scale response: 0.00

Results/Approval, Reports

In the default RDF, change:
Set Default Chord 0
to
Set Default Chord 3
(Peak should be centered in Chord 3)
This change must be made to both the sample and the calibration RDFs.

Segment/Boundaries

A - 0.50 mg
D - 0.010 mg
F - 0.00 mg

Carrier and diluent is helium degassed water.

1" is 70.0 cm of tubing on a 1 inch coil support
4" is 255 cm of tubing on a 4 inch coil support

Apparatus: Standard valve, flow cell, and detector head modules are used.

All manifold tubing is 0.8 mm (0.032 inches) i.d. This is 5.2 uL/cm.

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Notes: Transmission tubing should be replaced with 1 m of Teflon manifold tubing (0.8 mm i.d.) as transmission tubing may contain leachable phenolics. Use Teflon tube connectors (Lachat part No. 50008) with PTA as line weights with pin removed.

Manifold Diagram Revision Date: 29 October, 1991 found in section 17.3, p.16 of Lachat method.

XI. CALCULATIONS:

Using the data system prepare the calibration curve plotting area, or peak heights against concentrations. Calculate sample concentration using the calibration curve/data system. Quality Systems SOP QS09 "General and Commonly used Laboratory Calculations" provides details on general calculations used throughout the laboratory.

XII. REFERENCES

1. U.S. Environmental Protection Agency, Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983, Method 420.2 and Method 420.4.

2. Standard Methods for the Examination of Water and Wastewaters, 14th edition, Method 510 p. 574.

3. Code of Federal Regulations, Part 136.3 (7-1-88), Table 1B, Footnote 25.

4. Code of Federal Regulations 40, Ch. 1 , Pt. 136, Appendix B.

5. U.S. Environmental Protection Agency, "Methods for the Determination of Inorganic Substances in Environmental Samples", EPA/600/R-93/100, August 1993, Method 420.1.

6. Gales, M.E. and Booth, R.L., "Automated 4 AAP Phenolic Method", AWWA 68, 540 (1976).

7. Environmental Monitoring Systems Laboratory, office of research and development U.S. Environmental protection agency Cincinnati, Ohio 45268.

XIII. QUALITY CONTROL

A. Analyze a BLK and an BS (which is distilled) every 20 samples or once daily whichever comes first.

B. Distill duplicate spikes every 20 samples. (For the direct method this is achieved by adding 20 mls of 5.0 ppm std to 200 mls of sample which makes a 0.2 ppm spike when brought up to 500 mls volume.)

C. Calibration verification is required every 10 samples and if the calibration check standard does not meet ±10 percent of the curve value or the BS does not fall within the control limits, (normally 80 to 120) corrective action must be taken before analysis proceeds.

D. Corrective Action: Contaminated blanks, out-of-range LCS's, and spikes that do not fall within 75 to 125 percent range would necessitate an NCR. Consult your supervisor for specific action.

E. Quality Control SOP QS05, "Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results", provides details on data assessment and acceptance criteria for Quality Control Measures.

XIV. CORRECTIVE ACTIONS

A. INSTRUMENT RELATED

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1. ICV not within ± 10%

    a. If the problem is with the solution.

        i. Re-prepare, obtain new stock if necessary.

    b. If the problem is with the calibration. Recalibrate thru analysis of appropriate standards and recheck ICV.

2. CCV not within ± 10%

    a. If the problem is with the solution.

        i. Re-prepare, obtain new stock if necessary.

    b. If the problem is with the calibration.

        i. Recalibrate thru analysis of appropriate standards and re-prepare/reanalyze the previous ten sample according the following guidelines.

            a. If the CCV was biased high, any of the previous ten samples which were below the MDL do not require reanalysis.

            b. If the CCV was biased low, the previous ten samples must be re-analyzed.

3. CCB not >± MDL (USACE)(**For DOD QSM no analyte detected >LOD, frequency- beginning and ending a run and every 10 samples**)or ± RL.

    a. If the CCB is biased high.

        i. Any samples below the MDL or greater than 10X the CCB bias need not be reanalyzed.
        ii. Any samples above the detection limit but less than 10X the CCB level must be reanalyzed after the problem is corrected.

    b. If the CCB is biased low.

        i. Any samples greater than 10X the absolute CCB bias need not be reanalyzed.
        ii. All other samples must be reanalyzed after the problem is corrected.

4. BS not within our in-house generated control limits (or ±20%).

    a. If the problem is with the instrument.

        i. Reanalyze when instrument is in control.

        ii. If biased high, the impact upon the data user must be evaluated. The samples will be re-extracted or the data will be qualified on the final report.

B. SAMPLE MATRIX RELATED

1. Replicate analysis RPD not within ±20%

    i. The associated sample data must be qualified on the final report.

2. Spike analysis recovery not within ±25%

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i. If the analyte level in the sample is greater than 4X the spiking level, the %recovery can not be evaluated and no action is taken.

ii. If the analyte level in the sample is not greater than 4X the spiking level, the associated sample data must be qualified on the final report.

XV. HEALTH AND SAFETY

A. Care should be used in handling all samples. Safety glasses must be worn in the lab at all times. The use of gloves and lab coats is highly recommended.

B. Research into expected sample content and concentration should be done in order to be prepared for additional safety considerations. Generally, any samples which need special consideration have applicable notes on the sample logs.

C. MSDS sheets are available for all reagents and standards which have been purchased. These are located on the bookshelf inside the Data Quality Managers office.

XVI. POLLUTION PREVENTION

A. Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation. When wastes cannot be feasibly reduced at the source, the Agency recommends recycling as the next best option.

B. Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

C. For information about pollution prevention that may be applicable to laboratories and research institutions, consult "Less is Better: Laboratory Chemical Management for Waste Reduction," available from the American Chemical Society's Department of Government Regulations and Science Policy, 1155 16th Street N.W., Washington D.C. 20036, (202) 872-4477.

XVII. WASTE MANAGEMENT

A. Laboratory SOP QS14 on Waste Handling discusses general guidelines for the appropriate handling of wastes and the laboratory program on waste management.

B. The Environmental Protection Agency requires that laboratory waste management practices be conducted consistent with all applicable rules and regulations. Excess reagents, samples and method process wastes should be characterized and disposed of in an acceptable manner. The Agency urges laboratories to protect the air, water, and land by minimizing and controlling all releases from hoods and bench operations, complying with the letter and spirit of any waste discharge permit and regulations, and by complying with all solid and hazardous waste regulations, particularly the hazardous waste identification rules and land disposal restrictions. For further information on waste management consult the "Waste Management Manual for Laboratory Personnel," available from the American Chemical Society at the address listed in Section 14.3 from method 300.1.

XVIII. METHOD PERFORMANCE

A. The method support data are presented in section 17 of the Lachat method. This data was generated according to a Lachat Work Instruction during development of the method.

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B. Although Lachat Instrument publishes method performance data, including MDL, precision, accuracy and carryover studies, we cannot guarantee that each laboratory and instrument conditions, as well as laboratory technique, play a major role in determining method performance. The support data serves as a guide of the potential method performance. Some labs may not be able to reach this level of performance for various reasons, while other labs may exceed it.

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EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE

INORGANICS: SOP 198 **REVISION #: 07** **EFFECTIVE DATE: 20100831**

TOXICITY CHARACTERISTIC LEACHING PROCEDURE
METHOD 1311

APPROVALS:

Lab Director: _____ Date: 9/9/10

Data Quality Manager: _____ Date: 9/9/10

Section Supervisor: Betty DeVille Date: 9/9/10

Changes Summary

Revision 07, 08/31/10

- The SOP is an update from Revision 06 dated 12/22/08
- Summarize changes here!
- Additional requirements, based upon the DoD QSM 4.1, have been integrated into the routine sample flow; however, if the requirement is different from routine sample flow, then the requirement is outlined and documented as such to be followed only when DoD samples are analyzed.

METHOD 1311

TOXICITY CHARACTERISTIC LEACHING PROCEDURE

1.0 SCOPE AND APPLICATION

1.1 The TCLP is designed to determine the mobility of both organic and inorganic analytes present in liquid, solid, and multiphasic wastes.

1.2 If a total analysis of the waste demonstrates that individual analytes are not present in the waste, or that they are present but at such low concentrations that the appropriate regulatory levels could not possibly be exceeded, the TCLP need not be run.

2.0 SUMMARY OF METHOD

2.1 For a highly liquid waste, determine if the percent dry solids is less than 0.5%. If so, the sample is filtered and the filtrate is treated as the extraction fluid. If not, the sample is reduced in size to pass through a 9.5 mm sieve. The percent wet solids are then determined. A 5 g and 100 g aliquot of wet solids are generated. The liquid phase for the 100 g aliquot is stored at 4 degrees Celsius. The 5 g aliquot is used to determine the appropriate extraction fluid. The 100 g aliquot is added to the extraction fluid and tumbled for about 18 hr's. The sample is filtered and the pH of the fluid is determined. An appropriate amount of the liquid phase is added to the extraction fluid and the sample is preserved according to the test, which will be performed.

2.2 The TCLP extract for volatiles is analyzed by method 8260B according to SOP-202. The TCLP extract for semivolatiles is subject to separatory funnel extraction by method 3510 according to SOP-300. The TCLP extract for metals is divided for two separate digestions and analyses: (a) mercury digestion and analysis by 7470A (SOP-103), and (b) ICP-metals digestion by 3010A (SOP-100) and analysis by 6010B (SOP-116).

3.0 INTERFERENCES

3.1 Potential interferences that may be encountered during analysis are discussed in the individual analytical methods and related SOPs. (See section 2.2)

4.0 APPARATUS AND MATERIALS

4.1 Agitation apparatus: The agitation apparatus must be capable of rotating the extraction vessel in an end-over-end fashion at 30 $\pm$ 2 rpm. This rate is measured and recorded with each extraction or at least once per quarter to ensure accuracy of the equipment.

4.2 Extraction Vessels

4.2.1 Zero-Headspace Extraction Vessel (ZHE). The ZHE (depicted in Figure 2) allows for liquid/solid separation within the device, and effectively precludes headspace. This type of vessel allows for initial liquid/solid separation, extraction, and final extract filtration

without opening the vessel. The vessels shall have an internal volume of 500-600 mL, and be equipped to accommodate a 90-110 mm filter. The devices contain VITON®[1] O-rings which should be replaced frequently.

For the ZHE to be acceptable for use, the piston within the ZHE should be able to be moved with approximately 30 to 40 psi or less. If it takes more pressure to move the piston, the O-rings in the device should be replaced. If this does not solve the problem, the ZHE is unacceptable for TCLP analyses and the manufacturer should be contacted.

The ZHE should be checked for leaks after every extraction. If the device contains a built-in pressure gauge, pressurize the device to 50 psi, allow it to stand unattended for 10 minutes, and recheck the pressure. If the device does not have a built-in pressure gauge, pressurize the device to 50 psi, submerge it in water, and check for the presence of air bubbles escaping from any of the fittings. If pressure is lost, check all fittings and inspect and replace O-rings, if necessary. Retest the device. If leakage problems cannot be solved, the manufacturer should be contacted.

Some ZHEs use gas pressure to actuate the ZHE piston, while others use mechanical pressure. Whereas the volatiles procedure refers to pounds per square inch (psi), for the mechanically actuated piston, the pressure applied is measured in torque-inch-pounds.

4.2.2 Bottle Extraction Vessel. When the waste is being evaluated using the nonvolatile extraction, a jar with sufficient capacity to hold the sample and the extraction fluid is needed. Headspace is allowed in this vessel.

The extraction bottles may be constructed from various materials, depending on the analytes to be analyzed and the nature of the waste. It is recommended that borosilicate glass bottles be used instead of other types of glass, especially when inorganics are of concern. Plastic bottles, other than polytetrafluoroethylene, shall not be used if organics are to be investigated.

4.3 Filtration Devices: It is recommended that all filtrations be performed in a hood or well ventilated area.

4.3.1 Zero-Headspace Extractor Vessel (ZHE): When the waste is evaluated for volatiles, the zero-headspace extraction vessel is used for filtration. The device shall be capable of supporting and keeping in place the glass fiber filter and be able to withstand the pressure needed to accomplish separation (50 psi).

NOTE: When it is suspected that the glass fiber filter has been ruptured, an in-line glass fiber filter may be used to filter the material within the ZHE.

4.3.2 Filter Holder: When the waste is evaluated for other than volatile analytes, any filter holder capable of supporting a glass fiber filter and able to withstand the pressure needed to accomplish separation may be used. Suitable filter holders range from simple vacuum units to relatively complex systems capable of exerting pressures of up to 50 psi or more.

[1] VITON® is a trademark of Du Pont.

Vacuum filtration can only be used for wastes with low solids content (<10%) and for highly granular, liquid-containing wastes. All other types of wastes should be filtered using positive pressure filtration.

4.3.3 Materials of Construction: Extraction vessels and filtration devices shall be made of inert materials which will not leach or absorb waste components. Glass, polytetrafluoroethylene (PTFE), or type 316 stainless steel equipment may be used when evaluating the mobility of both organic and inorganic components.

4.4 Filters: Filters shall be made of borosilicate glass fiber, shall contain no binder materials, and shall have an effective pore size of 0.6 to 0.8 µm (Whatman GF/F), or equivalent. **Pre-filters must not be used. When evaluating the mobility of metals**, filters shall be acid-washed prior to use by rinsing with 1N nitric acid followed by three consecutive rinses with deionized distilled water (a minimum of 1 L per rinse is recommended). Glass fiber filters are fragile and should be handled with care.

4.5 pH Meters: The meter should be accurate to ± 0.20.

4.6 ZHE Extract Collection Devices: TEDLAR®[2] bags are used to collect the initial liquid phase and the final extract of the waste when using the ZHE device, only when both liquid and solid phases exist. Collect final extract in a 40 mL vial when only a solid phase exist.

4.7 ZHE Extraction Fluid Transfer Devices: Any device capable of transferring the extraction fluid into the ZHE without changing the nature of the extraction fluid is acceptable (e.g., a positive displacement or peristaltic pump, a gas tight syringe, pressure filtration unit (see Section 4.3.2), or other ZHE device).

4.8 Laboratory Balance: Accurate to within ± 0.01 grams may be used (all weight measurements are to be within ± 0.1 grams).

4.9 Beaker or Erlenmeyer flask, glass, various sizes.

4.10 Watchglass

4.11 Magnetic stirrer.

5.0 REAGENTS

5.1 Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

[2] TEDLAR® is a registered trademark of Du Pont.

5.2 Reagent Water. Reagent water is defined as water in which an interferant is not observed at or above the method's detection limit of the analyte(s) of interest. For nonvolatile extractions, ASTM Type II water or equivalent meets the definition of reagent water. For volatile extractions, it is recommended that reagent water be generated by any of the following methods.

5.2.1 A water purification system may also be used to generate reagent water for volatile extractions.

5.2.2 Reagent water for volatile extractions may also be prepared by boiling water for 15 minutes. Subsequently, while maintaining the water temperature at 90 $\pm$ 5 degrees C, bubble a contaminant-free inert gas (e.g. nitrogen) through the water for 1 hour. While still hot, transfer the water to a narrow mouth screw-cap bottle under zero-headspace and seal with a Teflon-lined septum and cap.

5.3 Hydrochloric acid (1N), HCl, made from ACS reagent grade.

5.4 Nitric acid (1N), HNO_3, made from ACS reagent grade.

5.5 Sodium hydroxide (15N), NaOH, made from ACS reagent grade.

5.6 Glacial acetic acid, CH_3CH_2COOH, ACS reagent grade.

5.7 Extraction fluid.

5.7.1 Extraction fluid #1: Add 11.4 mL glacial acetic acid to approximately 1800 mL DI water. Add 8.6 mL 15N sodium hydroxide and dilute to 2 L. Seal and invert four times. Determine the pH which should be 4.93 +/- 0.05. Record in appropriate reagent log (RL) notebook.

5.7.2 Extraction fluid #2: Add 11.4 mL glacial acetic acid to approximately 1800 mL DI water and dilute to 2 L. Seal and invert four times. Determine the pH which should be 2.88 +/- 0.05. Record in appropriate reagent log (RL) notebook.

NOTE: All extraction fluids are purchased "certified" or prepared fresh and in volume quantity that matches the number of TCLP extractions to be performed on a given day. The TCLP/SPLP log-book is used to record the fluid type of choice with indication of its traceability to the lot numbers of acetic acid and sodium hydroxide used.

5.8 Analytical standards shall be prepared according to the appropriate analytical method.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 Extreme care must be taken when taking samples. Samples should be collected using an appropriate sampling plan.

6.2 The TCLP may place requirements on the minimal size of the field sample, depending upon the physical state or states of the waste and the analytes of concern. An aliquot is needed for preliminary evaluation of which extraction fluid is to be used for the nonvolatile analyte

extraction procedure. Another aliquot may be needed to actually conduct the nonvolatile extraction. If volatile organics are of concern, another aliquot may be needed.

6.3 Preservatives will not be added to samples before TCLP extraction.

6.4 For volatiles, the samples shall be collected and stored in a manner intended to prevent the loss of volatile analytes (e.g., samples should be collected in Teflon-lined septum capped vials and stored at 4°C. Samples should be opened only immediately prior to TCLP extraction).

6.5 TCLP extracts should be prepared for analysis and analyzed as soon as possible following extraction. **Extracts must be spiked according to their prospective analytes before preservation. Extracts or portions of extracts for metallic analyte determinations must be acidified with nitric acid to a pH < 2, unless precipitation occurs (see Section 7.2.14 if precipitation occurs).** Extracts or portions of extracts for volatile analyte determinations shall not be allowed to come into contact with the atmosphere (i.e., no headspace) to prevent losses. Preserve according to the analytical methods as referenced in 2.2.

7.0 PROCEDURE

7.1 Preliminary Evaluations

Perform preliminary evaluations on a minimum 100 gram aliquot of waste. This aliquot may not actually undergo TCLP extraction. These preliminary evaluations include: (1) determination of the percent solids; (2) determination of whether the waste contains insignificant solids and is, therefore, its own extract after filtration; (3) determination of whether the solid portion of the waste requires particle size reduction; and (4) determination of which of the two extraction fluids are to be used for the nonvolatile TCLP extraction of the waste.

7.1.1 Percent wet solids: Percent wet solids is defined as that fraction of a waste sample (as a percentage of the total sample) from which no liquid may be forced out by an applied pressure.

7.1.1.1 If the sample will obviously yield no liquid when subjected to pressure filtration proceed to Section 7.1.3.

7.1.1.2 If the sample is liquid or has more than one phase, liquid/solid separation to make a preliminary determination of percent solids is required. This involves the filtration device described in Section 4.3.2 and is outlined in Sections 7.1.1.3 through 7.1.1.9.

7.1.1.3 Pre-weigh the filter.

7.1.1.4 Assemble the filter holder and filter following the manufacturer's instructions. Place the weighed filter in the buchner funnel.

7.1.1.5 Mix the sample and weigh out a representative subsample of (100 gram minimum) and record exact weight.

7.1.1.6 Allow sludges to stand to permit the solid phase to settle.

7.1.1.7 Quantitatively transfer the sample to the filter holder (liquid and solid phases). Spread the waste sample evenly over the surface of the filter. If filtration of the waste at 4°C reduces the amount of expressed liquid over what would be expressed at room temperature then allow the sample to warm up to room temperature in the device before filtering.

NOTE: If waste material (>1% of original sample weight) has obviously adhered to the container used to transfer the sample to the filtration apparatus, determine the weight of this residue and subtract it from the sample weight determined in Section 7.1.1.5 to determine the weight of the waste sample that will be filtered.

Gradually apply vacuum or gentle pressure of 1-10 psi, until air or pressurizing gas moves through the filter. If this point is not reached under 10 psi, and if no additional liquid has passed through the filter in any 2 minute interval, slowly increase the pressure in 10 psi increments to a maximum of 50 psi. After each incremental increase of 10 psi, if the pressurizing gas has not moved through the filter, and if no additional liquid has passed through the filter in any 2 minute interval, proceed to the next 10 psi increment. When the pressurizing gas begins to move through the filter, or when liquid flow has ceased at 50 psi (i.e., filtration does not result in any additional filtrate within any 2 minute period), stop the filtration.

7.1.1.8 The material in the filter holder is defined as the solid phase of the waste, and the filtrate is defined as the liquid phase.

NOTE: Some wastes, such as oily wastes and some paint wastes, will obviously contain some material that appears to be a liquid. Even after applying vacuum or pressure filtration, this material may not filter. If this is the case, the material within the filtration device is defined as a solid. Do not replace the original filter with a fresh filter under any circumstances.

7.1.1.9 Remove filter carefully from the buchner funnel so as to get as much of the solid as possible.

Record the weight of the liquid and solid phases. Calculate the percent solids as follows:

$$\text{Percent wet solids} = \frac{(\text{Filter wt.} + \text{sample wt.}) - \text{filter wt.}}{\text{Total weight of waste}} \times 100$$

7.1.2 If the percent solids is equal to or greater than 0.5%, then proceed either to Section 7.1.3 to determine whether the solid material requires particle size reduction or to Section 7.1.2.1 if it is noticed that a small amount of the filtrate is entrained in wetting of the filter. If the percent solids is less than 0.5%, then proceed to Section 7.2.9 if the nonvolatile TCLP is to be performed and to Section 7.3 with a fresh portion of the waste if the volatile TCLP is to be performed.

7.1.2.1 Remove the solid material and filter from the filtration apparatus.

7.1.2.2 Dry the filter and solid material at 100 ± 20°C. Record the final weight.

NOTE: Caution should be taken to ensure that the subject solid will not flash upon heating. It is recommended that the drying oven be vented to a hood or other appropriate device.

7.1.2.3 Calculate the percent dry solids as follows:

$$\text{Percent dry solids} = \frac{\text{(Wt. of dry waste + filter) - tared wt. of filter}}{\text{Initial wt. of waste}} \times 100$$

7.1.2.4 If the percent dry solids is less than 0.5%, then proceed to Section 7.2.9 if the nonvolatile TCLP is to be performed, and to Section 7.3 if the volatile TCLP is to be performed. If the percent dry solids is greater than or equal to 0.5%, and if the nonvolatile TCLP is to be performed, return to the beginning of this Section (7.1) and, with a fresh portion of waste, determine whether particle size reduction is necessary (Section 7.1.3) and determine the appropriate extraction fluid (Section 7.1.4). If only the volatile TCLP is to be performed, see the note in Section 7.1.4.

7.1.3 Determination of whether the waste requires particle size reduction: Using the solid portion of the sample, evaluate the solid for particle size. Particle size reduction is required, unless the solid passes through a 9.5 mm (0.375 inch) standard sieve). If the surface area is smaller or the particle size larger than described above, prepare the solid portion of the waste for extraction by crushing, cutting, or grinding the waste to a surface area or particle size as described above. If the solids are prepared for organic volatiles extraction, special precautions must be taken.

NOTE: Surface area criteria are meant for filamentous (e.g., paper, cloth, and similar) waste materials. Actual measurement of surface area is not required, nor is it recommended.

7.1.4 Determination of appropriate extraction fluid: If the solid content of the waste is greater than or equal to 0.5% and if the sample will be extracted for nonvolatile constituents, determine the appropriate fluid for the nonvolatiles extraction as follows:

NOTE: TCLP extraction for volatile constituents uses only extraction fluid #1. Therefore, if TCLP extraction for nonvolatiles is not required, proceed to Section 7.3.

7.1.4.1 Weigh out a small subsample of the solid phase of the waste, reduce the solid (if necessary) to a particle size of approximately 1 mm in diameter or less, and transfer 5.0 grams of the solid phase of the waste to a 250 mL beaker or Erlenmeyer flask.

7.1.4.2 Add 96.5 mL of reagent water to the beaker, cover with a watchglass, and stir vigorously for 5 minutes using a magnetic stirrer. Measure and record the pH. If the pH is <5.0, use extraction fluid #1. Proceed to Section 7.2.

7.1.4.3 If the pH is >5.0, add 3.5 mL 1N HCl, **slurry briefly**, cover with a watchglass, heat to 50°C, and hold at 50°C for 10 minutes. (Note: Do not mix the sample during heating). The hot block may be used for the purpose of heating and holding at 50°C for 10 minutes.

7.1.4.4 Let the solution cool to room temperature (use Hobart to aid in cooling, 30 to 60 minutes) and record the pH. If the pH is <5.0, use extraction fluid #1. If the pH is >5.0, use extraction fluid #2. Note: The pH must be measured as quickly as possible in the phase of the procedure. It is critical to measure the pH as soon as the sample has reached room temperature. Proceed to Section 7.2.

7.1.5 If the aliquot of the waste used for the preliminary evaluation was determined to be 100% solid, then it can be used for the Section 7.2 extraction (assuming at least 100 grams remain), and the Section 7.3 extraction (assuming at least 25 grams remain).

7.2 Procedure for Metals and Semi-Volatiles

A minimum sample size of 100 grams (solid and liquid phases) is recommended. If less than the specified amount is used, proportion extraction fluid accordingly and notify manager. In some cases, a larger sample size may be appropriate, depending on the solids content of the waste sample, whether the initial liquid phase of the waste will be miscible with the aqueous extract of the solid, and whether inorganics, semivolatile organics, pesticides, and herbicides are all analytes of concern. Enough solids should be generated for extraction such that the volume of TCLP extract will be sufficient to support all of the analyses required.

All glassware and equipment must be thoroughly cleaned before use. A hot soapy water wash, rinse with tap water, then repeat following with a DI water rinse. Rinse with 1:1 HNO_3 , Methanol and acetone, and a final rinse with DI water.

7.2.1 If the waste will obviously yield no liquid when subjected to pressure filtration (i.e., is 100% solid), weigh out a subsample of the waste (100 gram minimum) and proceed to Section 7.2.9.

7.2.2 If the sample is liquid or multiphasic, liquid/solid separation is required. This involves the filtration device described in Section 4.3.2 and is outlined in Sections 7.2.4 to 7.2.8.

7.2.3 Assemble the filter holder and filter following the manufacturer's instructions. Place the filter on the support screen and secure. Acid wash the filter if evaluating the mobility of metals (see Section 4.4).

7.2.4 Weigh out a subsample of the waste (100 gram minimum) and record the weight. If the waste contains <0.5% dry solids, the liquid portion, after filtration, is defined as the TCLP extract. Therefore, enough of the sample should be filtered so that the amount of filtered liquid will support all of the analyses required. For wastes containing >0.5% dry solids use

the percent solids information to determine the optimum sample size (100 gram minimum) for filtration.

7.2.5 Allow sludges to stand to permit the solid phase to settle. Wastes that settle slowly may be centrifuged prior to filtration. Use centrifugation only as an aid to filtration. If the waste is centrifuged, the liquid should be decanted and filtered, followed by filtration of the solid portion of the waste through the same filtration system.

7.2.6 Refer to Section 7.1.1.7.

7.2.7 Refer to Section 7.1.1.8.

7.2.8 If the waste contains <0.5% dry solids, proceed to Section 7.2.13. If the waste contains >0.5% dry solids, and if particle size reduction of the solid was needed in Section 7.1.3, proceed to Section 7.2.10. If the waste as received passes a 9.5 mm sieve, quantitatively transfer the solid material into the extractor bottle along with the filter used to separate the initial liquid from the solid phase, and proceed to Section 7.2.11.

7.2.9 Prepare the solid portion of the waste for extraction by crushing, cutting, or grinding the waste to a surface area or particle size as described in Section 7.1.3. When the surface area or particle size has been appropriately altered, quantitatively transfer the solid material into an extractor bottle. Include the filter used to separate the initial liquid from the solid phase.

NOTE: Sieving of the waste is not normally required. Surface area requirements are meant for filamentous (e.g., paper, cloth) and similar waste materials. Actual measurement of surface area is not recommended. If sieving is necessary, a Teflon coated sieve should be used to avoid contamination of the sample.

7.2.10 Determine the amount of extraction fluid to add to the extractor vessel as follows:

$$\text{Weight of extraction fluid} = \frac{20 \text{ x percent wet solids x weight of waste fltered}}{100}$$

Slowly add this amount of appropriate extraction fluid to the extractor vessel. Close the extractor bottle tightly (it is recommended that Teflon tape be used to ensure a tight seal), secure in rotary agitation device, and rotate at 30 $\pm$ 2 rpm for 18 $\pm$ 2 hours. Ambient temperature shall be maintained at 23 $\pm$ 2 C during the extraction period. Record both tumble rate and room temperature.

NOTE: As rotation continues, pressure may build up within the extractor bottle for some types of wastes. To relieve excess pressure, the extractor bottle should be periodically opened (e.g., after 15 minutes, and 30 minutes) and vented into a hood.

7.2.11 Following the 18 $\pm$ 2 hour extraction, separate the material in the extractor vessel into its component liquid and solid phases by filtering through a new glass fiber filter, as outlined in Section 7.2.7. For final filtration of the TCLP extract, the glass fiber filter may be changed, if necessary, to facilitate filtration. Filter(s) shall be acid-washed.

7.2.12 Prepare the TCLP extract as follows:

7.2.12.1 If the sample contained no initial liquid phase, the filtered liquid material obtained is defined as the TCLP extract. Proceed to Section 7.2.13.

7.2.12.2 If compatible (e.g., multiple phases will not result on combination), combine the filtered liquid resulting from Section 7.2.12 with the initial liquid phase of the waste obtained in Section 7.2.7. This combined liquid is defined as the TCLP extract. Proceed to Section 7.2.13.

7.2.12.3 If the initial liquid phase of the waste, as obtained from Section 7.2.7, is not or may not be compatible with the filtered liquid resulting from Section 7.2.11, do not combine these liquids. Analyze these liquids, collectively defined as the TCLP extract, and combine the results mathematically, as described in Section 7.2.14.

7.2.1.3 Following collection of the TCLP extract, the pH of the extract must be recorded. Immediately split aliquots, give to appropriate analyst for spiking and preservation of the extract for analysis. Metal aliquots must be acidified with nitric acid to pH <2. (If precipitation is observed upon addition of nitric acid to a small aliquot of the extract, then the remaining portion of the extract for metals analyses shall not be acidified and the extract shall be analyzed as soon as possible.) All other aliquots must be stored under refrigeration (4°C) until analyzed. TCLP extracts to be analyzed for metals shall be acid digested except in those instances where digestion causes loss of metallic analytes. Refer also to sections 2.2 and 6.5.

If the individual phases are to be analyzed separately, determine the volume of the individual phases (to $\pm$ 0.5%), conduct the appropriate analyses, and combine the results mathematically by using a simple volume-weighted average:

$$\text{Final Analyte Concentration} = \frac{(V_1)(C_1) + (V_2)(C_2)}{V_1 + V_2}$$

where:

V_1 = The volume of the first phase (L).
C_1 = The concentration of the analyte of concern in the first phase (mg/L).
V_2 = The volume of the second phase (L).
C_2 = On next page
C_2 = The concentration of the analyte of concern in the second phase (mg/L).

7.3 Volatiles Extraction Procedure

Use ZHE device to obtain TCLP extract for analysis of volatile compounds only.

The ZHE device has approximately a 500 mL internal capacity. The ZHE can thus accommodate a maximum of 25 grams of solid due to the need to add an amount of extraction fluid equal to 20 times the weight of the solid phase.

Charge the ZHE with sample only once and do not open the device until the final extract has been collected. Repeated filling of the ZHE to obtain 25 grams of solid is not permitted.

Do not allow the waste, the initial liquid phase, or the extract to be exposed to the atmosphere for any more time than is absolutely necessary. Any manipulation of these materials should be done when cold (4°C) to minimize loss of volatiles.

All glassware and equipment must be thoroughly cleaned before use. A hot soapy water wash, rinse with tap water, then repeat following with a DI water rinse. Rinse with methanol and a final rinse with DI water.

7.3.1 Pre-weigh the filtrate collection container and set aside. If using a TEDLAR® bag, express all liquid from the ZHE device into the bag, whether for the initial or final liquid/solid separation, and take an aliquot from the liquid in the bag for analysis.

7.3.2 Place the ZHE piston within the body of the ZHE (it may be helpful first to moisten the piston O-rings slightly with extraction fluid). Adjust the piston within the ZHE body to a height that will minimize the distance the piston will have to move once the ZHE is charged with sample (based upon sample size requirements determined from Section 7.3, Section 7.1.1 and/or 7.1.2). Secure the gas inlet/outlet flange (bottom flange) onto the ZHE body in accordance with the manufacturer's instructions. Secure the glass fiber filter between the support screens and set aside. Set liquid inlet/outlet flange (top flange) aside.

7.3.3 If the waste is 100% solid, weigh out a subsample (25 gram maximum) of the waste, record weight, and proceed to Section 7.3.5.

7.3.4 If the waste contains < 0.5% dry solids, the liquid portion of waste, after filtration, is defined as the TCLP extract. Filter enough of the sample so that the amount of filtered liquid will support all of the volatile analyses required. For wastes containing $\geq$ 0.5% dry solids, use the percent solids information determine the optimum sample size to charge into the ZHE.

The recommended sample size is as follows:

7.3.4.1 For wastes containing < 5% solids, weigh out a 500 gram subsample of waste and record the weight.

7.3.4.2 For wastes containing $\geq$ 5% solids, determine the amount of waste to charge into the ZHE as follows:

$$\text{Weight of waste to charge ZHE} = \frac{25}{\text{percent wet solids}} \times 100$$

7.3.5 If particle size reduction of the solid portion of the waste was required in Section 7.1.3, proceed to Section 7.3.6. If particle size reduction was not required in Section 7.1.3, proceed to Section 7.3.7.

7.3.6 Prepare the waste for extraction by crushing, cutting, or grinding the solid portion of the waste to a surface area or particle size as described in Section 7.1.3. The means used to

effect particle size reduction must not generate heat in and of itself. If reduction of the solid phase of the waste is necessary, exposure of the waste to the atmosphere should be avoided to the extent possible.

NOTE: Sieving of the waste is not recommended due to the possibility that volatiles may be lost. The use of an appropriately graduated ruler is recommended as an acceptable alternative. Surface area requirements are meant for filamentous (e.g., paper, cloth) and similar waste materials. Actual measurement of surface area is not recommended.

When the surface area or particle size has been appropriately altered, proceed to Section 7.3.7.

7.3.7 Waste sludges need not be allowed to stand to permit the solid phase to settle. Do not centrifuge wastes prior to filtration.

7.3.8 Quantitatively transfer the entire sample (liquid and solid phases) quickly to the ZHE. Secure the filter and support screens onto the top flange of the device and secure the top flange to the ZHE body in accordance with the manufacturer's instructions. Tighten all ZHE fittings and place the device in the vertical position (gas inlet/outlet flange on the bottom). Do not attach the extract collection device to the top plate.

NOTE: If waste material (>1% of original sample weight) has obviously adhered to the container used to transfer the sample to the ZHE, determine the weight of this residue and subtract it from the sample weight determined in Section 7.3.4 to determine the weight of the waste sample that will be filtered.

Attach a gas line to the gas inlet/outlet valve (bottom flange) and, with the liquid inlet/outlet valve (top flange) open, begin applying gentle pressure of 1-10 psi (or more if necessary) to force all headspace slowly out of the ZHE device into a hood. At the first appearance of liquid from the liquid inlet/outlet valve, quickly close the valve and discontinue pressure. If filtration of the waste at 4°C reduces the amount of expressed liquid over what would be expressed at room temperature, then allow the sample to warm up to room temperature in the device before filtering. If the waste is 100% solid (see Section 7.1.1), slowly increase the pressure to a maximum of 50 psi to force most of the headspace out of the device and proceed to Section 7.3.12.

7.3.9 Attach the pre-weighed filtrate collection container to the liquid inlet/outlet valve and open the valve. Begin applying gentle pressure of 1-10 psi to force the liquid phase of the sample into the filtrate collection container. If no additional liquid has passed through the filter in any 2 minute interval, slowly increase the pressure in 10 psi increments to a maximum of 50 psi. After each incremental increase of 10 psi, if no additional liquid has passed through the filter in any 2 minute interval, proceed to the next 10 psi increment. When liquid flow has ceased such that continued pressure filtration at 50 psi does not result in any additional filtrate within a 2 minute period, stop the filtration. Close the liquid inlet/outlet valve, discontinue pressure to the piston, and disconnect and weigh the filtrate collection container.

NOTE: Instantaneous application of high pressure can degrade the glass fiber filter and may cause premature plugging.

7.3.10 The material in the ZHE is defined as the solid phase of the waste and the filtrate is defined as the liquid phase.

(Some wastes, such as oily wastes and some paint wastes, will obviously contain some material that appears to be a liquid. Even after applying pressure filtration, this material will not filter. If this is the case, the material within the filtration device is defined as a solid and is carried through the TCLP extraction as a solid.)

If the original waste contained <0.5% dry solids, this filtrate is defined as the TCLP extract. Proceed to Section 7.3.15.

7.3.11 The liquid phase may now be either analyzed immediately or preserved and stored at 4°C under minimal headspace conditions until time of analysis. Determine the weight of extraction fluid #1 to add to the ZHE as follows:

$$\text{Weight of extraction fluid} = \frac{20 \text{ x percent wet solids x weight of waste filtered}}{100}$$

7.3.12 The following details how to add the appropriate amount of extraction fluid to the solid material within the ZHE and agitation of the ZHE vessel. Extraction fluid #1 is used in all cases.

7.3.12.1 With the ZHE in the vertical position, attach a line from the extraction fluid reservoir to the liquid inlet/outlet valve. The line used shall contain fresh extraction fluid and should be preflushed with fluid to eliminate any air pockets in the line. Release gas pressure on the ZHE piston (from the gas inlet/outlet valve), open the liquid inlet/outlet valve, and begin transferring extraction fluid (by pumping or similar means) into the ZHE. Continue pumping extraction fluid into the ZHE until the appropriate amount of fluid has been introduced into the device.

7.3.12.2 After the extraction fluid has been added, immediately close the liquid inlet/outlet valve and disconnect the extraction fluid line. Check the ZHE to ensure that all valves are in their closed positions. Manually rotate the device in an end-over-end fashion 2 or 3 times. Reposition the ZHE in the vertical position with the liquid inlet/outlet valve on top. Pressurize the ZHE to 5-10 psi (if necessary) and slowly open the liquid inlet/outlet valve to bleed out any headspace that may have been introduced due to the addition of extraction fluid. This bleeding shall be done quickly and shall be stopped at the first appearance of liquid from the valve. Re-pressurize the ZHE with 5-10 psi and check all ZHE fittings to ensure that they are closed.

7.3.12.3 Place the ZHE in the rotary agitation apparatus and rotate at 30 ± 2 rpm for 18 ± 2 hours. Ambient temperature (i.e., temperature of room in which extraction occurs) shall be maintained at 23 ± 2°C during agitation. Record both tumble rate and temperature.

7.3.13 Following the 18 ± 2 hour period, check the pressure behind the ZHE piston by checking gauge and quickly opening and closing the gas inlet/outlet valve and noting the escape of gas. If the pressure has not been maintained (i.e., no gas release observed), the device is leaking. Check the ZHE for leaking as specified in Section 4.2.1, and perform the extraction again with a new sample of waste. If the pressure within the device has been maintained, the material in the extractor vessel is once again separated into its component liquid and solid phases. If the waste contained an initial liquid phase, the liquid may be filtered directly into the same filtrate collection container (i.e., TEDLAR® bag or VOC vials) holding the initial liquid phase of the waste. A separate filtrate collection container must be used if combining would create multiple phases, or there is not enough volume left within the filtrate collection container. Filter through the glass fiber filter, using the ZHE device as discussed in Section 7.3.9. All extract shall be filtered and collected if the TEDLAR® bag is used, if the extract is multiphasic, or if the waste contained an initial liquid phase.

NOTE: An in-line glass fiber filter may be used to filter the material within the ZHE if it is suspected that the glass fiber filter has been ruptured.

7.3.14 If the original waste contained no initial liquid phase, the filtered liquid material obtained from above is defined as the TCLP extract. If the waste contained an initial liquid phase, the filtered liquid material obtained from above and the initial liquid phase (Section 7.3.9) are collectively defined as the TCLP extract.

7.3.15 Following collection of the TCLP extract, immediately prepare the extract for analysis (one of the vials will be spiked at this point) and store with minimal headspace at 4°C. Analyze the TCLP extract according to the appropriate analytical methods (refer to section 2.2). If the individual phases are to be analyzed separately (i.e., are not miscible), determine the volume of the individual phases (to 0.5%), conduct the appropriate analyses, and combine the results mathematically by using a simple volume-weighted average:

$$\text{Final Analyte Concentration} = \frac{(V_1)(C_1) + (V_2)(C_2)}{V_1 + V_2}$$

where:

V_1 = The volume of the first phases (L).
C_1 = The concentration of the analyte of concern in the first phase (mg/L).
V_2 = The volume of the second phase (L).
C_2 = The concentration of the analyte of concern in the second phase (mg/L).

8.0 QUALITY ASSURANCE

8.1 A minimum of one blank (using the same extraction fluid as used for the samples) must be analyzed for every 20 extractions that have been conducted in an extraction vessel. No bias correction is to be taken into consideration (Fr 57, 227).

8.2 A matrix spike shall be performed for each waste type (e.g., wastewater treatment sludge, contaminated soil, etc.). One matrix spike must be analyzed for each analytical batch. Follow

the matrix spike addition guidance provided in each analytical method. (The method and SOPs are referenced in section 2.2.)

8.2.1 Matrix spikes are to be added after filtration of the TCLP extract and before preservation.

8.2.2 The matrix spikes should be added at a concentration equivalent to the corresponding regulatory level. If the analyte concentration is less than one half the regulatory level, the spike concentration may be as low as one half of the analyte concentration, but may not be not less than ten times the method detection limit. In order to avoid differences in matrix effects, the matrix spikes must be added to the same volume of TCLP extract as that which was analyzed for the unspiked sample.

8.2.3 The matrix spike is to monitor the performance of the analytical methods used, and to determine whether matrix interferences exist. If interferences exist, an alternate approach may be required.

8.2.4 Matrix spike recoveries are calculated by the following formula:

$$\%R\ (\%Recovery) = 100\ (X_s - X_u)/K$$

where:

X_s = measured value for the spiked sample,
X_u = measured value for the unspiked sample, and
K = known value of the spike in the sample.

8.3 All quality control measures described in each analytical methods must be followed.

8.4 The use of method of standard addition (MSA) shall be employed for a metallic contaminant if: (1) Recovery of the contaminant from the TCLP extract is not at least 50% and the concentration does not exceed the regulatory level, and (2) The concentration of the contaminant measured in the extract is within 20% of the appropriate regulatory level.

8.4.1 The MSA requires preparing calibration standards in the sample matrix rather than reagent water. It requires taking four identical aliquots of the solution and adding known amounts of standard to three of these aliquots. The forth aliquot is the unknown. The first addition should be prepared so that the resulting concentration is approximately 50% of the expected concentration of the sample. The second and third additions should be prepared so that the concentrations are approximately 100% and 150% of the expected concentration of the sample. All four aliquots are maintained at the same final volume by adding reagent water. Analyze all four aliquots.

8.4.3 Prepare a plot, or subject data to linear regression, of instrument signals or external-calibration-derived concentrations as the dependant variable (y-axis) versus concentrations of the additions of standard as the independent variable (x-axis). Solve for the intercept of the abscissa (the independent variable, x-axis) which is the concentration in the unknown.

8.5 TCLP extraction holding times.

SAMPLE MAXIMUM HOLDING TIMES [DAYS]				
	From: Field collection To: TCLP extraction	From: TCLP extraction To: Preparative extraction	From: Preparative extraction To: Determinative analysis	Total elapsed time
Volatiles	14	NA	14	28
Semi-volatiles	14	7	40	61
Mercury	28	NA	28	56
Metals, except mercury	180	NA	180	360

NA = Not applicable

If holding times are exceeded, the values obtained will be considered minimal concentrations. Exceeding the holding time is not acceptable in establishing that a waste does not exceed the regulatory level. Of course, exceeding the holding time will not invalidate characterization if the waste exceeds the regulatory level.

EMPIRICAL LABS, LLC.
TRAINING ATTENDANCE RECORD

TRAINING TOPIC: **SOP198 Rev07 - Toxicity Characteristic Leaching Procedure (Method 1311)**

Group: **Betty Deville**

ATTENDEES:

NAMES (print)	SIGNATURE	REMARK	DATE	TIME	INSTRUCTOR
1 Kendra Gentry	Kendra Gentry		9-15-10	12:00	BLD
2 Chase Block	Chase Block		9/17/10	10:15	BLD
3					
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GC/MS SEMIVOLATILES
BY EPA METHOD 625 AND
SW846 METHOD 8270C AND 8270D
INCLUDING ADDITIONAL
APPENDIX IX COMPOUNDS

SOP NUMBER: SOP-201

REVISION NUMBER: 18

APPROVED BY:

SECTION MANAGER

QUALITY ASSURANCE OFFICER

EFFECTIVE DATE: 09/16/08

DATE OF LAST REVIEW 09/16/08

GC/MS SEMIVOLATILES

BY EPA METHOD 625 AND SW846 METHOD 8270C and 8270D

1.0 SCOPE AND APPLICATION

Please see Appendix for definitions.
This SOP (based primarily on SW-846 Method 8000B/8270C/8270D) is used for the analysis of semi-volatile organic compounds in a variety of matrices (soils, sediments, waters, etc.). Methods *Federal Register* Method 625 and CLP Method for Semi-volatiles have also been used in the development of this SOP. The analyses by these various methods are clearly defined in the respective regulatory manuals. A good understanding of these different methods is essential to the performance of each method. A laboratory list of 625 and 8270 analytes with example limits is found attached in the appendix. Other compounds may be analyzed by this SOP as detailed in section 1.0 of SW-846 Method 8270C. Any questions left by this SOP should be answered by reading the methods, paying close attention to SW-846 8000B/8270C/8270D, EPA 625 and CLP. If questions still remain unanswered, check with the Organic Lab Manager, QA/QC Officer and/or Technical Director.

2.0 METHOD SUMMARY

After sample preparation using the appropriate extraction technique, the sample is introduced into the GC/MS using direct injection. The analytes are separated in the gas chromatograph by a combination of the temperature program, the pressure program and the capillary column. The analytes are then detected by the mass spectrometer. Analytes are identified by comparing the mass spectra of known standards with the mass spectra from the sample. Analytes are quantitated relative to known standards using the internal standard method.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Section 3.0 and tables 3-1 and 3-2 of the Empirical Laboratories' Quality Assurance Manual include details concerning sample preservation, containers and handling of semi-volatile samples and extracts. All water and soil samples are stored in the appropriate walk-in coolers at a temperature of 4°C. All extracts are stored in the Hobart in the Extraction lab at a temperature of 4°C. Water samples have a holding time of 7 days from date of sampling. Soil samples have a holding time of 14 days from date of sampling (unless otherwise specified for the project).Extracts have 40 days from date of extraction to be analyzed

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

4.1 All raw data (samples & QC) must be evaluated for interferences. If contamination occurs, determine whether the source of interference is in the preparation or clean-up of the samples and take corrective action to eliminate the problem.

4.2 Contamination by carryover can occur when samples of high-concentration and low-concentration are analyzed sequentially. To reduce carryover, the sample syringe must be rinsed with solvent between injections. If an unusually high sample is detected, a solvent blank should be analyzed for cross contamination.

5.0. EQUIPMENT AND APPARATUS

5.1 HP 5890/6890/7890GC complete with electronic pressure control and temperature programmable gas chromatograph suitable for splitless injection.

5.2 Column: RTX-5MS (or equivalent) 30 m x 0.25 mm I.D. x 0.25 µm film thickness fused silica capillary column or RTX-5 SIL-MS 30 m x 0.28 mm I.D. x 0.5µm film thickness.

5.3 HP 5971/5973/5975 mass spectrometer capable of scanning from 35 to 500 amu every second or less, using 70 volts electron energy in electron impact ionization mode. The mass spectrometer is capable of producing a mass spectrum for decafluorotriphenylphosphine, DFTPP, which meets all the tuning criteria of the EPA methods.

5.4 HP 7673/7683 autosampler capable of reproducibility from one injection to another proven by meeting QC and calibration criteria.

5.5 HP GC/MS interface that gives acceptable calibration points at 50 ng per injection for each compound of interest and achieves acceptable tuning performance criteria.

5.6 Acquisition Software: HP Chemstation system is interfaced to the GC/MS. The system acquires and stores data throughout the chromatographic programs.

5.7 Data Processing Software: Target DB on Windows NT server data system is interfaced to the HP Chemstation. The system accepts and stores acquired data. It plots by extracted ion current profile (EICP). The system is also capable of integrating the abundances in any EICP between specified time or scan-number limits. The most recent NBS mass spectral library is installed.

6.0 REAGENTS

6.1 Methylene chloride **(Please read SOP-336 before handling this solvent in our laboratory.)** – Trace analysis grade.

6.2 Stock standards are purchased in mixtures from reputable vendors. The date they are received is noted on the label and recorded in the BNA standards log book. The date they are opened is noted on the label and recorded in the BNA standards log book along with their lot number and vendor. Each standard that is prepared is recorded in the BNA standards log book and given a sequential number. Each standards label is completed with the standard number, name, preparation date, expiration date, solvent and analyst initials. All stocks and standards are stored in the freezer at a temperature of -15°C $\pm$ 5°C from the date they are received/prepared. Standards are brought to room temperature before being used to make standards. Sonication is used if precipitation is observed after bringing to room temperature. The refrigerator and freezer temperature is monitored daily with an annually calibrated thermometer and recorded with calibration correction in the Extraction temperature/calibration logbook. Makeup of common standards is detailed below. See the BNA standards log book for makeup of other standards.

6.2.1 The Decafluorotriphenylphosphine (DFTPP) tuning standard is prepared as follows (includes benzidine, pentachlorophenol and 4,4'-DDT): Using a 100µL syringe, 100µL (GCM-150, Ultra Scientific @ 1000µg/mL, or equivalent) is injected into a 2.0mL volumetric flask containing approximately 1.2mL methylene chloride (Trace Grade) and diluted to volume with same making a 50µg/mL standard. After capping and inverting several times, the solution is transferred into 2 labeled 2ml, teflon-lined, screw-capped vials and stored in the freezer at -15°C ± 5°C for up to 6 months. A direct injection of 1.0µL is used to tune the instrument.

6.2.2 Calibration standards are prepared from a 200µg/mL working standard at a minimum of five concentrations. Calibration standards are prepared semi-annually unless the initial calibration verification standard indicates a problem. To makeup the 200µg/mL working standard inject the indicated amount of the following standards (or equivalent) into a 10mL volumetric containing approximately 5mL methylene chloride (Trace Grade) and dilute to volume with the same. After capping and inverting several times, the solution is transferred into an appropriate labeled vial, teflon-lined, screw-capped vial and stored in the freezer at -15°C ± 5°C for up to 6 months. See the Appendix for analytes contained in these mixes.

Standard (Interm.A in 10mls)	Conc (µg/mL)	Amount(µL)	Final (ug/mL)
Base/Neutrals Mix 1 (Vendor,Lot#)	2000	1000	200
Benzidines Mix 2 (Vendor,Lot#)	2000	1000	200
Acids Mix (Vendor,Lot#)	2000	1000	200
SV Mix w/ Pyridine & Carbazole (Vendor,Lot#)	2000	1000	200
BN Surrogate (Vendor,Lot#)	5000	400	200
Acid Surrogate (Vendor,Lot#)	10,000	400	400
Catechol (Standard#)	10,000	200	200
Biphenyl (Standard#)	10,000	200	200
Caprolactum (Standard#)	10,000	200	200
Acetophenone (Standard#)	10,000	200	200
Standard (Interm.B in 5mls)	**Conc (µg/mL)**	**Amount(µL)**	**Final (ug/mL)**
Benzidine (Mix # 2)	2000	500	200
Standard (Interm.C in 5mls)			
Atrazine (Standard#)	10,310	97	200
Benzaldehyde (Standard#)	10,590	94	200

Additional Appendix IX compounds can be added using 3 additional mixes, AppIX A,B,C. Refer to standards log.

To makeup the calibration standards, using a 1ml syringe add the appropriate amount of methylene chloride (trace grade) to a 2ml vial. Add the indicated amount of each intermediate standard to the vial. Add 20ul of internal standard to each screw-capped vial and stored in the freezer at -15°C ± 5°C for up to 6 months.

IntmA,Bor C	Amt. of 200ppm std	Amount of 2000ppm Internal Std
2 µg/mL	10 µL	20 µL
5 µg/mL	25 µL	20 µL
10 µg/mL	50 µL	20 µL
20 µg/mL	100 µL	20 µL
30 µg/mL	150 µL	20 µL
40 µg/mL	200 µL	20 µL
50 µg/mL	250 µL	20 µL

60 µg/mL	300 µL	20 µL
70 µg/mL	350 µL	20 µL
80 µg/mL	400 µL	20 µL
90 µg/mL	450 µL	20 µL
100 µg/mL	500 µL	20 µL

The makeup of the 50µg/mL CCV standard is detailed below. Occasionally, unusual compounds are added to the mix so it is best to check the BNA standards log book for exact standard makeup. Note: MS list spikes and full list spikes for LCS and/or MS/MSD are prepared from an alternate source or lot number other than the calibration standards.

Example: 50µg/mL CCV standard preparation:

SV3640

using 1ml syringe add the appropriate amount of methylene chloride to a
2ml vial. Add the indicated amount of intermediate / stock standard to the vial.
Add 20ul of internal standard to the vial (**SV 3635**).Soultion stored in freezer at -15deg C+/-5degC for upto 1 week.

50 ug/mL CCV

	Stock Standard	Concentration		50 ug/mL	
SV3515	BNA intermediate mix	200 PPM		250 uL	
SV3517	Benzidine Int.	200 PPM		250 uL	
SV3516	Atrazine benzaldehyde Int.	200 PPM		250 uL	

6.2.3 The Initial Calibration Verification (ICV) standard is prepared from a vendor stock standard at a concentration of 200µg/mL as detailed below.

Example: 50µg/mL ICV standard preparation:

(SV2100) ~ 50ug/ml ICV

Into a 1 mL volumetric flask containing Methylene Chloride ~ about 0.6ml, add 250uls of
SV1995 (readystock 200ppm)
and dilute to volume.

Top off w/20uls of Internal Standard **(SV2079)**
Prep'd: 01/08/03 Exp: 03/16/03

(SV2396) ~ 50ug/ml ICV (benzaldehyde & atrazine)

Into a 1 mL volumetric flask containing Methylene Chloride ~ about 0.6ml, add 250uls of
SV2305 (intermediate stock 200ppm) and dilute to volume.
Top off w/20uls of Internal Standard **(SV2393)**

Prep'd: 09/18/03 Exp: 03/18/04

7.0 PROCEDURE

Prior to using Federal Register 625, SW-846 8270C/8270D, or CLP (semivolatile method) the samples are prepared for chromatography using the appropriate sample preparation and clean up methods (generally SW-846 methods 3510, 3520, 3540, 3550, 3580, EPA method 625 or CLP).

7.1 Chromatographic conditions: Refer to corresponding instrument maintenance log for current gas chromatograph and mass spectrometer conditions.

7.2 Tuning - Prior to any calibration or analysis, DFTPP tuning criteria must be met for a 50 ng injection of the tuning standard [see below]. Tune must be met every 12 hours sample analysis is to be performed (every 24 hours for *Federal Register* Method 625 except for South Carolina which only allows 12 hours). The injection port performance compounds (pentachlorophenol, benzidine and 4,4'-DDT) are also injected to verify the performance of the injection port and must meet the following criteria. Degradation of DDT to DDE and DDE should not exceed 20%. Benzidine and pentachlorophenol should be present at their normal responses, and no peak tailing should be visible for 8270C. **Tailing factor should be 2.0 for 8270D for benzidine and pentachlorophenol**. For NPDES samples, the benzidine (base/neutral) tailing factor must not exceed 3.0 while the pentachlorophenol (acid) tailing factor cannot exceed 5.0. The calculation for tailing factors is best illustrated in Figure 13 of the *Federal Register* Method 625 which has been placed in the appendix. If degradation is excessive and/or poor chromatography is seen, the injection port may require cleaning and maintenance. It may also be necessary to break off 15-30cm of the capillary column. The mass spectrum of DFTPP is acquired as follows: by using one scan at the apex peak, or by by using the mean of the apex and the preceding and following scans or mean of a symmetric pattern of scans about the apex, or using the average across the entire peak. Background subtraction is accomplished using a single scan or more than 20 scans prior to the elution of DFTPP.

Mass	Ion Abundance Criteria
51	30-60% of mass 198
68	<2% of mass 69
70	<2% of mass 69
127	40-60% of mass 198
197	<1% of mass 198
198	Base peak, 100% relative abundance
199	5-9% of mass 198
275	10-30% of mass 198
365	>1% of mass 198
441	Present, but less than mass 443
442	>40% of mass 198
443	17-23% of mass 442

8270D has different tuning citeria for meeting DFTPP. See page 44 Table 3 of Method 8270D for criteria.

7.3 Calibration

7.3.1 Initial Calibration - An initial calibration curve at no less than five concentration levels must be analyzed (only three concentration levels are required for *Federal Register* Method 625) and shown to meet the initial calibration criteria before any sample analysis may be performed. Method 625 requires that the %RSD be less than 35% to use the average response factor for quantitation, the curve is to be used otherwise and should have a correlation

coefficient (***r***) of ≥0.995 linear, 0.99 and six points for quadratic. Method 8270C requires that the %RSD be less than 15% to use the average response factor for quantitation, the curve is to be used otherwise as long as ***r*** is ≥0.995 linear, 0.99 and six points for quadratic. In addition, there are calibration check compounds (CCCs) which must have a %RSD less than 30% and system performance check compounds (SPCCs) which must meet a minimum avarage response factor of 0.050. The lowest standard must be less than or equal to the reported quantitation limit and the highest standard must not exceed the linear range of the detector. Generally, levels for the curve are 2 ug/mL, 5 µg/mL, 10 µg/mL, 20 µg/mL, 30 µg/mL, 40 µg/mL, 50 µg/mL, 60 µg/mL, 70 µg/mL, 80 µg/mL, 90 ug/mL and 100 µg/mL. Any manual integrations are documented by inclusion of the integrated signals(**before and after manual integration**)initialed, reason and dated with the quantitation report and chromatogram. Refer to SOP-224 for guidance. All integrations are checked for acceptability. Response factors of less than 0.050 must be supported by the mass spectrum of the lowest standard. Retention times are set using the midpoint of the curve. **No quadratic curves are used for SouthCarolina. For 8270D the RSD for each target analyte should be less than or equal to 20% and each calibration level should meet the minimum response factors listed in Table 4. If the 20% RSD is not met, then the minimum correlation coefficient for the curve must be 0.99. If more than 10% of the compounds do not meet the 20% RSD or minimum correlation coefficient of 0.99, then the chromatographic system is considered too reactive to begin analysis. Injector maintenance should be performed and repeat the calibration procedure.**

CCCs:	Base/Neutral	Acid
	Acenapthene	4-Chloro-3-methylphenol
	1,4-Dichlorobenzene	2,4-Dichlorophenol
	Hexachlorobutadiene	2-Nitrophenol
	N-Nitroso-di-phenylamine	Phenol
	Di-n-octyl-phthalate	Pentachlorophenol
	Fluoranthene	2,4,6-Trichlorophenol
	Benzo(a)pyrene	

SPCCs:	Base/Neutral	Acid
	N-Nitroso-di-n-propylamine	2,4-Dinitrophenol
	Hexachlorocyclopentadiene	4-Nitrophenol

7.3.2 Initial Calibration Verification (ICV) - A second source standard at the 50 µg/mL level is used to check the validity of the curve. The standard recovery for all analytes must be between 75 and 125% (**70-130% for 8270D**). If the second source recovery is above 125% or 130% for 8270D, it is possible that the main standard has deteriorated for that compound. That standard should be remade and reevaluated. If that does not correct the problem, the standard should probably be replaced and a new curve generated. If the second source recovery is below 75% or 70% for 8270D, the second source standard may have deteriorated for that compound. The standard should be remade and reanalyzed. If this does not correct the problem, the standard should probably be replaced. If any compound in the ICV exceeds the criteria above, it may be evaluated and initialed by the organic section manager. If deemed acceptable,

the analyst may continue analysis. Any manual integrations are documented by inclusion of the integrated signals with the quantitation report and chromatogram. All integrations are checked for acceptability. For ICV standard preparation refer to standard log book.

7.4 Continuing Calibration Verification (CCV)- Every 12 hours a CCV at 50 µg/mL must be analyzed and calculated against the initial calibration curve, then shown to meet the calibration check criteria before any sample analysis may be performed. Acceptance criteria for 8270C consists of the same SPCC requirements as the initial calibration. The CCCs must be less than or equal to 20% difference or drift (%D, calculations follow in section 7.9). If any of the CCCs do not meet the above limits, then all required analytes must be <20%D. Internal standard areas should be within 50 to 200 percent of the area of the curve midpoint or the previous CCV. Retention times for the internal standards should be within 30 seconds of the retention time of the curve midpoint or the previous CCV. Method 625 requires a %D of less than 20% for all required analytes. Any manual integrations are documented by inclusion of the integrated signals with the quantitation report and chromatogram. All integrations are checked for acceptability. Samples are then quantitated against the initial calibration curve. Note: If any compound in the continuing calibration not subject to the criteria above exceeds 30%D, it must be evaluated and initialed by the organic section manager. If deemed acceptable, the analyst may continue analysis. **For 8270D, the 20% difference criteria must be applied to all compounds. If the criterion is not met for more than 20% of the compounds included in the initial calibration, then the GC system should undergo maintenance. If this does not solve the problem, then the initial calibration should be repeated. Each of the most common target analytes should meet the minimum response factors listed in Table 4. In situations where the failed compound is present, the data must be flagged as estimated. If the compound fails high in the CCV and is not present, the result can be reported as non-detect.**

7.5 LCS - The LCS is extracted 1 per extraction batch of up to 20 samples. The LCS containing all regular full list calibrated compounds is spiked into deionized water or sodium sulfate for soil using an alternate source or lot number than the calibration standards. See the LCS report forms in the appendix for example laboratory generated limits and the NPDES limits for 625 samples. Recoveries for the MS/MSD spike analytes in LCSs are charted annually to generate control limits for samples analyzed by method 8270C. In all cases, the lowest upper limit would be 100% and the lowest lower limit would be 10%. If enough data points are not present to generate limits, the limits default to CLP spike limits for spike analytes or 10-100% for all other analytes. See Section 8.3 below for corrective action.
When analyzing samples for DOD QSM Version 3, DOD limits will be used.

7.6 Method Blank - Method blanks are extracted at a minimum of 1 per extraction batch up to 20 samples. See Section 8.4 below for criteria and corrective action.

7.7 Samples - Prior to analysis, 1.0 mL samples are prepared by verifying volume and spiking with 20uL of the internal standard solution.

7.8 Instrument sequence-The instrument sequence log is filled out prior to sample analyses.

An example of a typical instrument sequence log follows:

1-DFTPP Tune (12:00 am)
2-CCV
3-LCS
4-Method Blank (or sample)
5-Sample
6-Sample
7-Sample
8-Sample
9-Sample
10-Sample
11-Sample-MS
12-Sample-MSD
13-Sample
14-Sample
15-Sample
16-DFTPP (12:00pm - 12 hours since last DFTPP/CCV)
17-CCV
18-Sample
19-Sample
20-Sample

7.9 Data Reduction/Evaluation - Each sample analysis sequence is documented using the computer run log generated on the chemstation. This run log is signed, dated and paginated then placed in a 3 ring binder for that instrument. After the sample has been analyzed, the data is processed through Target DB on the Windows NT data system. The following must be checked to determine if the sample will need any reanalysis or dilution. Formal data evaluation is detailed in SOP-200 and documented using the Analyst Data Review Checklist (see Appendix). **See SOP-224 for guidance on manual integrations.**

7.9.1 Internal Standards - Areas should be within 50 to 200 percent of the area of the curve midpoint. Retention time should be within 30 seconds of the retention time of the curve midpoint. If not, the sample and historical data should be evaluated to determine the cause of the problem. If matrix effect is confirmed by reextraction/reanalysis or historical data, complete a corrective action report and flag the affected compounds on the final report for matrix effect. Note: criteria applies to the continuing calibration, not samples, but is used as an indication of the sample analysis validity.

7.9.2 Surrogates – Control limits are determined annually by charting LCSs and method blanks. In all cases, the lowest upper limit would be 100% and the lowest lower limit would be 10%. All of the three surrogates for each fraction must be within the control limits in order for the extraction batch to be in control. If a surrogate exceeds the limits, the reason for the malfunction must be determined and a corrective action report must be completed. The sample must be reanalyzed, reextracted or flagged for QC problems. *Federal Register*

Method 625 contains no criteria for surrogate recovery. **When analyzing samples for DOD QSM Version 3, DOD limits will be used.**

Surrogate	Water	Soil/Sediment
Nitrobenzene-d5	30-110	30-110
2-Fluorobiphenyl	35-110	35-110
Terphenyl-d14	55-125	40-120
Phenol-d6	15-110	30-110
2-Fluorophenol	15-110	25-110
2,4,6-Tribromophenol	45-125	30-115

7.9.3 Analyte concentration must be within the range of the calibration curve after rounding to 2 significant figures. If an analyte exceeds the curve, a dilution must be performed and the next sample must be checked for carryover. Any dilution should keep the concentration of the analyte in question within the top half of the curve.

7.9.4 The qualitative identification of compounds is based on retention time and a comparison of the sample mass spectrum, after background subtraction, with characteristic ions in a reference mass spectrum from the NBS database (NBS75K.I). This database is used as it contains relatively uncontaminated mass spectra of each target compound which cannot be obtained from the daily calibrations during each 12 hour analytical period due to overlapping peaks in the mixes. Characteristic ions from the reference mass spectrum library are defined as the three ions of greatest relative intensity, or any ions over 30% relative intensity, if less than three such ions occur in the reference spectrum. In addition, the following criteria must be met. The RRT of the sample analyte must be within 0.06 RRT units of the RRT of the standard analyte. The relative intensities of the characteristic ions must agree within 30% of the relative intensities of the same ions in the reference spectrum. Structural isomers that produce very similar mass spectra should be identified as individual isomers so long as their GC retention times differ substantially. A library search may be made for analytes not associated with the calibration for the purpose of tentative identification. NOTE: The GC/MS analyst uses intelligence guided by experience to make the identifications. In uncontaminated spectra where ions are missing due to low concentration, if the major ions are present in the correct ratios at the correct retention time, the identification will be considered positive. In contaminated spectra, special emphasis will be placed upon higher mass ions, and the major ions will usually need to be present as major components of the spectrum (either unsubtracted or subtracted) for the identification to be positive. All assessments of relative intensities of ions will be made by visual estimates from the spectra.

7.9.5 Quantitation - Once a compound has been identified qualitatively, the concentration must then be quantitated. If the RSD of the compound's response factor is 15%(20% 8270D) or less, then the concentration may be determined using the average response factor ($\overline{RF}$) from the initial calibration data. Otherwise, the concentration must be determined from equations based on internal standard calibration using either linear or non-linear calibration. Calculations follow in Section 7.10.

7.10 Calculations:

7.10.1 The RF is calculated as follows:

$$RF = \frac{A_s \times C_{is}}{A_{is} \times C_s}$$

where:

A_s = Peak area (or height) of the analyte or surrogate.

A_{is} = Peak area (or height) of the internal standard.

C_s = Concentration of the analyte or surrogate.

C_{is} = Concentration of the internal standard.

7.10.2 Calibration verification involves the calculation of the percent drift (linear or quadratic) or the percent difference (average) of the instrument response between the initial calibration and each subsequent analysis of the verification standard. Use the equations below to calculate % Drift or % Difference, depending on the calibration procedure used.

$$\% \text{ Drift} = \frac{(\text{Calculated concentration} - \text{Theoretical concentration}) * 100}{\text{Theoretical Concentration}}$$

where the calculated concentration is determined from the initial calibration and the theoretical concentration is the concentration at which the standard was prepared.

$$\% \text{ Difference} = \frac{(\text{CCV RF} - \text{Average RF}) * 100}{\text{Average RF}}$$

where CCV RF is the response factor from the analysis of the verification standard and Average RF is the average response factor from the initial calibration. The % difference or % drift calculated for the calibration verification standard must be within ±20% for each CCC analyte, or for all target analytes if the CCCs are not target analytes, before any sample analyses may take place. **20% difference for 8270D.**

7.10.3 Concentration in water samples is calculated as follows: [Note: Using the units specified here for these terms will result in a concentration in units of ng/mL, which is equivalent to µg/L.]

$$\text{Concentration } (\mu g/L) = \frac{(A_s)(C_{is})(D)(V_i)}{(A_{is})(\overline{RF})(V_s)(1000)}$$

where:

A_s = Area (or height) of the peak for the analyte in the sample.

A_{is} = Area (or height) of the peak for the internal standard.

C_{is} = Concentration of the internal standard in the volume extracted in ug/L.

D = Dilution factor, if the sample was diluted prior to analysis. If no dilution was made, D = 1. The dilution factor is always dimensionless.

V_i = Volume of the extract injected (µL). The nominal injection volume for samples and calibration standards must be the same.

$\overline{RF}$ = Mean response factor from the initial calibration.

V_s = Volume of the aqueous sample extracted (mL). If units of liters are used for this term, multiply the results by 1000.

The 1000 in the denominator represents the number of µL in 1 mL. If the injection (V_i) is expressed in mL, then the 1000 may be omitted.

7.10.4 Concentration in non-aqueous samples is calculated as follows: [Note: Using the units specified here for these terms will result in a concentration in units of ng/g, which is equivalent to µg/kg.]

7.10.5

$$\text{Concentration } (\mu\text{g/kg}) = \frac{(A_s)(C_{is})(D)(V_i)}{(A_{is})(\overline{RF})(W_s)(1000)}$$

where: A_s,

A_{is}, C_{is}, D, and $\overline{RF}$ are the same as for aqueous samples, and

W_s = Weight of sample extracted (g). Either a dry weight or wet weight may be used, depending upon the specific application of the data. If units of kilograms are used for this term, multiply the results by 1000.

The 1000 in the denominator represents the number of µL in 1 mL. If the injection (V_i) is expressed in mL, then the 1000 may be omitted.

8.0 QUALITY ASSURANCE/QUALITY CONTROL/CORRECTIVE ACTIONS

8.1 Internals - All samples and QC are spiked with internal standards. See section 7.9.1 above for criteria and corrective action.

8.2 Surrogates - All samples and QC are spiked with surrogates. The surrogate recoveries from method blanks and LCS are used to generate control control limits for the surrogates. See section 7.9.2 above for criteria and corrective action. If any surrogate recoveries are below 10%, samples must be re-extracted if sample is available.

8.3 LCS Sample - The LCS is extracted 1 per extraction batch of up to 20 samples. The LCS is spiked using an alternate source or lot number than the calibration standards. If the LCS compound has a recovery above the upper limit, but the same compound is not detected in any of the batch samples, no corrective action is required. For all other situations, the LCS should be reanalyzed for the failed analytes only. If the second analysis fails, all associated samples should be reextracted/reanalyzed for the failed analytes only or the data must be evaluated for flagging due to QC problems.

8.4 Method Blanks - The concentration of all method target analytes should be below the MDL for each method target analyte(**<RL for common lab contaminants and <1/2 RL for other targets for DOD QSM Ver.3 projects**). The first step of corrective

action is to assess the effect on the samples. If an analyte is found only in the method blank, but not in any batch samples, no further corrective action may be necessary. Steps should be taken to find/reduce/eliminate the source of this contamination in the method blank. If an analyte is found in the method blank and some, or all, of the other batch samples, then corrective action is required. The source of contamination must be investigated and appropriate action taken and documented to find/reduce/eliminate the source of this contamination. The method blank, and any samples containing the same contaminant, may need to be reextracted/reanalyzed. For the common laboratory contaminants, meeting the above requirements is not practical. Random cases of contamination are difficult to control, however, daily contamination is not acceptable and corrective action is essential. If a contaminant is found in the method blank and the samples, the compound concentration must be flagged with a 'B' on the final report unless the concentration is greater than 10x that found in the method blank.

8.5 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Sample - 1 in 20 samples are spiked for a MS/MSD (for full list spikes, the full list spiking solution is used). Control limits for the MS/MSD recoveries are the same as those for the LCS found in the appendix. RPD limits are found on the LCS report forms in the appendix. Samples which do not meet these criteria due to matrix must be evaluated for flagging on the final report due to QC problems. Generally, batch control is not based on MS/MSD results unless general method failure is determined to be the problem. In that case, the samples and associated QC would be reanalyzed for the failed analytes only. MS data evaluation must include the consideration of the following factors. **When analyzing samples for DOD QSM Version 3, DOD limits will be used.**

8.5.1 Sample matrix - If the sample is a soil, grab sample or sequentially collected water sample it may affect the %R and RPD of the MS/MSD. Corrective action must be taken in the form of reanalysis if a method problem is indicated.

8.5.2 Original sample concentration - If a spiked compound has a problem and the concentration of that compound in the original sample was two or more times the concentration of the spike, no further corrective action may be necessary other than the generation of a corrective action report to document the problem.

8.5.3 MS vs. MSD - If a spiked compound has a similar problem in both the MS and MSD and is not traced to a method problem, no further action may be necessary other than the generation of a corrective action report to document the problem.

8.5.4 Non-target Interference - The presence of significant non-target interference should be brought to the immediate attention of your supervisor who should discuss the problem with the client/project manager to determine the action to be taken.

8.5.5 Demonstration of Capability (DOC) – Each new analyst must complete a demonstration of capability by analyzing four LCSs with acceptable precision and accuracy. This also must be done when a new instrument is installed or a significant change to the method has been made.

9.0 HEALTH AND SAFETY

9.1 Care should be used in handling all samples. Safety glasses must be worn in the lab at all times. The use of gloves and lab coats is highly recommended.

9.2 Research into expected sample content and concentration should be done in order to be prepared for additional safety considerations. Generally, any samples which need special consideration have applicable notes on the sample logs.

9.3 MSDS sheets are available for all reagents and standards which have been purchased. These are located on the bookshelf outside the office supply storage room.

10.0 WASTE MANAGEMENT AND POLLUTION PREVENTION

10.1 Please see Waste Disposal, SOP-210 and SOP-405 for proper disposal of waste coming from this area within our laboratory.

10.2 Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

11.0 TABLE OF DEFINITIONS, REFERENCES & EXAMPLE FORMS

Definitions and examples of the LCS report sheets (625 water limits, in-house water limits and in-house soil limits), the analyst data review checklist and figure 13 from *Federal Register* method 625 for the tailing factor calculation are located in the appendix. **When analyzing samples for DOD QSM Version 3, DOD limits will be used for surrogates, LCS, and MS/MSD.**

APPENDIX

TABLE OF DEFINITIONS

1. amu- atomic mass unit
2. BNA- Base neutral/acid
3. °C- degrees Centigrade
4. CCC- Calibration Check Compound
5. CCV- Continuing Calibration Verification
6. CLP- Contract Laboratory Program
7. %D- percent difference
8. DFTPP- Difluorotriphenyphosphine
9. EICP- extracted ion current profile
10. EPA- Environmental Protection Agency
11. g- gram or grams
12. GC- Gas Chromatograph
13. GC/MS- Gas Chromatograph/Mass Spectrometer
14. ICV- Initial Calibration Verification
15. I.D.- inner diameter
16. ISTD- internal standard
17. LSC- Laboratory Sample Concentrator
18. MDL- method detection limit
19. MS- Matrix Spike
20. MSD- Matrix Spike Duplicate
21. M.S.- Mass Spectrometer
22. µm- micometer
23. µL- microliter
24. mL- milliliter
25. mm- millimeter
26. ng- nanogram
27. NPDES- National Pollutant Discharge Elimination System
28. P&T- purge and trap
29. QC- quality control
30. %R- percent recovery
31. RPD- relative percent difference
32. RRT- relative retention time
33. %RSD- percent relative standard deviation
34. SOP- Standard Operating Procedure
35. Surr.- surrogate
36. SPCC- System Performance Check Compound
37. TCLP- Toxicity Characteristic Leaching Procedure
38. USACE- United States Army Corps Of Engineers
39. LCS – Lab Control Sample

Refer to SOP-431 for additional definitions

REFERENCES

1. *40 CFR, Part 136*; Appendix A
2. *Test Methods for Evaluating Solid Waste*, SW-846
3. *National Environmental Laboratory Accreditation Conference*; CH. 5, 2003
4. USACE, *EM 200-1-3; Appendix 1; Shell*, 2/2001
5. *DOD Quality Systems Manual for Environmental Laboratories*, Ver.3, 01/2006

FORM 3

WATER SEMIVOLATILE LAB CONTROL SAMPLE (625)

Lab Name: Empirical Laboratories Contract:

Lab Code: NA Batch No.: NA SAS No.: NA SDG No.:

Matrix Spike - Client Sample No.:

COMPOUND	SPIKE ADDED (ug/L)	SAMPLE CONCENTRATION (ug/L)	LCS CONCENTRATION (ug/L)	LCS % REC #	QC. LIMITS REC.
Acenaphthene	100.00	0.0000	100.00	100	47-145
Acenaphthylene	100.00	0.0000	100.00	100	33-145
Anthracene	100.00	0.0000	100.00	100	27-133
Benzidine	100.00	0.0000	100.00	100	D-110
Benzo(a)anthracene	100.00	0.0000	100.00	100	33-143
Benzo(b)fluoranthene	100.00	0.0000	100.00	100	24-159
Benzo(k)fluoranthene	100.00	0.0000	100.00	100	11-162
Benzo(g,h,i)perylene	100.00	0.0000	100.00	100	D-219
Benzo(a)pyrene	100.00	0.0000	100.00	100	17-163
bis(2-Chloroethoxy)meth	100.00	0.0000	100.00	100	33-184
bis(2-Chloroethyl)ether	100.00	0.0000	100.00	100	12-158
bis(2-Chloroisopropyl)e	100.00	0.0000	100.00	100	36-166
Bis(2-ethylhexyl)phthal	100.00	0.0000	100.00	100	8-158
4-Bromophenyl-phenyleth	100.00	0.0000	100.00	100	53-127
Butylbenzylphthalate	100.00	0.0000	100.00	100	D-152
4-Chloro-3-methylphenol	100.00	0.0000	100.00	100	22-147
2-Chloronaphthalene	100.00	0.0000	100.00	100	60-118
2-Chlorophenol	100.00	0.0000	100.00	100	23-134
4-Chlorophenyl-phenylet	100.00	0.0000	100.00	100	25-158
Chrysene	100.00	0.0000	100.00	100	17-168
Dibenz(a,h)anthracene	100.00	0.0000	100.00	100	D-227
1,2-Dichlorobenzene	100.00	0.0000	100.00	100	32-129
1,3-Dichlorobenzene	100.00	0.0000	100.00	100	D-172
1,4-Dichlorobenzene	100.00	0.0000	100.00	100	20-124
3,3'-Dichlorobenzidine	100.00	0.0000	100.00	100	D-262
2,4-Dichlorophenol	100.00	0.0000	100.00	100	39-135
Diethylphthalate	100.00	0.0000	100.00	100	D-114
2,4-Dimethylphenol	100.00	0.0000	100.00	100	32-119

Column to be used to flag recovery and RPD values with an asterisk

* Values outside of QC limits

COMMENTS: _____

FORM 3

WATER SEMIVOLATILE LAB CONTROL SAMPLE (625)

Lab Name: Empirical Laboratories Contract:

Lab Code: NA Batch No.: NA SAS No.: NA SDG No.:

Matrix Spike - Client Sample No.:

COMPOUND	SPIKE ADDED (ug/L)	SAMPLE CONCENTRATION (ug/L)	LCS CONCENTRATION (ug/L)	LCS % REC #	QC. LIMITS REC.
Dimethylphthalate	100.00	0.0000	100.00	100	D-112
Di-n-butylphthalate	100.00	0.0000	100.00	100	1-118
4,6-Dinitro-2-methylphe	100.00	0.0000	100.00	100	D-181
2,4-Dinitrophenol	100.00	0.0000	100.00	100	D-191
2,4-Dinitrotoluene	100.00	0.0000	100.00	100	39-139
2,6-Dinitrotoluene	100.00	0.0000	100.00	100	50-158
Di-n-octylphthalate	100.00	0.0000	100.00	100	4-146
Fluoranthene	100.00	0.0000	100.00	100	26-137
Fluorene	100.00	0.0000	100.00	100	59-121
Hexachlorobenzene	100.00	0.0000	100.00	100	D-152
Hexachlorobutadiene	100.00	0.0000	100.00	100	24-116
Hexachlorocyclopentadie	100.00	0.0000	100.00	100	15- 70
Hexachloroethane	100.00	0.0000	100.00	100	40-113
Indeno(1,2,3-cd)pyrene	100.00	0.0000	100.00	100	D-171
Isophorone	100.00	0.0000	100.00	100	21-196
Naphthalene	100.00	0.0000	100.00	100	21-133
Nitrobenzene	100.00	0.0000	100.00	100	35-180
2-Nitrophenol	100.00	0.0000	100.00	100	29-182
4-Nitrophenol	100.00	0.0000	100.00	100	D-132
N-Nitroso-di-methylamin	100.00	0.0000	100.00	100	29- 66
N-Nitrosodiphenylamine	100.00	0.0000	100.00	100	23-100
N-Nitroso-di-n-propylam	100.00	0.0000	100.00	100	D-230
Pentachlorophenol	100.00	0.0000	100.00	100	14-176
Phenanthrene	100.00	0.0000	100.00	100	54-120
Phenol	100.00	0.0000	100.00	100	5-112
Pyrene	100.00	0.0000	100.00	100	52-115
1,2,4-Trichlorobenzene	100.00	0.0000	100.00	100	44-142
2,4,6-Trichlorophenol	100.00	0.0000	100.00	100	37-144

Column to be used to flag recovery and RPD values with an asterisk

* Values outside of QC limits

RPD: 0 out of 0 outside limits
Spike Recovery: 0 out of 56 outside limits

COMMENTS: _____

FORM 3

WATER SEMIVOLATILE LAB CONTROL SAMPLE (In-House)

Lab Name: Empirical Laboratories Contract:

Lab Code: NA Batch No.: NA SAS No.: NA SDG No.:

Matrix Spike - Client Sample No.:

COMPOUND	SPIKE ADDED (ug/L)	SAMPLE CONCENTRATION (ug/L)	LCS CONCENTRATION (ug/L)	LCS % REC #	QC. LIMITS REC.
Acenaphthene	100.0	0.0000	100.00	100	40-112
4-Chloro-3-methylphenol	200.0	0.0000	200.00	100	32-110
2-Chlorophenol	200.0	0.0000	200.00	100	29-110
1,4-Dichlorobenzene	100.0	0.0000	100.00	100	26-110
2,4-Dinitrotoluene	100.0	0.0000	100.00	100	46-122
4-Nitrophenol	200.0	0.0000	200.00	100	21-110
N-Nitroso-di-n-prop.(1)	100.0	0.0000	100.00	100	39-110
Pentachlorophenol	200.0	0.0000	200.00	100	32-133
Phenol	200.0	0.0000	200.00	100	10-110
Pyrene	100.0	0.0000	100.00	100	51-137
1,2,4-Trichlorobenzene	100.0	0.0000	100.00	100	28-110

COMPOUND	SPIKE ADDED (UG/L)	MSD CONCENTRATION (UG/L)	MSD % REC #	% RPD #	QC LIMITS RPD	QC LIMITS REC.
Acenaphthene	100.0	100.00	100	0	31	40-112
4-Chloro-3-methylphenol	200.0	200.00	100	0	42	32-110
2-Chlorophenol	200.0	200.00	100	0	40	29-110
1,4-Dichlorobenzene	100.0	100.00	100	0	28	31-110
2,4-Dinitrotoluene	100.0	100.00	100	0	38	46-122
4-Nitrophenol	200.0	200.00	100	0	50	21-110
N-Nitroso-di-n-prop.(1)	100.0	100.00	100	0	38	39-110
Pentachlorophenol	200.0	200.00	100	0	50	32-133
Phenol	200.0	200.00	100	0	42	10-110
Pyrene	100.0	100.00	100	0	31	51-137
1,2,4-Trichlorobenzene	100.0	100.00	100	0	28	28-110

(1) N-Nitroso-di-n-propylamine
Column to be used to flag recovery and RPD values with an asterisk
* Values outside of QC limits

RPD: 0 out of 11 outside limits
Spike Recovery: 0 out of 22 outside limits

COMMENTS: _____

FORM 3

SOIL SEMIVOLATILE LAB CONTROL SAMPLE (In-House)

Lab Name: Empirical Laboratories Contract:

Lab Code: ELABN Case No.: NA SAS No.: NA SDG No.:

Matrix Spike - Client Sample No.: Level:(low/med) LOW

COMPOUND	SPIKE ADDED (ug/Kg)	SAMPLE CONCENTRATION (ug/Kg)	LCS CONCENTRATION (ug/Kg)	LCS % REC #	QC. LIMITS REC.
Acenaphthene	10000	0.0000	10000	100	27-116
4-Chloro-3-methylphenol	20000	0.0000	20000	100	18-111
2-Chlorophenol	20000	0.0000	20000	100	10-110
1,4-Dichlorobenzene	10000	0.0000	10000	100	14-110
2,4-Dinitrotoluene	10000	0.0000	10000	100	34-110
4-Nitrophenol	20000	0.0000	20000	100	24-120
N-Nitroso-di-n-prop.(1)	10000	0.0000	10000	100	24-112
Pentachlorophenol	20000	0.0000	20000	100	10-114
Phenol	20000	0.0000	20000	100	10-110
Pyrene	10000	0.0000	10000	100	33-150
1,2,4-Trichlorobenzene	10000	0.0000	10000	100	19-110

COMPOUND	SPIKE ADDED (ug/Kg)	LCSD CONCENTRATION (ug/Kg)	LCSD % REC #	% RPD #	QC LIMITS RPD	QC LIMITS REC.
Acenaphthene	10000	10000	100	0	19	27-116
4-Chloro-3-methylphenol	20000	20000	100	0	42	18-111
2-Chlorophenol	20000	20000	100	0	50	10-110
1,4-Dichlorobenzene	10000	10000	100	0	27	14-110
2,4-Dinitrotoluene	10000	10000	100	0	47	34-110
4-Nitrophenol	20000	20000	100	0	50	24-120
N-Nitroso-di-n-prop.(1)	10000	10000	100	0	38	24-112
Pentachlorophenol	20000	20000	100	0	47	40-110
Phenol	20000	20000	100	0	35	10-110
Pyrene	10000	10000	100	0	36	33-150
1,2,4-Trichlorobenzene	10000	10000	100	0	23	19-110

(1) N-Nitroso-di-n-propylamine
Column to be used to flag recovery and RPD values with an asterisk
* Values outside of QC limits
RPD: 0 out of 11 outside limits
Spike Recovery: 0 out of 22 outside limits

COMMENTS: _____

BNA STANDARDS USED

base/neutral mix (2000ppm)		**acids mix (2000ppm)**
bis(2-Chloroethyl)ether		2,4-Dinitrophenol
bis(2-Chloroisopropyl)ether		2-Methylphenol
1,3-Dichlorobenzene		4-Methylphenol
1,2-Dichlorobenzene		Benzoic acid
1,4-Dichlorobenzene		4,6-Dinitro-2-methylphenol
Hexachloroethane		4-Nitrophenol
N-Nitroso-di-methylamine		2,4,5-Trichlorophenol
N-Nitroso-di-n-propylamine		2,4,6-Trichlorophenol
2,4-Dinitrotoluene		Phenol
2,6-Dinitrotoluene		Pentachlorophenol
Fluorene		2-Nitrophenol
Dimethylphthalate		4-Chloro-3-methylphenol
Hexachlorocyclopentadiene		2,4-Dichlorophenol
Anthracene		2,4-Dimethylphenol
4-Bromophenyl-phenylether		Benzoic acid
Di-n-butylphthalate		
bis(2-Chloroethoxy)methane		
1,2-Diphenylhydrazine		**semivoa misc.mix(2000ppm)**
Fluoranthene		Aniline
Hexachlorobenzene		Benzyl alcohol
N-Nitrosodiphenylamine		Carbazole
Phenanthrene		4-Chloroaniline
Hexachlorobutadiene		Dibenzofuran
Isophorone		2-Methylnaphthalene
Naphthalene		2-Nitroaniline
Nitrobenzene		3-Nitroaniline
1,2,4-Trichlorobenzene		4-Nitroaniline
Acenaphthene		Pyridine
Acenaphthylene		
2-Chloronaphthalene		
4-Chlorophenyl-phenylether		**Benzidine mix (2000ppm)**
Diethylphthalate		Benzidine
Benzo(a)anthracene		3,3'-Dichlorobenzidine
Bis(2-ethylhexyl)phthalate		
Butylbenzylphthalate		
Chrysene		**individual mixes (10,000ppm)**
p-(Dimethylamino)azobenzene		Caprolactam
Pyrene		Benzaldehyde
Benzo(b)fluoranthene		Atrazine
Benzo(k)fluoranthene		1,1'-Biphenyl
Benzo(g,h,i)perylene		Catechol
Benzo(a)pyrene		
Dibenz(a,h)anthracene		
Di-n-octylphthalate		
Indeno(1,2,3-cd)pyrene		

INTERNAL STANDARD ASSOCIATION / QUANT ION TABLE					
COMPOUND	***I.S**	**Q.M**	**COMPOUND**	***I.S**	**Q.M**
1,4-Dichlorobenzene-d4 **(I.S)(1)**		152	Dimethylphthalate	59	163
Acetophenone	1	105	Hexachlorocyclopentadiene	59	237
Aniline	1	93	2,4-Dinitrophenol	59	184
Benzaldehyde	1	106	2,4-Dinitrotoluene	59	165
Benzyl alcohol	1	108	2,6-Dinitrotoluene	59	165
bis(2-Chloroethyl)ether	1	93	Fluorene	59	166
bis(2-Chloroisopropyl)ether	1	45	2-Nitroaniline	59	65
1,3-Dichlorobenzene	1	146	3-Nitroaniline	59	138
1,2-Dichlorobenzene	1	146	4-Nitroaniline	59	138
1,4-Dichlorobenzene	1	146	4-Nitrophenol	59	65
2-Methylphenol	1	108	2,4,5-Trichlorophenol	59	196
4-Methylphenol	1	108	2,4,6-Trichlorophenol	59	196
3-Methylphenol	1	108	2-Fluorobiphenyl (S)	59	172
Phenol	1	94	Phenanthrene-d10 **(I.S) (79)**		188
Pyridine	1	79	Anthracene	79	178
Hexachloroethane	1	117	Atrazine	79	200
N-Nitroso-di-methylamine	1	42	4-Bromophenyl-phenylether	79	248
N-Nitroso-di-n-propylamine	1	70	Carbazole	79	167
2-Fluorophenol (S)	1	112	Di-n-butylphthalate	79	149
Phenol-d6 (S)	1	99	4,6-Dinitro-2-methylphenol	79	198
Naphthalene-d8 **(I.S)(35)**		136	1,2-Diphenylhydrazine	79	77
Benzoic acid	35	105	Fluoranthene	79	202
bis(2-Chloroethoxy)methane	35	93	Hexachlorobenzene	79	284
Caprolactam	35	113	N-Nitrosodiphenylamine	79	169
4-Chloroaniline	35	127	Pentachlorophenol	79	266
4-Chloro-3-methylphenol	35	107	Phenanthrene	79	178
2,4-Dichlorophenol	35	162	2,4,6-Tribromophenol (S)	79	330
2,4-Dimethylphenol	35	107	Chrysene-d12 **(I.S) (92)**		240
Hexachlorobutadiene	35	225	Benzidine	92	184
Isophorone	35	82	Benzo(a)anthracene	92	228
2-Methylnaphthalene	35	141	Bis(2-ethylhexyl)phthalate	92	149
Naphthalene	35	128	Butylbenzylphthalate	92	149
Nitrobenzene	35	77	Chrysene	92	228
2-Nitrophenol	35	139	3,3'-Dichlorobenzidine	92	252
1,2,4-Trichlorobenzene	35	180	p-(Dimethylamino)azobenzene	92	225
Catechol	35	110	Pyrene	92	202
Nitrobenzene-d5 (S)	35	82	Terphenyl-d14 (S)	92	244
Acenaphthene-d10 **(I.S) (59)**		164	Perylene-d12 **(I.S) (101)**		264
Acenaphthene	59	153	Benzo(b)fluoranthene	101	252
Acenaphthylene	59	152	Benzo(k)fluoranthene	101	252
1,1'-Biphenyl	59	154	Benzo(g,h,i)perylene	101	276
2-Chloronaphthalene	59	162	Benzo(a)pyrene	101	252
4-Chlorophenyl-phenylether	59	204	Dibenz(a,h)anthracene	101	278

Dibenzofuran	59	168	Di-n-octylphthalate	101	149
Diethylphthalate	59	149	Indeno(1,2,3-cd)pyrene	101	276
I.S=internal standard, Q.M=quant mass, S=surrogate					

INTERNAL STANDARD ASSOCIATION / QUANT ION TABLE					
COMPOUND	***I.S**	**Q.M**	**COMPOUND**	***I.S**	**Q.M**
1,4-Dichlorobenzene-d4 **(I.S)(1)**		152	Diphenylamine	59	169
Pentachloroethane	1	167	Thionazin	59	107
2-Picoline	1	93		59	
N-Nitrosomethylethylamine	1	88		59	
Methyl methanesulfonate	1	80		59	
N-Nitrosodiethylamine	1	102		59	
Ethyl methanesulfonate	1	79		59	
N-Nitrosopyrrolodine	1	100		59	
N-Nitrosomorpholine	1	56		59	
0-Toluidine	1	106		59	
	1			59	
	1			59	
	1			59	
	1		Phenanthrene-d10 **(I.S) (79)**		188
	1		4-Nitroquinoline-1-oxide	79	190
	1		Phenacetin	79	108
	1		4-Aminobiphenyl	79	169
	1		Pentachloronitrobenzene	79	237
	1		Sulfotepp	79	97
	1		Phorate	79	75
Naphthalene-d8 **(I.S)(35)**		136	Diallate	79	86
1- Methylnaphthalene	35	141	Dimethoate	79	87
N-Nitrosopiperidine	35	114	Pronamide	79	173
a,a-Dimethylphenethylamine	35	58	Disulfoton	79	88
O,O,O-Triethylphosphorothioate	35	97	Dinoseb	79	211
Hexachloropropene	35	213		79	
2,6-Dichlorophenol	35	162		79	
p-Phenylenediamine	35	108	Chrysene-d12 **(I.S) (92)**		240
N-Nitrosodi-n-butylamine	35	84	Methapyrilene	92	97
Safrole	35	162	p-(Dimethylamino)azobenzene	92	225
1,2,4,5-Tetrachlorobenzene	35	216	Chlorobenzilate	92	251
	35		3,3'- Dimethylbenzidine	92	212
	35		2- Acetylaminofluorene	92	181
	35		7,12-Dimethylbenz[a]anthracene	92	256
	35		Aramite	92	185
	35		Methyl parathion	92	109
	35		Parathion	92	109
Acenaphthene-d10 **(I.S) (59)**		164	Isodrin	92	193
Isosafrole	59	162	Kepone	92	272
1,4-Naphthoquinone	59	158	Famphur	92	218
Pentachlorobenzene	59	250	Perylene-d12 **(I.S) (101)**	101	
2-Naphthylamine	59	143	3-Methylcholanthrene	101	268
1-Naphthylamine	59	143	Hexachlorophene	101	196
2,3,4,6-Tetrachlorophenol	59	232		101	
5-Nitro-o-toluidine	59	152		101	

I.S=internal standard, Q.M=quant mass, S=surrogate

Internal Standards & Surrogates

BNA internals (2000ppm)		**Acid surrogate (7500ppm)**
1,4-Dichlorobenzene-d4 **(I.S)(1)**		2-Fluorophenol (S)
Naphthalene-d8 **(I.S)(35)**		Phenol-d6 (S)
Acenaphthene-d10 **(I.S) (59)**		2,4,6-Tribromophenol (S)
Phenanthrene-d10 **(I.S) (79)**		**2,-Chlorophenol-d4 (S)**
Chrysene-d12 **(I.S) (92)**		
Perylene-d12 **(I.S) (101)**		**BN surrogate (5000ppm)**
		Nitrobenzene-d5 (S)
		Terphenyl-d14 (S)
		2-Fluorobiphenyl (S)
		1,2-Dichlorobenzene-d4 (S)

Reporting Limits

	Soil ug/KG	Water ug/L		Soil ug/KG	Water ug/L
Pyridine	330	5.0	**Acenaphthylene**	330	5.0
N-Nitroso-di-methylamine	330	5.0	**2,6-Dinitrotoluene**	330	5.0
Aniline	330	5.0	**3-Nitroaniline**	1300	20
Phenol	330	5.0	**Acenaphthene**	330	5.0
bis(2-Chloroethyl)ether	330	5.0	**2,4-Dinitrophenol**	3300	50
2-Chlorophenol	330	5.0	**4-Nitrophenol**	1300	20
1,3-Dichlorobenzene	330	5.0	**Dibenzofuran**	330	5.0
1,4-Dichlorobenzene	330	5.0	**2,4-Dinitrotoluene**	330	5.0
Benzyl alcohol	330	5.0	**Diethylphthalate**	330	5.0
1,2-Dichlorobenzene	330	5.0	**4-Chlorophenyl-phenylether**	330	5.0
2-Methylphenol	330	5.0	**Fluorene**	330	5.0
bis(2-Chloroisopropyl)ether	330	5.0	**4-Nitroaniline**	1300	20
3-Methylphenol	330	5.0	**2,3,4,6-Tetrachlorophenol**	330	5.0
4-Methylphenol	330	5.0	**1,1'-Biphenyl**	330	5.0
N-Nitroso-di-n-propylamine	330	5.0	**1,2-Diphenylhydrazine**	330	5.0
Hexachloroethane	330	5.0	**Carbazole**	330	5.0
Benzaldehyde	330	5.0	**4,6-Dinitro-2-methyl phenol**	1300	20
Nitrobenzene	330	5.0	**N-Nitrosodiphenylamine**	330	5.0
Isophorone	330	5.0	**4-Bromophenyl-phenylether**	330	5.0
2-Nitrophenol	330	5.0	**Hexachlorobenzene**	330	5.0
2,4-Dimethylphenol	1300	20	**Pentachlorophenol**	1300	20
Benzoic acid	3300	50	**Phenanthrene**	330	5.0
bis(2-Chloroethoxy)methane	330	5.0	**Anthracene**	330	5.0
2,4-Dichlorophenol	330	5.0	**Di-n-butylphthalate**	330	5.0
1,2,4-Trichlorobenzene	330	5.0	**Fluoranthene**	330	5.0
Naphthalene	330	5.0	**Atrazine**	330	5.0
4-Chloroaniline	330	5.0	**Benzidine**	3300	50
Hexachlorobutadiene	330	5.0	**Pyrene**	330	5.0
4-Chloro-3-methylphenol	330	5.0	**Butylbenzylphthalate**	330	5.0
2-Methylnaphthalene	330	5.0	**3,3'-Dichlorobenzidine**	330	5.0
1-Methylnaphthalene	330	5.0	**Benzo(a)anthracene**	330	5.0
Acetophenone	330	5.0	**Chrysene**	330	5.0
1,2,4,5-Tetrachlorobenzene	330	5.0	**Bis(2-ethylhexyl)phthalate**	330	5.0
Caprolactam	330	5.0	**Di-n-octylphthalate**	330	5.0
Hexachlorocyclopentadiene	330	5.0	**Benzo(b)fluoranthene**	330	5.0
2,4,6-Trichlorophenol	330	5.0	**Benzo(k)fluoranthene**	330	5.0
2,4,5-Trichlorophenol	330	5.0	**Benzo(a)pyrene**	330	5.0
2-Chloronaphthalene	330	5.0	**Indeno(1,2,3-cd)pyrene**	330	5.0
2-Nitroaniline	1300	20	**Dibenz(a,h)anthracene**	330	5.0
Dimethylphthalate	330	5.0	**Benzo(g,h,i)perylene**	330	5.0

ANALYST DATA REVIEW CHECKLIST

Sample Number(s):	
Batch Number(s):	
Method:	**8260B/8270C/8270D (Circle One)**

QA/QC Item	Yes	No	NA	Second Level Review
1. Is the BFB/DFTPP tune performed every 12 hours and is the tuning criteria met?				
2. Are the RRFs and % RSDs within QC limits for appropriate analytes for the initial calibration? Check the retention times for compounds with the same spectra. Check compounds with different conc.(eg. m/p-xylene, ketones,etc.).				
3. Was the initial calibration curve verified by a second source calibration standard (ICV) and have criteria been met?				
4. Does the Continuing Calibration Standard (CCV) meet the criteria for the CCCs and SPCCs.				
5. Is the Method Blank run at the desired frequency and is its concentration for target analytes less than the MDLs?				
6. Are the LCS, MS, MSD within control limits and run at the desired frequency?				
7. Are all sample holding times met, analytes within calibration range, IS areas and surrogate recoveries within QC limits?				
8. Was the Method Blank, LCS, MS, MSD and samples loaded to the GCMS_LFSYS Tablespace within the Target DB Database?				

Comments on any "No" response:

Primary-Level Review: _____ Date: _____

Second-Level Review: _____ Date: _____

GAS CHROMATOGRAPHY/ELECTRON CAPTURE DETECTOR (GC/ECD)

ORGANOCHLORINE PESTICIDES/POLYCHLORINATED BIPHENYLS (PCB) BY

EPA METHOD 608/608.2 AND

SW846 METHOD 8081A, 8081B/8082, 8082A

SOP NUMBER: SOP-211

REVISION NUMBER: 20

APPROVED BY:

SECTION MANAGER

QUALITY ASSURANCE OFFICER

EFFECTIVE DATE: 04/27/09

Date of Last Review: 04/27/09

GAS CHROMATOGRAPHY/ELECTRON CAPTURE DETECTOR (GC/ECD) ORGANOCHLORINE PESTICIDES/POLYCHLORINATED BIPHENYLS (PCB) BY EPA METHOD 608/608.2 AND SW-846 METHOD 8081A, 8081B/8082, 8082A

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure, SOP, (based primarily on SW-846 Methods 8000B/8081A/8082) is used for the analysis of Pesticide/PCB organic compounds in a variety of matrices (soils, sediments, waters, etc.). Methods SW-846 8082, *Federal Register* Method 608/608.2 and CLP Method for Pesticides have also been used in the development of this SOP. The analyses by these various methods are clearly defined in the respective regulatory manuals. A good understanding of these different methods is essential to the performance of each method. The normal laboratory list of analytes with their LCS limits is found attached in the appendix. Other compounds may be analyzed by this SOP as detailed in section 1.0 of SW-846 Methods 8081A, 8081B/8082, 8082A. Any questions left by this SOP should be answered by reading the methods, paying close attention to SW-846 8000B/8081A, 8081B/8082, 8082A, EPA 608/608.2 and CLP. If questions still remain unanswered, check with the Organic Lab Manager, Quality Assurance Officer and/or Technical Director.

2.0 METHOD SUMMARY

After sample preparation using the appropriate extraction technique, the sample is introduced into the GC using direct injection. The analytes are separated in the gas chromatograph by a combination of the temperature program and the capillary column. The analytes are then detected by the ECD. Pesticide analytes are identified and confirmed based on the retention time of known standards. PCB and multi-component pesticide analytes are identified based on pattern recognition. Analytes are quantitated relative to known standards using the external standard method.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Section 3.0 and tables 3-1 and 3-2 of the Empirical Laboratories, LLC Quality Assurance Manual includes details concerning sample preservation, containers and handling of samples and extracts. All water and soil samples are stored in the appropriate walk-in cooler in sample storage at a temperature of 1°C – 4.4°C. All extracts are stored in the Hobart in Semivolatile laboratory at a temperature of 1°C – 4.4°C. Water samples have a holding time of 7 days from date of sampling to extraction. Soil samples have a holding time of 14 days from date of sampling to extraction (unless otherwise specified for the project). Extracts have a holding time of 40 days from extraction to analysis.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Section 3.0 of SW-846 Methods 8081A/8082 and Section 4.0 of Methods 8081B/8082A details interferences and potential problems which may be encountered when dealing with pesticide/PCB analyses. Please see sample clean-up SOPs (307, 308, 309, 330, and 334) to evaluate possible clean-up options for any encountered interferences.

5.0. EQUIPMENT AND APPARATUS

5.1 GC's:

5.1.1 Agilent 6890N- complete with temperature programmable gas chromatograph suitable for split/splitless injection.

5.2 Columns:

5.2.1 RTX-CLP (or equivalent): 30 meter x 0.32 mm ID x 0.5 µm film thickness fused silica column.

5.2.2 RTX-CLP II (or equivalent): 30 meters x 0.32 mm ID x 0.5 µm film thickness fused silica column.

5.3 Autosamplers:

5.3.1 Agilent 7683 autosamplers capable of reproducibility from one injection to another, proven by meeting QC and calibration criteria.

5.4 Acquisition Software: HP Chemstation system is interfaced to the GC. The system acquires and stores data throughout the chromatographic program.

5.5 Data Processing Software: Target DB Windows NT data system is interfaced to the HP Chemstation. The system accepts, processes and stores acquired data.

6.0 REAGENTS

6.1 Hexane - pesticide quality or equivalent.

6.2 Stock standards are purchased in mixtures from reputable vendors. The date they are received is noted on the label and recorded in the GC standards logbook. The date they are opened is noted on the label and recorded in the GC standards logbook along with their lot number and vendor and given a sequential number. Each standard that is prepared is recorded in the GC standards logbook and given a sequential number. The following are noted in the logbook: standard makeup, solvent used, date received, date opened, date prepared, expiration date and analyst. Each standard label is completed with the standard number, name, preparation date, expiration date, solvent and analyst initials. All stocks and standards are stored in the refrigerator at a temperature of 1°C-4.4°C from the date they are received/prepared. The refrigerator and freezer temperature is monitored daily with an annually calibrated thermometer and recorded with calibration correction in the GC refrigerator temperature logbook. See the GC standards log book for makeup of intermediate and calibration standards.

6.2.1 The Initial Calibration Verification (ICV) intermediate standard is prepared from the vendor stock standards in the same manner as the Calibration intermediate standards above and is stored in the refrigerator at a temperature of 1°C-4.4°C for up to 6 months. The ICV standard is then prepared at a concentration near the midpoint in the same manner as the Calibration standards above.

7.0 PROCEDURE

The GC/ECD should be primed by injecting a pesticide standard at 100 µg/L and/or PCB standard at 10,000 µg/L, 10 times more concentrated than the mid-level standard. Inject this prior to beginning initial or daily calibration.

7.1 Chromatographic conditions:

7.1.1 ZB MR1/MR2 columns:

GC	ECD3
Purge on	0.50 min.
Injector/Detector temperature	250/350°C
Column flow	@3.4 mL/min
Initial column temperature	100°C for 0.5 minutes
Temperature ramp	15°C/min
Intermediate column temperature	220°C for 5.0 minutes
Second Temperature Ramp	35°C/min
Final Column Temperature	340°C for 2.0 minutes

7.1.2 RTX-CLP/RTX CLPII columns:

GC	ECD4
Purge on	0.50 min.
Injector/Detector temperature	200/330°C
Column flow	@2.4 mL/min
Initial column temperature	110°C for 0.5 minutes
Temperature ramp	15°C/min
Final column temperature	320°C for 2.0 minutes

7.2 Eval Mix – Before pesticide calibration and/or sample analysis, a degradation check standard (evaluation mix) of endrin and 4,4-DDT must be injected. Degradation of either compound must not exceed 15 percent. If 15 percent degradation is exceeded, then corrective action must be taken (GC system maintenance, see SOP-222).

7.3 Calibration - (See SW-846 Method 8000B Section 7.4.2).

7.3.1 Initial Calibration – For single component pesticides and surrogates, a six point calibration is injected and analyzed for each analyte of interest. For Toxaphene and Technical Chlordane a single point standard is analyzed unless they are expected then a five point calibration is injected and analyzed. Injection volume for standards and samples is equal to 2 µL using the same injection technique to introduce both standards and samples (use of auto-injectors makes this a constant). All calibration integrations must be evaluated and any manual integrations are documented by the inclusion of the chromatogram (which includes peak integrations) with the quantitation report. The percent relative standard deviation (RSD) of the calibration factor must be <20% over the working range for each analyte of interest. When the 20% criteria is exceeded for an analyte, a linear calibration may be used if the correlation coefficient (r) is $\geq$0.995, $\geq$0.99 for quadratic with 6 points. Otherwise, a new standard curve should be prepared for each analyte that exceeded the criteria.

Initial calibration for Aroclors may be accomplished by using a six-point curve that contains Aroclors 1016 and 1260. The mixture of these two Aroclors contains many of the peaks represented in the other five Aroclor mixtures(1221, 1232, 1242, 1248 & 1254). The curves for Aroclors 1016 and 1260 are used to show the linearity of the detector and can be used to demonstrate that a sample does not contain peaks that represent any one of the Aroclors. The 1016/1260 curve may also be used to quantitate any 1016 or 1260 hits that may be seen in the samples. The analyst has the choice of running a curve for the other five Aroclor mixtures or when the calibration factor for the

curve for 1016/1260 is <20% a single point calibration at the midpoint level concentration can be used for the other Aroclors. The injection procedure for Aroclors is the same as single component pesticides. The percent relative standard deviation (RSD) of the calibration factor must be <20% but this applies to the average of the quantitation peaks. When the 20% criteria is exceeded for an analyte, a linear calibration may be used if the correlation coefficient factor (r) is ≥0.995, ≥0.99 for quadratic with 6 points. Otherwise, a new standard curve should be prepared for each analyte that exceeded the criteria.

7.3.2 Initial Calibration Verification - A second source standard at the midpoint level is used to check the validity of the curve. The standard recovery for all analytes must be between 85 and 115%(**80-120% DOD QSM and 8081B/8082A**). If the second source recovery is above 115%, it is possible that the main standard has deteriorated for that compound. That standard should be remade and reevaluated. If that does not correct the problem, the standard should probably be replaced and a new curve generated. If the second source recovery is below 85%, the second source standard may have deteriorated for that compound. This standard should be remade and reanalyzed. If this does not correct the problem, the standard should be replaced. All calibration integrations must be evaluated and any manual integrations are documented by the inclusion of the chromatogram (which includes peak integrations) with the quantitation report.

7.3.3 Continuing Calibration Verification (CCV) - A mid-level standard must be analyzed every 12 hours (not to exceed 20 samples and cannot exceed 15 percent difference (%D), (**at the beginning and end of sequence and after every 10 field samples, 20%D no average DOD QSM and 8081B/8082A**) from the average calibration factor of the calibration curve. A CCV must also be analyzed at the end of the analysis sequence. If a CCV fails, GC maintenance may be necessary (see SOP-222), reanalysis may be required (for samples analyzed since the last valid CCV) and a corrective action report must be completed. If none of the failed target compounds exceed 30% D and the average of all the %Ds are < 15% then the CCV may be used without any further corrective action. Alternatively, analytes may be flagged depending on their concentration and the status of the analyte in the mid-level standard. No reanalysis is necessary if the analyte is undetected in the samples and recovered high in the CCV. All calibration integrations must be evaluated and any manual integrations are documented by the inclusion of the chromatogram (which includes peak integrations) with the quantitation report. Samples are then quantitated against the initial calibration curve.

7.4 RT Windows - Retention time criteria set forth in SW-846 method 8000B section 7.6 are used to set retention time windows. New in-house retention time windows are established after every major change to the system (new column or temperature program) and at initial calibration using the midpoint standard RTs. If the established retention time window is less than +/-0.03 minutes, the window defaults to +/-0.03 minutes. Retention times are updated with the first CCV of the day or the mid-level standard of the curve if samples are analyzed directly after a curve.

7.5 Laboratory Control Sample (LCS) - The LCS is extracted 1 per extraction batch of up to 20 samples. The LCS is spiked with standards prepared from an alternate vendor or lot number than the calibration standards. See section 8.2 below for criteria and corrective action.

7.6 Method Blank - Method blanks are extracted at a minimum of 1 per extraction batch – up to 20 samples. See section 9.3 below for criteria and corrective action.

7.7 Samples - Prior to using Method 608, SW-846 8081A, 8081B/8082, 8082A or CLP (pesticide method) the samples are prepared for chromatography using the appropriate sample preparation and clean up methods (generally SW-846 methods 3510, 3541, 3640, 3550, 3580, EPA method 608 or CLP).

7.7.1 Example of a sequence run log:

1-Primer A/B Mix-1000 or Primer PCB-10,000
2- EVAL Mix (Pest only)
3- CCV A/B Mix
4- CCV Toxaphene (single point)
5-CCV Chlordane (single point)
6- CCV PCB 1660
7- Method Blank
8-LCS A/B Mix
9-LCS PCB
10-Sample
11-Sample
12-Sample
13-Sample
14-Sample
15-Sample
16-Sample
17-Sample
18-Sample
19-Sample
20-Sample
21-Sample-MS
22-Sample-MSD
23-Sample
24-Sample
25-Sample
26-Sample
27-Sample
28-Sample
29- CCV A/B Mix
30-CCV PCB

7.8 Data Reduction/Evaluation - Each sample analysis sequence is documented in the run logbook for the instrument. After the sample has been analyzed, the data is processed through the Target DB Windows NT data system. Quantitative measurements are performed as described in SW-846 8081A section 7.5.6, and section 11.5.6.1 8081B. Rounding is performed using CLP

odd/even rounding rules. The following must be checked to determine if the sample will need any reanalysis, cleaning or dilution. Formal data evaluation is detailed in SOP-216 (documented using the USACE Analyst Data Review Checklist for USACE projects).

7.8.1 Analyte concentration after rounding to 2 significant figures must be within the range of the calibration curve. If an analyte exceeds the curve, a dilution must be performed and the next sample must be checked for carryover. Any dilution should keep the concentration of the analyte in question within the mid-range to the top half of the curve.

7.8.2 If the sample shows signs of sulfur contamination in the time range where sulfur compounds elute a sulfur cleanup is required [see SOP-307].

7.8.3 If the sample has extraneous peaks eluting in the chromatogram an acid cleanup is required for PCB samples and may be applicable for certain pesticides, (acid clean-up may be required for all PCB samples, check with your supervisor), [see SOP-308].

7.8.4 If the sample has extraneous peaks that are not removed by acid (PCB samples) and is not a sulfur interference, a florisil cleanup is recommended [see SOP-309]. A silica cleanup may also be used [see SOP-331].

7.8.5 Surrogates – Control and warning limits are determined by using all blank spikes in the calculation, (LCSs and method blanks). All limits used are generated in-house or client specified (with the exception that if the in-house limit's highest lower limit would be 90 and the lowest upper limit would be 110 examples: **98**-120 would be **90**-120 or 45-**75** would be 45-**110**). Surrogate standard recovery must be checked to determine if it is within these limits. Two surrogates are added to each sample for pesticides. Only one surrogate, DCB, is added to each PCB sample. Corrective action should be evaluated when any surrogate(s) is outside the action limits for a sample. When only one surrogate for pesticides exceed control limits on the primary and/or confirmation column corrective action may not be required. If both surrogates for pesticides (or DCB for PCB analyses) exceed control limits on the primary and/or confirmation column corrective action is required. A corrective action form should be filled out and given to the organic lab manager when both surrogates for pesticides (or DCB for PCB analyses) are outside the action or warning limits. The organic lab manager will then make suggestions as to what action should be taken, for example: the sample may need to be reanalyzed, reextracted, or flagged on the report for a QC problem. **DOD limits will be used for DOD QSM projects.**

	WATER	SOIL/SEDIMENT	WIPES
Surrogate	In-House	In-House	In-House
TCMX	25-120	30-120	80-143
DCB	25-130	35-140	73-142

7.9 Identification/Quantitation [See SW-846 method 8081A section 7.6 or method 8082 sections 7.7-7.9].

7.9.1 Single peak components are identified by retention time on a primary column

with confirmation by retention time on a secondary or confirmation column. Which column is used for primary/confirmation is determined by the chromatography in the region of the compound. The control limit for percent difference (%D) of compounds that confirmed from the primary column on the confirmation column is 40%. If both columns are equivalent, the highest concentration is reported. If a compound result is >40% difference, it should be flagged with a "P". (**"J" flagged for DOD QSM projects**)

7.9.1.1 Due to coelution of certain compounds confirmation for all analytes may not be achieved. The analyst must use experience and judgment to decide if the compound is there. If a call is made, the data should be flagged appropriately.

7.9.1.2 If a compound is outside of it's window on one column but in the window on the other column, the analyst will need to use their judgment or seek guidance from the organic lab manager or another experienced analyst to decide if the analyte is there.

7.9.2 Multi-peak components (PCB's, Toxaphene and Technical Chlordane) are identified by pattern recognition using an on scale standard chromatogram to compare to an on scale sample chromatogram enabling the analyst to judge whether the sample pattern matches a standard pattern. Confirmation of multi-peak components is required by the method and may be accomplished in several ways. If the sample is from a source known to contain specific Aroclors then this information may be used as a confirmation. Documentation of this approach must meet the requirements outlined in Sec. 7.7.3 of SW-846 Method 8082. Another approach is to use a column of dissimilar stationary phase and compare the pattern to a known Aroclor standard. Finally if the concentration is high enough GC/MS may be used as confirmation.

7.9.2.1 Generally, five unique peaks representing the full range of the multi-peak component are used in the quantitation of the multi-peak components. Note: for USACE projects, five peaks are necessary for the quantitation of multi-peak components.

7.9.2.2 Multi-peak components that still have matrix interference after appropriate sample cleanup steps have been taken may need to be hand calculated using peaks that do not have interference. This should be brought to the organic lab manager's attention.

7.9.2.3 Multi-peak components that exhibit a weathered pattern may need to be hand calculated by the analyst. The analyst will need to use peaks that exhibit the full range of weathering. The number of peaks used to quantitate the multi-peak component will depend on the analyst's judgment of what it will take to achieve the truest concentration of the component. This should be brought to the organic lab manager's attention.

7.9.3 Quantitation – Once a compound has been identified qualitatively, the concentration must then be quantitated. If the RSD of the compound's response factor is 20% or less, then the concentration may be determined using the mean calibration factor, CF, from the initial calibration data. Otherwise, the analyst must use either a calibration curve or a

non-linear calibration model such as polynomial equation for quantitation. Calculations follow in Section 8.0. **Refer to SOP-224 for guidance for manual integrations**

8.0 Calculations:

8.1 Calculate the calibration factor (CF) for each analyte at each concentration as:

$$CF = \frac{\textit{Peak Area (or Height) of the Compound in the Standard}}{\textit{Mass of the Compound Injected (in nanograms)}}$$

8.2 The mean CF is calculated as follows:

$$\overline{CF} = \frac{\sum_{i-1}^{n} CFi}{n}$$

8.3 The standard deviation (SD) and the relative standard deviation (RSD) of the calibration factors for each analyte are calculated as follows:

$$SD = \sqrt{\frac{\sum_{i-1}^{n} (CFi - \overline{CF})^2}{n-1}}$$

$$RSD = \frac{SD}{CF} \times 100$$

8.4 Calibration verification involves the calculation of the percent drift (linear or quadratic) or the percent difference (average) of the instrument response between the initial calibration and each subsequent analysis of the verification standard. Use the equations below to calculate % Drift or % Difference, depending on the calibration procedure used.

$$\% \text{ Drift} = \frac{(\text{Calculated concentration} - \text{Theoretical concentration}) * 100}{\text{Theoretical Concentration}}$$

where the calculated concentration is determined from the initial calibration and the theoretical concentration is the concentration at which the standard was prepared.

$$\% \text{ Difference} = \frac{(\text{CCV CF} - \text{Average CF}) * 100}{\text{Average CF}}$$

where CCV CF is the calibration factor from the analysis of the verification standard and mean CF is the average calibration factor from the initial calibration. The % difference or % drift calculated for the calibration verification standard must be within ±15% for each analyte before any sample analyses may take place.

8.5 Concentration in water samples is calculated as follows:
[Note: Using the units specified here for these terms will result in a concentration in units of ng/mL, which is equivalent to μg/L.]

$$\text{Concentration } (\mu\text{g/L}) = \frac{(A_x)(V_t)(D)}{(\overline{CF})(V_i)(V_s)}$$

where:

A_x = Area (or height) of the peak for the analyte in the sample.
V_t = Total volume of the concentrated extract (μL).
D = Dilution factor, if the sample was diluted prior to analysis. If no dilution was made, D = 1. The dilution factor is always dimensionless.
V_i = Volume of the extract injected (μL). The nominal injection volume for samples and calibration standards must be the same.
CF = Mean response factor from the initial calibration.
V_s = Volume of the aqueous sample extracted (mL). If units of liters are used for this term, multiply the results by 1000.

The 1000 in the denominator represents the number of μL in 1 mL. If the injection (V_i) is expressed in mL, then the 1000 may be omitted.

8.6 Concentration in non-aqueous samples is calculated as follows:
[Note: Using the units specified here for these terms will result in a concentration in units of ng/g, which is equivalent to μg/kg.]

$$\text{Concentration } (\mu\text{g/kg}) = \frac{(A_x)(V_t)(D)}{(\overline{CF})(V_i)(W_s)}$$

where:

A_x, V_t, D, and CF are the same as for aqueous samples, and
W_s = Weight of sample extracted (g). Either a dry weight or wet weight may be used, depending upon the specific application of the data. If units of kilograms are used for this term multiply the results by 1000.

The 1000 in the denominator represents the number of μL in 1 mL. If the injection (V_i) is expressed in mL, then the 1000 may be omitted.

9.0 QUALITY ASSURANCE/QUALITY CONTROL/CORRECTIVE ACTIONS

9.1 Surrogates - All samples and QC are spiked with surrogates. The surrogate recoveries from method blanks and LCS are charted to generate control limits and charts for diagnostic purposes. 8000B See section 7.8.5 above for criteria and corrective action.

9.2 LCS Sample - The LCS is extracted with every extraction batch - up to 20 samples. To prepare the LCS, a blank is spiked with standards prepared from an alternate vendor or lot number than the calibration standards. The recoveries are charted to generate control charts and limits. See the LCS report form in the appendix for the laboratory generated limits. These limits default to method limits if generated limits are wider. If the LCS compound has a recovery above the upper limit, but the same compound is not detected in any of the batch samples, no corrective action is required. For all other situations, the LCS should be reanalyzed for the failed analytes only or results for that analyte should be flagged. If the second analysis fails, all associated samples should be reextracted/reanalyzed for the failed analytes only. **DOD limits will be used for DOD QSM projects.**

9.3 Method Blanks - The concentration of all method target analytes should be below the MDL **(<RL, common laboratory contaminates; < ½ RL, all other compounds or client/authority specified)** for each method target analyte. If contamination exceeds the requirement, the following corrective actions must be taken. The first step is to assess the effect on the samples. If an analyte is found only in the method blank, but not in any batch samples, no further corrective action may be necessary. Steps should be taken to find/reduce/eliminate the source of this contamination in the method blank. If an analyte is found in the method blank and some, or all, of the other batch samples, then corrective action is required. The source of contamination must be investigated and appropriate action taken and documented to find/reduce/eliminate the source of this contamination. The method blank, and any samples containing the same contaminant, would likely be reextracted/reanalyzed. For the common laboratory contaminants, meeting the above requirements is not practical. Random cases of contamination are difficult to control, however, daily contamination is not acceptable and corrective action is essential. If a contaminant is found in the method blank and the samples, the compound concentration must be flagged with a 'B' on the final report unless the concentration is greater than 5x that found in the method blank.

9.4 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Sample - 1 in 20 samples are spiked for a MS/MSD (for 608 projects, 1 in 10 samples are spiked for MS). For project specified full list MS/MSDs, the LCS standard is used for spiking. Criteria for the MS/MSD are found in Table 5-3 of the Laboratory Quality Assurance Manual. Both the percent recoveries (%R) and relative percent differences (RPDs) are contained in this table (for project specified full list MS/MSDs, the MS/MSD limits are the same as the LCS limits). Samples that do not meet these criteria due to matrix should be evaluated for placing a flag on the final report due to QC problems. The associated LCS results should be used to verify method performance (section 8.4.3 Method 8081A). MS data evaluation must include the consideration of the following factors.

9.4.1 Sample matrix - If the sample is a soil, grab sample or sequentially collected water sample it may affect the %R and RPD of the MS/MSD. Corrective action must be taken in the form of reanalysis if a method problem is indicated.

9.4.2 Original sample concentration - If a spiked compound has a problem and the concentration of that compound in the original sample was more than four times the concentration of the spike, no further corrective action may be necessary other than the generation of a corrective action report to document the problem. In this case, the MS/MSD may be evaluated as sample duplicates.

9.4.3 MS vs. MSD - If a spiked compound has a similar problem in both the MS and MSD and is not traced to a method problem, no further action may be necessary other than the generation of a corrective action report to document the problem.

9.4.4 Non-target Interference - The presence of significant non-target interference should be brought to the immediate attention of your supervisor who should discuss the problem with the client/project manager to determine the action to be taken.

9.4.5 Documentation of capability (DOC) – Each analyst must perform a DOC to demonstrate proficiency with this method. Refer to SOP-413 for guidance.

10.0 HEALTH, SAFETY, WASTE MANAGEMENT AND POLLUTION PREVENTION

10.1 Care should be used in handling all samples. Safety glasses must be worn in the lab at all times. The use of blue nitrile gloves and lab coats is highly recommended.

10.2 Research into expected sample content and concentration should be done in order to be prepared for additional safety considerations. Generally, any samples that need special consideration have applicable notes on the sample logs.

10.3 MSDS sheets are available for all reagents and standards that have been purchased. These are located in the bookshelves across from the Quality Assurance Officers cube.

10.4 Please see Waste Disposal, SOP-210 and SOP-405 for proper disposal of waste coming from this area within our laboratory. Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

11.0 EXAMPLE FORMS

Examples of the water and soil LCS report sheet and the USACE analyst data review checklist are located in the appendix.

12.0 REFERENCES

1. *Test Methods for Evaluating Solid Waste Physical/Chemical Methods, SW-846*; Method 8081A, 8081B, 8082, 8082A

2. USEPA *Code of Federal Requlations, 40, CH 1,PT 136;* Method 608, 608.2; APX-B

3. USEPA *Contract Laboratory Program(CLP) for Organics ILM04.2; ILM04.3*

4. DOD Quality Systems Manual, Ver. 3/4.1

13.0 DEFINITIONS

Refer SOP-431 for a list of definitions.

APPENDIX

FORM 3
WATER PESTICIDE/PCB LAB CONTROL SAMPLE
(In- House)

Lab Name: Empirical Laboratories, LLC Contract:

Lab Code: NA Batch No.: NA SAS No.: NA SDG No.:

Matrix Spike - Client Sample No.: LCS

COMPOUND	SPIKE ADDED (µg/L)	SAMPLE CONCENTRATION (µg/L)	LCS CONCENTRATION (µg/L)	LCS % REC #	QC. LIMITS REC.
Aldrin	0.05000	NA	0.05000	100	25-110
alpha-BHC	0.1000	NA	0.1000	100	45-125
alpha-Chlordane	0.05000	NA	0.05000	100	50-125
beta-BHC	0.05000	NA	0.05000	100	50-130
4,4'-DDD	0.1000	NA	0.1000	100	55-130
4,4'-DDE	0.1000	NA	0.1000	100	45-130
4,4'-DDT	0.1000	NA	0.1000	100	50-140
Dieldrin	0.1000	NA	0.1000	100	55-130
delta-BHC	0.05000	NA	0.05000	100	40-135
Endosulfan I	0.1000	NA	0.1000	100	50-120
Endosulfan II	0.1000	NA	0.1000	100	55-135
Endosulfan sulfate	0.1000	NA	0.1000	100	55-130
Endrin	0.1000	NA	0.1000	100	40-150
Endrin aldehyde	0.1000	NA	0.1000	100	40-130
Endrin ketone	0.1000	NA	0.1000	100	60-130
gamma-BHC (Lindane)	0.1000	NA	0.1000	100	50-130
gamma-Chlordane	0.05000	NA	0.05000	100	50-125
Heptachlor	0.1000	NA	0.1000	100	35-125
Heptachlor epoxide	0.05000	NA	0.05000	100	50-130
Methoxychlor	0.5000	NA	0.5000	100	50-140
PCB-1248	10.00	NA	10.00	100	50-140

Column to be used to flag recovery values with an asterisk

* Values outside of QC limits

Spike Recovery: 0 out of 21 outside limits

COMMENTS: _____

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FORM 3
SOIL PESTICIDE/PCB LAB CONTROL SAMPLE
(In-House)

Lab Name: Empirical Laboratories, LLC Contract:

Lab Code: NA Batch No.: NA SAS No.: NA SDG No.:

Matrix Spike - Client Sample No.: LCS

COMPOUND	SPIKE ADDED (µg/kg)	SAMPLE CONCENTRATION (µg/kg)	LCS CONCENTRATION (µg/kg)	LCS % REC #	QC. LIMITS REC.
Aldrin	5.0000	NA	5.0000	100	30-135
4,4'-DDT	10.000	NA	10.000	100	30-160
Dieldrin	10.000	NA	10.000	100	30-150
Endrin	10.000	NA	10.000	100	35-160
gamma-BHC (Lindane)	10.000	NA	10.000	100	30-145
Heptachlor	10.000	NA	10.000	100	40-150
PCB-1248	1000.0	NA	1000.0	100	50-150

Column to be used to flag recovery values with an asterisk

* Values outside of QC limits

Spike Recovery: 0 out of 7 outside limits

COMMENTS: _____

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ANALYST DATA REVIEW CHECKLIST

Sample Number(s):	
Batch Number(s):	
Method:	**8081/8082**

QA/QC Item	Yes	No	NA	Second Level Review
A. Initial Calibration				
1. Did the evaluation mix pass criteria?				
2. Does the curve consist of at least five Calibration Standards?				
3. Is the low standard near, but above the MDL?				
4. Are the % RSDs within QC limits for all analytes?				
B. Second Source Verification				
1. Was the initial calibration curve verified by a second source calibration standard (ICV) and have criteria been met?				
C. Continuing Calibration				
1. Are the Continuing Calibration Verification (CCV) standards analyzed every 20 samples or every 12 hours and at the end of the sequence?				
2. Are the % differences within QC limits for all analytes?				
D. Sample Analysis				
1. Did the evaluation mix pass criteria?				
2. Are all sample holding times met?				
3. Are all samples with concentrations > the highest standard used for initial calibration diluted and reanalyzed?				
4. For single peak analytes - are all compounds identified on the primary column confirmed on the secondary column?				
5. For multi-peak analytes - does the pattern of the analyte in the sample match the pattern of the standard?				

6. Are surrogate recoveries within QC limits? (one surrogate both columns) _____ _____ _____ _____

ANALYST DATA REVIEW CHECKLIST

E. QC Samples

1. Is the Method Blank extracted at the desired frequency and is its concentration for target analytes less than the MDLs? _____ _____ _____ _____
2. Is the Laboratory Control Sample and its percent recovery within QC limits? _____ _____ _____ _____
3. Is the Matrix Spike/Matrix Spike Duplicate extracted at the desired frequency and is the percent recovery/RPD within QC limits? _____ _____ _____ _____

F. Others

1. Are all nonconformances included and noted? _____ _____ _____ _____
2. Are all calculations checked at the minimum frequency? _____ _____ _____ _____
3. Did analyst initial/date the appropriate printouts and report sheets? _____ _____ _____ _____
4. Are all sample IDs and units checked for transcription errors? _____ _____ _____ _____
5. Are all manual integrations checked by a second reviewer to verify they were performed correctly? _____ _____ _____ _____

Comments on any "No" response:

_____

Analyst: _____ Date: _____

Second-Level Review: _____ Date: _____

GC/MS SEMI-VOLATILE BNA-AQUEOUS MATRIX EXTRACTION USING SW-846 METHOD 3510C FOR 8270C/625 ANALYSIS

SOP NUMBER: SOP-300

REVISION NUMBER: 17

APPROVED BY:

SECTION MANAGER

QUALITY ASSURANCE OFFICER

EFFECTIVE DATE: 09/23/08

DATE OF LAST REVIEW: 09/23/08

GC/MS BNA - AQUEOUS MATRIX EXTRACTION USING SW846 METHOD 3510C/8270C, 625

I. SCOPE AND APPLICATION/SUMMARY

1. This SOP describes the extraction of BNAs from water by separatory funnel extraction using SW846 Method 3510C and 625. Samples are extracted with methylene chloride and concentrated to an appropriate final volume.

II. INTERFERENCES

1. Solvents, reagents, glassware, and other sample processing apparatus can add interferences to sample analysis. Method blanks must be extracted under the same conditions as samples to demonstrate freedom from interferences.
2. Phthalate esters commonly found in plastics can interfere with the analysis. Plastics should be avoided.
3. Soap residue can degrade certain analytes such as aldrin and heptachlor. Glassware should be solvent rinsed to avoid this problem.

III. APPARATUS AND MATERIALS

- Separatory Funnel - 2-Liter with Teflon stopcock
- Beaker - 400 mL
- Drying /Chromatographic column - 20 mm I.D. x 300 mm or funnel
- Turbo-Vap evaporation tube - 200 mL tube made by Zymark to fit into Turbo-Vap evaporator
- Metal rack - capable of holding six glass evaporation tubes
- Turbo-Vap Evaporator - heated and capable of temperature control ($\pm$5°C); the bath should be vented into a hood.
- Vials - 2 mL glass amber, with Teflon-lined screw cap and 40 mL with Teflon lid.
- pH indicator paper - close range (1.0 - 2.0) and (10.0 - 12.0); wide range (1.0 - 12.0)
- Syringe - 1 mL, 500 mL
- Graduated cylinder - Glass, Class A, 1000 mL, 500 mL, and 100 mL
- Pasteur pipette - length 9" and 5-3/4"
- Pasteur pipette bulb
- Labels - Avery
- Teflon Bottles - 250 mL and 1000 mL
- Ring stand - 3 prong
- Aluminum foil - heavy duty
- 10 mL disposable pipette
- Nitrogen tank - equipped with pressure regulator

IV. REAGENTS

- Reagent Water - Reagent water is gathered in a carboy from source in the instrument lab daily. Remaining water in the carboy is dumped at the end of each day.

- Sodium Hydroxide Solution - (10N), Weigh 400 g NaOH (purchased in a plastic container from Fisher # S318-3 or equivalent) into a 1200 mL fleaker beaker and cover with reagent water. Swirl until all pellets are dissolved. This mixture gets very hot. Let stand until cool. Transfer to a 1-liter volumetric flask with several rinses of reagent water and dilute to 1 liter with reagent water. Transfer to a 1000-mL Teflon container.

- Sodium Sulfate - Granular, anhydrous, trace pure 10 - 60 mesh (purchased in plastic bulk containers from Fisher # S415-10S or equivalent) placed in Pyrex tray and heated at 400°C for a minimum of 4 hrs, removed and cooled in open air in the extraction lab, placed in a 2.5 kg glass amber jug and left at room temperature.

- Glass Wool - Silane Treated (purchased from Supelco #2-0410 or equivalent).

- Sulfuric Acid Solution - (1:1), slowly add 500 mL of H2SO4 (Baker, suitable for trace metal analysis #9673-33 or equivalent) to 500 mL of reagent water in a 1000 mL Teflon container. This mixture will get very warm. Allow to cool before use.

- Extraction Solvent - Methylene Chloride (**Please read SOP-336 before handling this solvent in our laboratory.)** (Dichloromethane - Omnisolv - suitable for spectrophotometry and gas chromatography #DX0831-1 or equivalent).

- The GC/MS operator makes up all surrogates and spikes. Verify the amount of surrogate/spike to add to the sample prior to addition. It can change if a different detection limit is required or the volume of sample being analyzed changes.

  BNA Surrogate - The base neutral and acid surrogates are normally mixed together in one solution. This solution is purchased from a reputable vendor. Use 0.5 mL of this solution per 1000 mLs of aqueous sample for surrogate amount of 100:200 ug/mL per sample. **(For low level PAHs use 1.0ml of a 1.0µg/mL BN Surrogate spiking solution.)**

  BNA Spiking Solution - The base neutral and acid spiking solutions are normally mixed together in one solution (**This spiking solution contains all the compounds that are normally calibrated by GC/MS**). This solution is prepared in methanol by making a dilution of stock purchased from a reputable vendor. Use 0.5 mL of this solution per 1000 mLs of aqueous sample for LCS amount of 100ppm per sample. There are two separate spiking solutions available – one solution has a more complete list of BNA compounds than the other which is called the short or matrix spike list. The long list should be used on all extractions unless your supervisor has approved the short list. The short list may be used for any 'phenol only' extractions. **(For low level PAHs use 1.0 ml of a 1.0ppm of the LLPAH spiking solution.)**

BNA TCLP Spike – 0.5 mL is added per 100-mL volume. Each matrix type must have its own TCLP spike. TCLP spike should be added after the TCLP has been filtered but prior to refrigeration. From the volume provided by Wet Chemistry, remove a 100-mL aliquot into a suitable container with a teflon lid, and spike as indicated above.

V. PROCEDURE

1. All waters have a seven-day holding time counted from the hour they are sampled. Determine the samples necessary to extract from the following sources (Note: never extract samples of unknown origin without discussion with supervisor):
   - Each day a backlog report will be provided indicating sample numbers with the respective analysis required. Line through all the extractions that have been completed and plan to do the remaining analysis within the required holding time.
   - Samples requiring RUSH turn around time may be logged in throughout the day which will require your immediate attention. Log-in personnel will generally communicate this need.
   - Check with log-in throughout the day and examine the COC (chain of custody) forms that arrive with each set of samples. If an analysis is ongoing, extra QC may be avoided by picking up those extractions on the same day.

2. Wearing lab coat, gloves and safety glasses, get samples from refrigerator. Samples must be signed out of the walk-in refrigerator. Enter the sample numbers, your initials and the date and time removed on the log provided. Inspect as to whether they are in glass amber jar and have a Teflon lid. Find out if any special dilutions need to be made for this client. Routine procedures for difficult matrices are listed below:

   SLUDGE - use only 100 mL and dilute to 1000 mL with reagent water.
   TCLP EXTRACT - use only 100 mL and dilute to 1000 mL with reagent water. A separate matrix spike of 100 mLs (which has already been spiked as explained in the BNA TCLP Spike section above) should be set up at the same time. Dilute to 1000 mL with reagent water.
   BAD MATRIX – for example a liquid that is partially sediment, see your supervisor to find out what dilution, if any should be made. **SPLP extract- use 1 liter**.
   NPDES client - a special list of compounds is required including benzidine. Method 625 requires that there be a spike every ten samples. The sample must be extracted and concentrated in the same day. A GC/MS screen is recommended; therefore this extraction should be coordinated with the GC/MS operator. 1 mL is added to the LCS and the matrix spike.
   ACID EXTRACT WITH BAD MATRIX - a cleanup step is added. Samples are taken to a high pH, extracted with 60 mLs methylene chloride one time as explained below in the BASE NEUTRAL EXTRACTION section. This extract is discarded. The samples are then taken to a low pH and extracted as an acid extraction. Acid extractions may be concentrated in the TurboVap.

3. **LOW LEVEL POLYAROMATIC HYDROCARBONS (PAHs) –** Samples require a BNA extraction. Use the Surrogate and BN spiking solutions specified. Low level PAHs are normally concentrated on the Turbo-Vap using Round-Bottom TV tubes to a final volume of 0.5 mL

4. Mark the amber glass container of each sample at the water meniscus with "white out" for later determination of sample volume. Check the pH by inverting the sample and touching the wide range pH paper to the portion that remains on the lid. Record this pH in the logbook.

5. Get out enough separatory funnels to extract the number of samples you have plus any additional spikes and a method blank. A method blank and an LCS must be processed with each set of samples. If the sample is a TCLP, blank fluid may be provided along with the extracted TCLP sample(s). Use only 100 mL and dilute to 1000 mL with reagent water. A matrix spike and a duplicate or a matrix spike duplicate must be processed for each analytical batch (up to a maximum of 20 samples). In the event that adequate sample is not provided to do an MS/MSD, an LCS duplicate should be done. Rinse separatory funnels with methylene chloride. Place an Avery label on each separatory funnel containing the following information: Lab #, Client name, Type of Analysis, Initial Volume-Final Volume, and the Lab prepbatch code. The lab batch code is defined as MMDDYYB# where #: 1 = 1st method blank of the day; 2 = 2nd method blank of the day; etc. The Method Blank and LCS label should include all lab #s in this set of samples.

6. Using the 1000-mL glass graduated cylinder marked NANO PURE WATER ONLY, measure 1000 mL of reagent water from the carboy and transfer it to a separatory funnel for the method blank and LCS. Transfer sample to separatory funnel that corresponds to the lab # on the sample bottle.

7. Verify the amount of surrogate/spike to add to the sample prior to addition. It can change if a different detection limit is required or the volume of sample being analyzed changes. Set out the surrogate/spike at least ten minutes before use to allow it to warm to room temperature.

   Generally 0.5 mL of BNA surrogate is added to each sample, spike, and blank with a syringe designated for BNA surrogate. **For low level PAHs use 1.0ml of a 1.0ppm LLPAH Surrogate spiking solution.** Someone must verify that the surrogate has been added by placing a check mark on each label as it is added.

   NOTE: Be sure to invert syringe and eliminate air bubble when obtaining surrogate solution and spiking solution.

   For the sample in each analytical batch selected for spiking, use the 0.5-mL glass syringe designated for BNA spike, to add 0.5 mL of BNA spiking solution. **For low level PAHs use 1.0 mL of the 1.0ppm LLPAHs spiking solution.** Someone must verify that the spike has been added by placing a check mark on each label as it is added. **For DOD QSM projects, all target compounds will be spiked into the LCS and MS/MSD.**

Enter the ID# of the surrogate/spike used and the initials of the person that verified their addition to the sample in the BNA logbook.

8. **ACID EXTRACTION:** Adjust the pH to between 1.0 and 2.0, using 2 mL of 1:1 H2SO4. Add to each sample, spike and method blank. Stopper and shake to insure that pH throughout the sample is changed. Check the drop of liquid hanging from the lid with short-range pH paper. Compare the color to the chart on the pH paper. If the color is not within range add more H2SO4 solution in small increments, as required to attain the proper pH.

9. Add 40 mL of Methylene Chloride to each empty sample bottle and to the LCS, method blank and MS/MSD funnels. Swirl the 40-mL of methylene chloride that you added to the empty sample bottle and transfer to the corresponding separatory funnel.

10. Seal and shake the separatory funnel vigorously for 2 minutes with periodic venting to release excess pressure. Alternatively, Teflon funnels may be used and placed in the shaker apparatus with the stopcocks slightly open. When this apparatus is used, the shake should be for 3 minutes.

    NOTE: Methylene chloride creates excessive pressure very rapidly; therefore, initial venting should be done immediately after the separatory funnel has been sealed and shaken once.

11. Allow the sample to sit for 10 minutes, if necessary, after it has been shaken. It will separate into two layers with the solvent layer on the bottom. If it forms an emulsion (thick, cloudy, viscous, mixture that you cannot see through), drain what you believe to be 40 mL into a 250 mL centrifuge bottle. If the layers are clearly separated, drain the solvent layer into a 400-mL glass beaker.

12. Following Steps 9 and 10, extract two more times with 40 mLs of methylene chloride. Combine the three solvent extracts into the same 400-mL beaker.

13. **BASE NEUTRAL EXTRACTION: Adjust the pH to 11 or slightly greater**, using 10N NaOH. Start by adding 5.0 mLs to each sample, spike, and method blank. Stopper and shake to insure that pH throughout the sample is changed. Check the drop of liquid hanging from the lid with short-range pH paper. Compare the color to the chart on the pH paper. If the color is not within range add more 10N NaOH in small increments, as required to attain the proper pH. **BNA extraction is necessary when doing low level PAHs.**

    NOTE: This step is critical to the extraction procedure. Too much NaOH solution could cause you to lose certain Base Neutral compounds. Be careful on this step.

14. **<u>FOR 8270 extraction</u>**: Extract one more time with 40 mL of methylene chloride following Steps 9 and 10. Combine BN and Acid extracts in a same 400ml beaker, unless

the BN extract has large amount of emulsion; then it will be necessary to use a separate 400 mL beaker. Concentrate BN and acid extracts for one final extract.
NOTE: It has been demonstrated that two acid and one BN extraction can be used for normal 8270 samples. This procedure cannot be used for DOD or 625 samples.

For 625 extraction: extract 3 more times with 40 mL methylene chloride following steps 9 and 10. Combine BN extracts in separate 400 mL beaker. Concentrate BN and acid extracts separately for one final extract.

15. In the log book marked BNA extractions, enter the Client name, the Lab #, the date extracted, the initial volume, and 1.0 mL for the final volume and anything unusual that may have occurred with this sample. The final volume for low level PAHs is 0.5 mL.

16. Prepare to dry the sample by either of the following methods:
    16A. Get a ring stand with a double burette clamp attached to it. Cover the burette clamp ends with aluminum foil to prevent the possibility of solvent touching the plastic coated ends and dripping into the extract. Place a drying column into the burette clamp and transfer a small amount of glass wool to the top of it. Tamp it to the bottom with a glass rod so that it adequately covers the hole at the bottom. Add approximately 10 cm of Sodium Sulfate to the column. Rinse with 20 to 30 mL of methylene chloride and discard this rinse into the Chlorinated Waste container in the hood. OR

    16B. Set up a ring stand with funnels. Place a small amount of glass wool in the bottom of it, add ~2” sodium sulfate to the column and rinse with 20-30 mL methylene chloride. Discard this rinse into the Chlorinated Waste container in the hood.

17. If the extract was drained into a centrifuge bottle, at this point you will need to take it to the centrifuge. Push the "ON" button to turn the centrifuge on. Be sure that the large holders are available for the 250-mL centrifuge bottles. The sample must always be balanced. If necessary use a dummy bottle making it similar weight using reagent water. Set the rpm at 2500 and the temperature at 0°C. Close the lid and be sure to press it down until you hear it click. Move the lever at the front of the lid to the "LOCK" position. Turn the time to approximately 15 minutes and bring it back to 10 minutes. As the rotor begins to move, you will be able to see the rpm's in the digital readout. Stay with the centrifuge until it has come up to the rpm's set to insure that it does not become unbalanced. This looks like 8888 on the digital readout. Should this occur, refer to the manual. When the cycle is complete, the digital readout will read 0000. Push the "OPEN" button and the lid will pop up. Move the lever at the front of the lid to the "UNLOCK" position. Open lid and remove sample. The sample will usually be in two layers with the extract on the bottom.

18. Remove any water layer from the extract in the beaker or centrifuge bottle, by one of two methods. Remove with a Pasteur pipette by carefully pulling up the water layer, on top, and not the solvent. Discard this layer in the sink. Use the smallest amount possible of

Na2SO4 by sprinkling the top layer with Na2SO4 until it hardens, separates, and drops to the bottom.

19. TURBO-VAP CONCENTRATION

Low level PAH sample concentration is primarily done by Turbo-Vap using Round-Bottom TV tubes.

- Rinse a Turbo-Vap tube with methylene chloride and arrange it underneath a rinsed, packed drying column or funnel. Pour the extract through the column so that it will collect in the tube. Rinse the 400-mL beaker, which contained the solvent extract twice with 10 to 15 mL of methylene chloride and add each rinse to the column to complete the quantitative transfer. After all the extract has passed through the column, rinse the column with 10 to 15 mL of methylene chloride. Total volume in the glass evaporator tube should not exceed 200 mLs to avoid splattering on the lid of the Turbo-Vap.
- Record the numbers of the Turbo-Vap tube in the BNA logbook and remove the tube to a metal holder. To help prevent cross contamination, place a piece of aluminum foil over the Turbo-Vap tube and punch a small hole in the top so that the nitrogen can be accessed.

- Turbo-Vap Operation: Adjust the pressure of nitrogen gas tank to >30 psi. Make sure the tank has 200 psi or more on the main valve. The temperature of the bath should be approximately 40°C -50°C.

- Place the glass evaporator tube in the Turbo-Vap. Be sure to push tube down so the tip slides into the sensor well. Close the lid to start concentration. Check that each position with a tube has an orange light showing. If the orange light is not steady, bubbles may be in the sensor and need removal. (See Turbo-Vap manual).

- When the beep sounds indicating the end of concentration, the extract will be at approximately one half mL (half way up tip of tube). Remove the tube from the bath. Use a 9" Pasteur pipette to draw up the sample and transfer it to the 2-mL vial. THIS IS THE MOST CRITICAL PART OF THE ENTIRE OPERATION!!! A single drop represents about 10 percent of the total sample. Before you move the tip of the pipette from the tube to the vial, be sure that a drop will not form on the end and fall off.

- Draw ~0.25 mL of methylene chloride into a 0.50 mL syringe and add this aliquot to the centrifuge tube. Draw the methylene chloride into a pipette and rinse the sides of the tube several times. Transfer this rinse to the 2-mL vial. Add methylene chloride from the syringe and repeat the rinsing process until you have ~ 1 mL in the sample extract vial. Compare this volume to a 2-mL dummy vial containing 1 mL of solvent to insure that you have not exceeded 1 mL. For low level PAHs the final volume is 0.5mL. The methylene chloride rinse volume must be adjusted to achieve this final volume. Compare the volume to a 2mL dummy vial containing 0.5 mL of

solvent to insure that you have not exceeded 0.5 mL. The GC/MS operator will adjust the sample to the desired final volume and add internal standard just prior to analyses. Cover the extract with a Teflon-sealed screw cap and transfer the label to the vial.

20. Determine the original sample volume by refilling the sample bottle to the mark made with "white out." Transfer the liquid to a plastic 1000-mL graduated cylinder and record the sample volume in the BNA logbook and the Avery label to the nearest 10-mL.

21. The extract is now ready to be analyzed. Refrigerate at 4°C or carry directly to the instrument operator. Samples must be signed into the Sample Extract refrigerator. On log provided, enter the sample numbers, the analyst initials, and the date and time the samples were placed into the refrigerator.

VI. DOCUMENTATION OF CAPABILITY (DOC)

Each analyst must perform a DOC to demonstrate proficiency with this method. Refer to SOP-413 for guidance.

VII. WASTE MANAGEMENT AND POLLUTION PREVENTION

Please see Waste Disposal SOP-405 for the proper disposal of waste generated from this area.

Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

VIII. METHOD PERFORMANCE

Refer to SOP-201 for method performance.

IX. HEALTH AND SAFETY

Refer to the MSDS sheets for the chemicals used for health and safety information.
Also see SOP-336 for proper use of methylene chloride.

REFERENCES

1. *Test Methods for Evaluating Solid Waste*, SW-846, Third Edition
2. 40 CFR, Method 625.

DEFINITIONS

BNA- base/neutral acid
°C - degrees centigrade

COC - chain of custody
DL - detection limit
g - grams
KD - kuderna danish
LCS - laboratory control sample
µg/L - micrograms per liter
µL - microliter
µg/ml - micrograms per milliliter
ml - milliliter
mm - millimeter
MS - matrix spike
MSD - matrix spike duplicate
PAH- polynuclear aromatic hydrocarbon
RL - reporting limit
SOP - standard operating procedure
v/v - volume to volume

Refer to SOP-431 for further definitions

Fraction: Semi-volatiles Matrix: Water EX0__

Supervisor_____

#	Client	Lab No.	Date Extracted	Setup Initials	pH	Initial Volume(ml)	Final Volume(ml)	Surrogate Added	Surr Initials	Spike Added	Spk Initials	KD	10ml Conc.	15ml Cent.	Conc. Initials	Solvent Lot/Vendor Methylene Chloride	Notes/Comments	#
1										NA	NA							1
2										NA	NA							2
3										NA	NA							3
4										NA	NA							4
5										NA	NA							5
6										NA	NA							6
7										NA	NA							7
8										NA	NA							8
9										NA	NA							9
10										NA	NA							10
11										NA	NA							11
12										NA	NA							12
13										NA	NA							13
14										NA	NA							14
15										NA	NA							15
16										NA	NA							16
17										NA	NA							17
18										NA	NA							18
19										NA	NA							19
20										NA	NA							20
								SAS	SAS							SAS		
								SAS	SAS							SAS		
								SAS	SAS							SAS		
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								SAS	SAS							SAS		

PESTICIDE/PCBs
AQUEOUS MATRIX EXTRACTION
FOR EPA METHOD 608/608.2 AND
SW846 METHOD 8081A/8082
USING SW846 METHOD 3510C

SOP NUMBER: **SOP-302**

REVISION NUMBER:

16

APPROVED BY:

SECTION MANAGER

QUALITY ASSURANCE OFFICER

EFFECTIVE DATE: **09/23/08**

DATE of LAST REVIEW: **09/23/08**

PESTICIDE/PCB - AQUEOUS MATRIX EXTRACTION BY EPA METHOD 608/608.2 AND SW-846 METHOD 8081A/8082 USING SW846 METHOD 3510C

I. SCOPE AND APPLICATION

1. This SOP describes the extraction of pesticides/PCBs from water by separatory funnel extraction using SW846 Method 3510C and Method 608/608.2.

II. SUMMARY

1. Aqueous samples are extracted three times with methylene choride. The extracts are dried through sodium sulfate and concentrated and exchanged to hexane.

III. INTERFERENCES

1. Solvents, reagents, glassware, and other sample processing apparatus can add interferences to sample analysis. Method blanks must be extracted under the same conditions as samples to demonstrate freedom from interferences.
2. Phthalate esters commonly found in plastics can interfere with the analysis. Plastics should be avoided.
3. Soap residue can degrade certain analytes such as aldrin and heptachlor. Glassware should be solvent rinsed to avoid this problem.

IV. APPARATUS AND MATERIALS

- Separatory Funnel - 2 Liter with Teflon stopcock
- Beaker - 400 mL
- Drying/Chromatographic column - 20 mm I.D. x 300 mm (or funnel)
- Turbo-Vap evaporation tube - 200-mL tube made by Zymark to fit into Turbo-Vap evaporator.
- Metal rack - capable of holding six glass evaporation tubes.
- Turbo-Vap Evaporator - heated and capable of temperature control (+5°C); the bath should be vented into a hood.
- Vials 10-mL glass, with Teflon-lined screw cap
- pH indicator paper - wide range (1.0 -12.0)
- Syringe - 1 mL, 500 µL
- Graduated cylinder - Glass, Class A, 1000 mL, 500 mL, and 100 mL
- Pasteur pipette - length 9"
- Pasteur pipette bulb
- Labels - Avery
- Teflon Bottles - 250 mL and 1000 mL
- Volumetric Flasks - Class A, glass, 1000 mL, 500 mL,100 ml, 50 ml.
- Ring stand - 3 prong

- Burette clamp - double
- Aluminum foil - heavy duty
- 10 mL disposable pipette
- Nitrogen tank - equipped with pressure regulator
- Boiling chips - Teflon

V. REAGENTS

- Reagent water - Reagent water is gathered in a carboy from source in the instrument lab daily. Remaining water in the carboy is dumped at the end of each day.
- Sodium Sulfate (Na2SO4) - Granular, anhydrous, trace pure 10 - 60 mesh (purchased in bulk containers from Fisher # S415-10S or equivalent] placed in a Pyrex tray and heated at 400°C for 4 hrs minimum, removed and cooled in open air in the extraction lab, placed in a 2.5 kg glass amber jug and left at room temperature.
- Glass Wool - Silane Treated (purchased from Supelco #2-0410 or equivalent).
- Sulfuric Acid Solution - (1:1), slowly add 500 mL of H2SO4 (Baker, suitable for trace metal analysis #9673-33 or equivalent) to 500 mL of reagent water in a 1000 mL Teflon container. This mixture will get very warm. Allow to cool before use.
- Sodium Hydroxide Solution - (10N), Weigh 400 g NaOH (purchased in a plastic container from Fisher # S318-3 or equivalent) into a 1200 mL fleaker beaker and cover with reagent water. Swirl until all pellets are dissolved. This mixture gets very hot. Let stand until cool. Transfer to a 1-liter volumetric flask with several rinses of reagent water and dilute to 1 liter with reagent water. Transfer to a 1000-mL Teflon container.
- Extraction Solvent - Methylene Chloride **(Please read S0P-336 before handling this solvent in our laboratory.)** (Dichloromethane - Omnisolv - suitable for spectrophotometry and gas chromatography #DX0831-1 or equivalent)
- Hexane - suitable for gas chromatography (Omnisolv HX0298-1 or equivalent)
- The GC operator makes up all surrogates and spikes. Verify the amount of surrogate/spike to add to the sample prior to addition. It can change if a different detection limit is required or the volume of sample being analyzed changes.

  TCMX/DCB (2, 4, 5, 6 - Tetrachloro-meta-xylene/Decachlorobiphenyl) - Surrogate solution is prepared in acetone by making a cut on stock purchased from a reputable vendor. The final concentration is 0.5 µg/mL. Generally use 1.0 mL of this solution per 1000ml of aqueous sample.

  PCB Spiking Solution - The PCB of choice (1242, 1248, 1254, or 1016/1260 are the most common) is prepared in acetone at a concentration of 5.0 PPM. PCB stock is usually purchased from RESTEK or equivalent. The PCB to use may be determined by viewing historical data or asking the GC operator. Generally use 0.2- 1.0 mL per 1000ml of aqueous sample.

  Pesticide Spiking Solution - A spiking solution is prepared at the appropriate concentration of 1 ppm. Generally use 1 mL per 1000ml of aqueous sample. For 608 samples, 1 out of every 10 samples must be spiked.

- TCLP's - When necessary to set up a TCLP, in addition to setting up the sample, two matrix spikes must be set up and should include the following: 1.0 mL is added per 100 mL volume. Each matrix type must have its own TCLP spike.

  TCLP Spike 1 - includes Chlordane at 10 µg/mL and Toxaphene at 10 µg/mL. These spikes are made up individually and are also used as the LCS spike. Add 1 mL of each to a 100-mL aliquot.

  TCLP Spike 2 - includes Mix A and Mix B @ 100 to 1000 µg/L ppb (also used as the pesticide spiking solution). These spikes are combined into one solution. Add 1 mL per 100-mL aliquot.

VI. PROCEDURE

1. All waters have a seven-day holding time counted from the hour they are sampled. Determine the samples necessary to extract as follows:

   Each day a backlog report will be provided indicating sample numbers with the respective analysis required. Line through all the extractions that have been completed and plan to do the remaining analysis within the required holding time.

   Samples requiring RUSH turn around time may be logged in throughout the day that will require your immediate attention. Login personnel will generally communicate this need.

   Check with login throughout the day and examine the COC (chain of custody) forms that arrive with each set of samples. If an analysis is ongoing, extra QC may be avoided by picking up those extractions on the same day.

2. Wearing lab coat, gloves and safety glasses, get samples from cooler. Samples must be signed out of the walk-in refrigerator. Enter the sample numbers, your initials and the date and time removed on the log provided. Inspect as to whether they are in glass amber jar and have a Teflon lid. Find out if any special dilutions need to be made for this client. Routine procedures for difficult matrices are listed below:

   SLUDGE - use only 100 mL and dilute to 1000 mL with reagent water.
   TCLP EXTRACT - use only 100 mL for the sample and dilute to 1000 mL with reagent water. Two matrix spikes of 100 mLs (per client matrix). Dilute to 1000 mL with reagent water.
   BAD MATRIX – for example a liquid that is partially sediment, see your supervisor to find out what dilution, if any, should be made.
   NPDES client - Samples for method 608/608.2 are checked by login to make sure the pH of the sample is in the range of 5.0 and 9.0. If the sample is not in this range, extraction personnel will be notified. At that time, it is the responsibility of the extraction lab to adjust the pH of the sample to the appropriate range (pH of 5-9 using NaOH solution or H2SO4, as necessary) or to extract the sample within 72 hours of sampling. If a pH adjustment is made, the details of the adjustment must be recorded on the sample chain of

custody and the outside of the sample bottle. Set up one full list matrix spike for every ten samples.

3. Mark the amber glass container of each sample at the water meniscus with "white out" for later determination of sample volume. Check the pH by inverting the sample and touching the wide range pH paper to the portion that remains on the lid. Record this pH in the logbook

4. Get out enough separatory funnels to extract the number of samples you have plus any additional spikes and a method blank. A method blank and an LCS are to be processed with each set of samples. If the sample is a TCLP, a blank may be provided along with the extracted TCLP sample(s). Use only 100 mL and dilute to 1000 mL with reagent water. A matrix spike and a duplicate or a matrix spike duplicate must be processed for each analytical batch (up to a maximum of 20 samples) except for TCLPs and 608 samples as noted above. In the event that adequate sample is not provided to do an MS/MSD, an LCS duplicate should be done. Rinse separatory funnels with methylene chloride. Place an Avery label on each separatory funnel containing the following information: Lab #, Client name, Type of Analysis, Initial Volume - Final Volume, and the Lab Prep Batch Code. The lab prep batch code is defined as MMDDYYP# where #: 1 = 1st Method Blank for the day; 2 = 2nd Method Blank for the day; etc. The Method Blank and LCS label should include all lab #s in this set of samples.

5. Using the 500 mL glass graduated cylinder marked NANO PURE WATER ONLY, measure 1 liter of reagent water from the carboy and transfer it to a separatory funnel for the Method Blank and LCS. Transfer sample to separatory funnel that corresponds to the lab # on the sample bottle. Add 50 mL of Methylene Chloride to the empty bottle.

6. Verify the amount of surrogate/spike to add to the sample prior to addition. It can change if a different detection limit is required or the volume of sample being analyzed changes. Set out the surrogate/spike at least ten minutes before use to allow it to warm to room temperature.

   Using the 1.0-mL glass syringe marked TCMX/DCB surrogate, add 1.0 mL of TCMX/DCB surrogate to each sample, blank and spike. A second analyst must verify that the surrogate and spike has been added. Enter the ID# of the standard, amount, and the initials of the analysts in the extraction logbook.

7. Determine if the sample will require a Pesticide Spike or a PCB Spike or both. Proceed as follows:

   Pesticide and PCB - set up two LCS's – one for Pesticide getting a MIX A&B spike and one for PCB, which should be spiked with PCB 1016/1260. In addition to the LCS's, a matrix sample spike and duplicate is spiked for pesticides and PCBs.

Pesticide only – To the sample in each analytical batch selected for spiking, add 1.0mL of Pesticide Spike (Mix A&B) with a glass syringe dedicated for Pesticide Spike.

PCB only - To the sample in each analytical batch selected for spiking, add 1.0 mL of PCB 1016/1260 or 1248 (project specific) unless otherwise specified using a 1.0-mL glass syringe dedicated to that PCB.

NOTE: Due to limited volume received, usually it is necessary to use 1/2 liter to do a spike so that a spike duplicate can be extracted also. If only one liter is provided for spiking purposes, use a 500-mL glass cylinder to measure out half the sample. Transfer to a separatory funnel labeled for the Spike. Measure the remaining sample and transfer to a separatory funnel labeled Spike Duplicate. Add 1/2 the normal amount of spiking solution and 1/2 the normal amount of surrogate.

Enter the ID# of the surrogate and spike used and the initials of the person that verified their addition to the sample in the extraction logbook.

8. If necessary, adjust the pH to between 5.0 and 9.0 using NaOH solution or H2SO4. If a pH adjustment is made, the details of the adjustment must be recorded in the extraction logbook.

9. Swirl the 50-mL of methylene chloride that you added to the empty sample bottle and transfer to the corresponding separatory funnel. In addition, add 50 mLs of methylene chloride to the method blank, LCS, and spikes.

10. Seal and shake the separatory funnel vigorously for 2 minutes with periodic venting to release excess pressure. Alternatively, teflon separatory funnels may be placed in the shaker apparatus with the stopcock slightly open. When this apparatus is used, the shake should be for 3 minutes.

    NOTE: Methylene chloride creates excessive pressure very rapidly; therefore, initial venting should be done immediately after the separatory funnel has been sealed and shaken once.

11. Allow the sample to set for 10 minutes, if needed, after it has been shaken. It will separate into two layers with the solvent layer on the bottom. If it forms an emulsion (thick, cloudy, viscous, mixture that you cannot see through), drain what you believe to be 50 mL into a 250 mL centrifuge bottle. If the layers are clearly separated, drain the solvent layer into a 400-mL glass beaker.

12. Following Steps 10 and 11, extract two more times with 40 mLs of methylene chloride. Combine the three solvent extracts into the same 400-mL beaker.

13. In the logbook marked Pest/PCB extractions, enter the Client name, the Lab #, the date extracted, and anything unusual that may have occurred with this sample.

14. Dry the sample by either of the following methods:
    14.1 Get a ring stand with a double burette clamp attached to it. Cover the burette clamp ends with aluminum foil to prevent the possibility of solvent touching the plastic coated ends and dripping into the extract. Place a drying column into the burette clamp and transfer a small amount of glass wool to the top of it. Tamp it to the bottom with a glass rod so that it adequately covers the hole at the bottom. Add approximately 10 cm of Sodium Sulfate to the column. Rinse with of methylene chloride 20-30 mL and discard this rinse.

    14.2 Set up a ring stand with funnels. Place a small amount of glass wool in the bottom of it. Add ~2” sodium sulfate to the column and rinse with 20-30 mL methylene chloride. Discard this rinse.

15. If the extract was drained into a centrifuge bottle, at this point you will need to take it to the centrifuge. Push the "ON" button to turn the centrifuge on. Be sure that the orange holders are available for the 250-mL centrifuge bottles. The sample must always be balanced. If necessary, use a dummy bottle with similar weight using reagent water. Set the rpm at 2500 and the temperature at 25°C. Close the lid and be sure to press it down until you hear it lock. Move the lever at the front of the lid to the "LOCK" position. Turn the time to approximately 15 minutes and bring it back to 10 minutes. As the rotor begins to move, you will be able to see the rpm's in the digital readout. Stay with the centrifuge until it has come up to the rpm's set to insure that it does not become unbalanced. This looks like 8888 on the digital readout. Should this occur, refer to the manual. When the cycle is complete, the digital readout will read 0000. Push the "OPEN" button and the lid will pop up. Move the lever at the front of the lid to the "UNLOCK" position. Open lid and remove sample. The sample will usually be in two layers with the extract on the bottom.

16. Remove any water layer from the extract in the beaker or centrifuge bottle, by one of two methods. Remove with a Pasteur pipette by carefully pulling up the water layer, on top, and not the solvent. Discard this layer. Use the smallest amount possible of Na2SO4 by sprinkling the top layer with Na2SO4 until it hardens, separates, and drops to the bottom.

17. TURBO-VAP CONCENTRATION

    17.1. Rinse a Turbo-Vap tube and arrange it underneath a rinsed, packed drying column/funnel. Pour the extract through the column so that it will collect in the tube. Rinse the 400-mL beaker twice with 10 mL of methylene chloride. Rinse the column with 10 to 15 mL of methylene chloride. For solvent exchange purposes add 50 mL of hexane to each tube. Total volume in the glass evaporator tube should not exceed 200 mLs to avoid splattering on the lid of the Turbo-Vap. While waiting for the drying column/funnel to quit dripping, record the numbers of the Turbo-Vap tube in the Pesticide/PCB logbook and remove the tube to a metal holder.

17.2 Turbo-Vap Operation: Adjust pressure of nitrogen gas tank to >30 psi. Make sure the tank has 200 psi or more on the main valve. Temperature of the bath should be at 40°C -50°C. To help prevent cross contamination, cover the turbovap tube with aluminum foil and punch a small hole in the top.

17.3 Place the glass evaporator tube in the Turbo-Vap. Be sure to push tube down so the tip slides into the sensor well. Close the lid to start concentration. Check that each position with a tube has an orange light showing. If the orange light is not steady, bubbles may be in the sensor and need removal. (See Turbo-Vap manual).

17.4 When the Pesticide and/or PCB samples concentrate to approximately one mL, remove the tube from the Zymark.

NOTE: **For PCBs Only*** Some wastewater samples will form a gel like substance when the hexane is concentrated. Proceed with these samples as follows: Add just enough methylene chloride to make the gel go back into solution. Acid clean the extract and reconcentrate. Exchange with hexane again. If gel forms again, add enough methylene chloride to get gel back into solution. Transfer to a suitable container and record the final volume on the label and the extraction logbook. Note the percentage of methylene chloride in sample also.

17.5 When the beep sounds indicating the end of concentration, the extract will be at approximately one – one half mL (half way up tip of tube). Remove the tube from the bath. Hold the tube and the sample vial in one hand at about a 45° angle. Use a 9" Pasteur pipette to draw up the sample and transfer it to the 4.0-mL vial. Spilling a drop or two during the transfer is critical because one drop represents 5% of the sample.

17.6 Add 1 ml of hexane to the turbovap tube. Draw into the pipette and rinse down the conical portion of the tube several times. Transfer this rinse to the 4.0-mL vial. Rinse again with 1 ml of hexane and transfer to the sample vial. Adjust the volume to 4.0 ml with hexane. Cover the extract with a Teflon-sealed screw cap and transfer the label to the vial.

18. The extract obtained above may now be analyzed. Refrigerate to 4°C. Samples must be signed into the Hobart refrigerator. On log provided, enter the sample numbers, analyst initials, and the date and time the samples were placed into the Hobart.

NOTES:

If the final extract is yellow or dark in color or the matrix is oily and viscous, further cleanup may be desired. Refer to the Florisil Cartridge Cleanup Method, the Copper Cleanup Method, and/or the Acid Cleanup Method for further information. (SOP-309, 307, and/or 308)

Pesticides that have aldrin detected in them may be cleaned using the SW-846 method 3630 (Silica Gel Cleanup). The GC Lab would notify extraction personnel if this cleanup is necessary.

VII. DOCUMENTATION OF CAPABILITY (DOC)

Each analyst must perform a DOC to demonstrate proficiency with this method. Refer to SOP-413 for guidance.

VIII. WASTE MANAGEMENT AND POLLUTION PREVENTION

Please see Waste Disposal SOP-405 for the proper disposal of waste generated from this area.

Quantity of chemicals purchased should be based on expected usage during its shelf life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

IX. METHOD PERFORMANCE

Refer to SOP-211 for method performance.

X. HEALTH AND SAFETY

Refer to the MSDS sheets for the chemicals used for health and safety information. Also see SOP-336 for proper use of methylene chloride.

REFERENCES

1. *Test Methods for Evaluating Solid Waste*, SW-846, Third Edition
2. 40 CFR, Method 608.

DEFINITIONS

°C - degrees centigrade
COC - chain of custody
DL - detection limit
g - grams
KD - kuderna danish
LCS - laboratory control sample
µg/L - micrograms per liter
µL - microliter
µg/ml - micrograms per milliliter
ml - milliliter
mm - millimeter
MS - matrix spike
MSD - matrix spike duplicate
PCBs - polychlorinated biphenyls
Pest - pesticides
RL - reporting limit
SOP - standard operating procedure
TCMX - tetrachloro-m-xylene
v/v - volume to volume

Refer to SOP-431 for further definitions

SOP Title:

BNA & Pesticide/PCBs & TPH NON-AQUEOUS MATRIX (MICROWAVE EXTRACTION) USING SW-846 METHOD 3546

SOP NUMBER: SOP-343

REVISION NUMBER: 0

APPROVED BY:

SECTION MANAGER

QUALITY ASSURANCE OFFICER

EFFECTIVE DATE: 08/01/09

DATE OF LAST REVIEW: 08/01/09

BNA & Pesticide/PCB & TPH NON-AQUEOUS MATRIX
(Microwave Extraction)
Using SW846 METHOD 3546

1. SCOPE AND APPLICATION

a. This SOP describes the extraction of BNAs, pesticides/PCBs, and TPHs from soil, sediment, sludges and waste solids by an automated method (3546).

2. SUMMARY

a. Soil and solid samples are mixed with sodium sulfate and extracted with solvent in a Microwave extractor for BNAs, Pesticides/PCBs, or TPHs. The extracts are then concentrated by a Turbo Vap concentrator.

3. INTERFERENCES

a. Solvents, reagents, glassware, and other sample processing apparatus can add interferences to sample analysis. Method blanks must be extracted under the same conditions as samples to demonstrate freedom from interferences.
b. Phthalate esters commonly found in plastics can interfere with the analysis. Plastics should be avoided.
c. Soap residue can degrade certain analytes such as aldrin and heptachlor. Glassware should be solvent rinsed to avoid this problem.

APPARATUS AND MATERIALS

d. Stainless Steel spatula
e. Microwave extractor unit with 40 position carousel, electronic components, and ample ventilation
f. Microwave extraction Teflon tubes, capacity approximately 75mL
g. Suitable Teflon cap and screw-top lid
h. Drying column (Chromatographic column) – 20mm I.D. x 300mm
i. Vial – 2mL clear with Teflon-lined screw cap
j. Vial – 12mL clear with Teflon-lined screw cap
k. Syringe – 1mL, 500uL
l. Pasteur pipet – 9" length
m. Pasteur pipet bulb
n. Labels – Dymo
o. Aluminum foil – heavy duty
p. Nitrogen tank – equipped with pressure regulator
q. TurboVap Concentrator with 200mL concentrator tubes
r. Teflon funnels for pouring off
s. Balance – capable of weighing to 0.1grams
t. Aluminum pie pans for mixing samples
u. Filter paper – 185mm

4. REAGENTS

a. Sodium Sulfate (Na2SO4) – Granular, anhydrous, trace pure 10-60 mesh (purchased in bulk containers from Fisher #S415-10S or equivalent)
b. Methylene Chloride (Please read SOP – 336 before handling this solvent in our laboratory) (Dichloromethane) – suitable for spectrophotometry and gas chromatography (Fisher #D151-4 or equivalent)
c. Hexane – suitable for spectrophotmetry and gas chromatography (Fisher #H303-4)
d. Surrogate/Spike Solutions – Verify the amount of surrogate/spike to add to the sample prior to addition. It can change if a different detection limit is required or the volume of sample being analyzed changes or if the initial concentration of stock is different than that listed below:
    i. **BNA Surrogate (100ug/mL)** – The base neutral and acid surrogates are mixed together in one solution. This solution is prepared in methanol by making a dilution of stock purchased from a reputable vendor. Use 0.5mL of this solution per 15g of non-aqueous sample. **(For low-level PAHs use 1.0mL of 1.0ug/mL BN Surrogate spiking solution.)**
    ii. **BNA Spiking Solution #1 & #2 (100 ug/mL)** – The base neutral and acid spiking solutions are mixed together in one solution. This solution is prepared in methanol by making a dilution of stock purchased from a reputable vendor with same compounds as for calibration. Use 0.5 mL of this solution per 15g of non-aqueous sample. **(For low-level PAHs use 1.0mL of 1.0 ug/mL PAH spiking solution.) The BNA Spiking solutions contain all targets that are calibrated for GC/MS. DOD QSM requires all targets to be spiked in the LCS and MS/MSD.**
    iii. **TCMX/DCB (2,4,5,6-Tetrachloro-meta-xylene/Decachlorobiphenyl) Surrogate solution is** prepared in acetone by making a cut on stock purchased from a reputable vendor. 0.5mL at 0.5 ug/mL of this solution is added per 15g of non-aqueous sample.
    iv. **PCB Spiking Solution** – Arochlor 1016/1260 or the PCB of choice (1242, 1248, 1254, or 1260 are the most common) is prepared in acetone at a concentration of 5.0ug/mL. PCB stock is usually purchased from RESTEK or equivalent. The PCB to use may be determined by viewing historical data or asking the GC operator. Use 0.5mL per 15.0g of non-aqueous sample.
    v. **Pesticide Spiking Solution** – A spiking solution is prepared at 1.0 ug/mL. Use 0.5mL per 15g of non-aqueous sample.
    vi. **TPH Surrogate** – Surrogate solution is prepared in acetone by diluting stock ortho-terphenyl standard to a final concentration of 20 ug/mL. Use 1mL per 15 grams of sample.
    vii. **TPH Spike** – A spiking solution is prepared by extractions analyst that has a concentration of 1000 ug/mL in acetone.

5. SAMPLE COLLECTION, PRESERVATION, AND HOLDING TIMES

a. Samples are collected in an appropriate size wide-mouth glass jar (4oz. or 8 oz.) with a Teflon-lined cap.
b. Samples are preserved by cooling to 4°C.
c. Holding time is 14 days from collection date to extraction.

6. PROCEDURE

a. All soils have a 14-day holding time counted from the day they are sampled. Determine the samples necessary to extract using the following information (DO NOT extract samples for which you have no information.):
    i. Each day a backlog is generated in ELEMENT providing all relevant sample information, including samples numbers and respective analysis required.
    ii. Samples requiring RUSH turn around time may be logged in throughout the day which will require your immediate attention. Log-in personnel will generally communicate this need.
    iii. Check the backlog throughout the day to re-evaluate priority if needed.
b. Wearing lab coat, gloves, and safety glasses, get samples from cooler. Samples must be signed out of the walk-in refrigerator. Enter the sample numbers, your initials, and the date and time removed on the log provided. Inspect as to whether they are in glass and have a Teflon lid. Find out if any special dilutions need to be made for this client. If the sample has a particularly bad matrix or a strange matrix, see your supervisor to find out if a microwave extraction is truly necessary.
c. Get twice the number of aluminum pie pans to prepare the number of samples you have plus any additional spikes of LCSs and a method blank. A method blank and LCS must be processed with each set of samples. A matrix spike, a duplicate or a matrix spike duplicate and a LCS must be processed for each analytical batch (up to a maximum of 20 samples). Using the LIMS, create a batch of samples and print off sample labels. The LIMS will create a unique batch sequence number.
d. Decant and discard any water layer on a sediment sample by carefully pouring this off into a trashcan.
e. Dump the entire sample into an aluminum pie pan and mix sample thoroughly with a spatula until mixture is homogenous. Discard any foreign objects such as sticks, leaves, and rocks.

It is extremely important that waste (when appropriate), soil and sediment samples be mixed thoroughly to ensure that the sample is as representative as possible of the sample media. The most common method of mixing is referred to as quartering. The quartering process should be performed as follows:

- *The material in the sample pan (inorganic-plastic/organic-aluminum) should be divided into quarters and each quarter should be mixed individually.*
- *Two quarters should then be mixed to form halves.*
- *The two halves should be mixed to form a homogenous matrix.*

This procedure should be repeated several times until the sample is adequately mixed.

NOTE: Samples that are clay type materials should be handled in a different manner. Due to these type sample matrices having an affinity to stick to most anything that touches it, another approach must be followed. Obtain a representative sub-sample aliquot from the center or middle section of the sample container

f. Place an aluminum pie pan on the balance and zero it. Calibrate balance with ASTM class-1 Troemner weights or equivalent, bracketing desired weight (50g, 20g, 10g, 5g, 1g). Record calibration in the Extraction calibration/temperature logbook. Using a spatula, transfer the **appropriate weight, {10-20 grams depending upon client or project specific Detection Limits (DL) and/or Reporting Limits (RL)}**, of a representative sample to the nearest 0.1 gram. Normally 10 or 15g sample weights are used. Record this amount on your label. Put your label on the side of the 400-mL beaker. For spiking purposes, weigh 3 aliquots of the appropriate sample. Pick a sample with a good matrix, one that mixes well, non-oily, etc.

g. Add ~ 15 grams of sodium sulfate to the aluminum pie pan. Using a spatula and/or a glass rod, mix the sample thoroughly with the sodium sulfate until it becomes a sandy texture. If necessary, add additional sodium sulfate. When removing the spatula or glass rod from the mixed sample, leave behind all the sample possible. Cover the aluminum pie pan with foil and continue to weigh up the remaining samples. For the method blank and LCS, weigh up 15 grams of sodium sulfate. The matrix used for the method blank and LCS must be free of the analytes of interest and processed through the same analytical steps as the samples.

h. Verify the amount of surrogate/spike to add to the sample prior to addition. It can change if a different detection limit is required or the volume of sample being analyzed changes. Set out the surrogate/spike at least ten minutes before use to allow it to warm to room temperature. Someone must verify that the surrogate/spike has been added by watching and signing off on bench sheet.

NOTE: Surrogate and spike should be added just prior to extraction.

i. Using the 1-mL glass syringe designated for BNA surrogate, add 0.5 mL of BNA surrogate to each sample, spike, and blank. **(For low level PAHs use 1.0 ml of the 1.0 µg/mL BN Surrogate spiking solution.)** or using the 1.0-mL glass syringe marked TCMX/DCB surrogate, add 0.5 mL of TCMX/DCB surrogate to each sample, blank and spike. TPH samples will need 1.0 mL of appropriate.

   For the BNA sample in each analytical batch selected for spiking, use the 0.5-mL glass syringe marked Base Neutral Acid Spiking to add 0.5 mL of the Base Neutral Acid Spiking solution. **(For low level PAHs use 1.0 ml of the 1.0µg/mL PAH spiking solution.)**
   For Pest/PCB samples, determine if the sample will require a Pesticide Spike and/or a PCB Spike. Proceed as follows:
   Pesticide and PCB - set up two LCS's – one for Pesticide getting an AB MIX spike and one for PCB, which should be spiked with PCB 1660. In addition to the LCSs, a matrix spike/matrix spike duplicate is necessary for the pesticide. Prepare a PCB matrix spike/ matrix spike duplicate if requested by the client.
   Pesticide only – To the sample in each analytical batch selected for spiking, add 0.5 mL of Pesticide Spike (Mix A&B) with a glass syringe dedicated for Pesticide Spike.
   PCB only - To the sample in each analytical batch selected for spiking, add 0.5 mL of PCB 1016/1260 (unless otherwise specified, 1248 for BB&L) using a 1.0 mL glass syringe dedicated to that PCB. Add 20 grams of Na2SO4.

j. Place a Teflon cap and Teflon screw top on the Teflon microwave tube. Using the cap tightener station, tighten the caps and invert sample to insure proper mixing and check for leaks in cap.

k. Place microwave tubes in microwave carousel making sure they are in order and spaced evenly throughout the carousel to insure proper heating while in microwave.

l. Place microwave carousel in microwave making sure the carousel is properly lined up with the turning mechanism.

m. Choose saved program option based on total number of samples to extract and begin process by pressing the start button. The program is set to EPA method 3546 specifications.

   For 1-15 samples:
   Max power: 800W 100%
   Ramp time: 15:00
   Control temperature (in Celsius): 110
   Hold time: 10:00
   Cool down: 5:00

For 16-40 samples:
Max power: 1600W 100%
Ramp time: 15:00
Control temperature (in Celsius): 110
Hold time: 10:00
Cool down: 5:00

n. Allow samples to cool in the carousel for an additional 30 minutes before attempting to handle the extracts.
o. Transfer the extract to a pre-rinsed turbo vap tube by first passing through a funnel with P4filter paper sodium sulfate. All tubes and funnels should be pre-rinsed with Methylene Chloride. After pouring the extract into the turbo, rinse the microwave tube 3 times with Methylene Chloride and transfer the rinsate to the turbo. Finally, rinse the funnel with an adequate amount of Methylene Chloride using a Teflon squirt bottle. This ensures optimum transfer of all compounds of interest.
p. Now concentrate the extract to 1.0mL using the turbovap concentrator.
    i. **Turbo-Vap Operation:** Adjust the pressure of nitrogen gas tank to 50 psi. Make sure the tank has 200 psi or more on the main valve. The temperature of the bath should be approximately 50-55°C. The pressure target range should be about 20-25 psi.
    ii. Place the turbo vap tube in the Turbo-Vap. Be sure to push tube down so the tip slides into the sensor well. Close the lid to start concentration. Check that each position with a tube has an orange light showing. If the orange light is not steady, bubbles may be detected by the sensor and need removal. (See Turbo-Vap manual).
    iii. When the beep sounds indicating the end of concentration, the extract will be at approximately 1 mL. Remove the tube from the bath.
q. BNA and TPH samples need to be concentrated to ~1.0mL while Pesticides and PCB should be concentrated to ~5.0mL in turbo vap. Using clean solvent, rinse turbo with Pasteur pipet and bring sample to volume in sample vial.

7. DOCUMENTATION OF CAPABILITY (DOC)

a. Each analyst must perform a DOC to demonstrate proficiency with this method. Refer to SOP-413 for guidance.

8. WASTE MANAGEMENT AND POLLUTION PREVENTION

a. Please see Waste Disposal SOP-405 for the proper disposal of waste generated from this area.
b. Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

9. METHOD PERFORMANCE

a. Refer to SOP-201 SOP-211 and SOP-219 for method performance.

10. REFERENCES

a. EPA Methods SW-846, Method 3546

11. DEFINITIONS

a. Refer to SOP-431 for definitions.

12. HEALTH AND SAFETY

a. Wear appropriate personal protection equipment when working with chemicals or samples.
b. Use the lab hoods when working with solvents.
c. Use caution when mixing strong acids or bases. Solutions will become extremely hot when mixing with water. Avoid splashing these solutions so they won't come in contact with the skin or eyes. If this happens, flush with lots of water. Contact your supervisor if serious and medical attention is needed.

LABORATORY SAMPLE RECEIVING, LOG IN AND STORAGE STANDARD OPERATING PROCEDURES

SOP NUMBER: **SOP-404**

REVISION NUMBER: **13**

APPROVED BY:

SECTION MANAGER

TECHNICAL DIRECTOR

EFFECTIVE DATE: **06/29/09**

DATE OF LAST REVIEW : **06/29/09**

LABORATORY SAMPLE RECEIVING, LOG IN AND STORAGE

This SOP lists in as much detail as possible our daily procedures for sample receiving, log in and storage of laboratory samples. Keep in mind that there may be project specific requirements that are more strict or different than our routine procedures. In these instances, the project specific requirements must be met and followed. Although a few project specific requirements are detailed in this SOP, i.e. USACE certification issues, not every situation can be addressed. If there is ever any uncertainty on what procedures must be followed, please see the Testing Coordinator immediately. If ever in doubt, always go with the more stringent requirements. This document will constantly be reviewed and revised as necessary.

SAMPLE ACCEPTANCE CRITERIA

A sample may be rejected for compliance purposes if it does not meet the following criteria. Analyses may only proceed after notification and approval to proceed from the client or from the laboratory manager.

1. Sample must be properly preserved and in the proper container for the requested analysis.
2. Sample integrity must be maintained. The container shall be intact without cracks, leaks, or broken seals.
3. Adequate sample volume must be received for the requested analysis, including volume for any requested QA/QC (MS/MSD).
4. The sample ID on the bottle label must match the sample ID listed on the chain of custody.
5. The sample container label and the chain of custody must be completed with indelible ink. The sample label must be intact and list all necessary information; to include: sample date, sample time, sampler, and sample ID/location. The chain of custody shall also indicate sample date and time, requested analyses, and all necessary client information.
6. Sample temperature must be less than 6°C or received on ice.
7. Sample must be within holding time for the requested analysis.

These issues are discussed in more detail below under the "Sample Receiving" section of this document.

I. Sample Receiving

A. Samples are received at the Empirical Laboratories on 621 Mainstream Drive, Suite 270 Nashville, TN 37228.

1. The majority of samples are shipped in coolers by couriers such as Federal Express and UPS. All couriers are generally received in the Empirical Laboratories Sample Receiving (SR) area loading dock in back of the laboratory. The laboratory is located close to the Federal Express (FedEx) distribution station, therefore we do pick up our

coolers at the FedEx location and transport them back directly to the laboratory. Some coolers and/or samples are delivered directly to the SR area by the sampler and/or client.

2. Some coolers and/or samples may be received directly by Empirical Laboratories Sample Receiving personnel. If samples are hand delivered by the client make sure that necessary paperwork is included and that you sign and date the chain of custody, as well as record the temperature of the samples on the chain of custody as well. If the *Empirical Laboratories* ***Chain of Custody [Attachment II]*** is used the white and yellow copy of the chain of custody is retained and the pink copy must be given to the client.

B. When going through the required steps for Sample Receiving and Sample Log In, keep in mind that a ***Corrective Action Report (CAR) for Sample Receiving [Attachment III]*** must be completed to document any problems, discrepancies, project changes, etc. encountered during the process. This includes but is not limited to incorrect sample containers, improper preservatives [chemical and temperature], chain of custody discrepancies, sample descriptions, etc. A CAR may be completed just to keep a record of a situation, which is not actually "out of compliance."

1. Make sure that all information on the CAR is stated clearly and very detailed. Many times it is necessary to refer to these documents a year or more after they were completed. Document all correspondence including name, date, company and response.

2. The CAR forms must be numbered starting with No. 001 at the beginning of the year (e.g. 01-001). No two forms should have the same number. All CARs must be forwarded to the Project Manager and/or receiving manager for approval and distribution. THIS MUST BE DONE ASAP OF WHEN THE PROBLEM/SITUATION IS DISCOVERED.

C. Visually inspect all coolers for tampering, custody seals present and intact (if applicable) leakage, etc. If a cooler has been damaged beyond repair, unpack the samples and discard the cooler as to not reuse it. If you suspect a cooler may be damaged or is extremely dirty this cooler must not be reused. If coolers were sent by Federal Express, examine the Federal Express airbills for the number of packages in the shipment and make sure that all the packages (coolers, boxes etc.) in a group have been received. If there are any problems the Project Manager must be contacted immediately. If anything looks unusual, take the time to check it out and document the situation and findings.

D. Open each cooler in order to quickly inspect the contents and to locate the chain of custody. Sample Receiving personnel should wear the following personal protection equipment: gloves, safety glasses and a laboratory coat. All coolers received from projects with the **US Army Corps of Engineering (USACE) and AFCEE** projects should be opened under the hood in the sample storage room. Sign then list the date and time received on the chain of custody. The time received <u>must</u> reflect the actual time the samples were received even though they may be logged into the system at a later time. Samples received on Saturday may be processed on the following Monday morning, or samples received late in the day during the week may be processed the next morning. All cooler(s) <u>must</u> be opened, examined for

leakage, breakage etc., the temperature measured and the chain of custody signed and dated to reflect the actual date and time which they were received. The samples must be delivered to the appropriate analytical department or put in cold storage as soon as possible.

1. Attach any shipping receipts, work orders, etc. to the chain of custody.

2. If a chain of custody or other paperwork is not sent, the client must be contacted and the samples temporarily placed on hold in cold storage. In some instances the log-in person may complete a chain of custody. The required information may be found on the sample containers or it may be necessary to call the client to get the missing information (i.e. sample ID, collection date and time, etc.). Note on the chain of custody that it was completed by laboratory personnel and record the name of the person with whom you spoke. All attempts to encourage our customers to complete a chain of custody or submit written information for samples must be made.

3. Project specific paperwork may be required. For all projects, a ***Cooler Receipt Form [Attachment IV]*** must be completed for each cooler received. Sample receiving personnel must begin completing this form as soon as a cooler is received and complete this form as samples go through the log in process.

E. The temperature of each cooler or set of samples must be measured as quickly as possible using a thermometer with 0.1°C increments. This thermometer must be calibrated against a NIST certified thermometer once a year and this information recorded in a bound notebook. The Certificate of Calibration for the NIST thermometer is kept on file at the QAO's desk. The thermometer must be tagged with the unique identification number of SR#1 and serial #; (Sample Receiving #1), the date calibrated and the correction factor. This information must also be recorded in a bound notebook. Only this thermometer can be used for recording the temperature of sample coolers upon receipt.

1. To measure the temperature, open the temperature control blank if supplied, point the IR thermometer at the liquid surface, wait 30 seconds for temperature to stabilize. Read the temperature to the nearest 0.1 °C. The corrected value temperature must also be recorded on the chain of custody. (This value will also be recorded into the LIMS at a later point.). All regulatory compliance samples received from North Carolina that do not meet the temperature requirement will be segregated and the client will be notified of the non-compliance. The samples will not be analyzed until we receive client notification to proceed with analyses.

2. If the temperature exceeds 6°C for any sample, the Project Manager or Sample Receiving personnel must contact the client immediately. There may be tighter temperature control limits for specific project requirements. The customer must make the decision to either continue with the analyses or resample. Make sure the client is aware that if the samples are analyzed, the following qualifier is normally included on the final report: "The shipping cooler temperature exceeded 6°C upon receipt to Empirical Laboratories. This may have an impact on the analytical results. The concentration may be considered as

estimated." Not all samples for the project will be flagged, just those samples received above 6°C.

Many times we are not able to get in touch with the client quickly and the best judgment on how to handle the samples must be made after discussion with the Testing Coordinator and/or Laboratory Director or Technical Director. The samples may still need to go through the log in process although it may be eventually determined that the samples will not be analyzed or the samples may temporarily be placed on hold and not logged in. Above all do not allow the samples to set out at room temperature for an extended period of time while waiting for a decision. **A CAR outlining the problem and all correspondence must be completed.**

The only exceptions to the 6°C rule are:

a. Water samples for all Metals, (except Chrome 6+ and mercury) that have been preserved with HNO_3 to a pH of ≤ 2. *Keep in mind that non-aqueous sample for Metals must be cooled.*

b. Samples for Fluoride, Chloride and Bromide.

c. Waste/Product samples for all parameters.

d. Samples generated in the Aquatic Toxicology laboratories and brought directly to Sample Receiving after they are collected. Sample receiving personnel should place these in cold storage as soon as possible.

e. Samples collected locally by Empirical Laboratories personnel or local customers that hand deliver their samples. In some instances these samples may not have had time to cool down; however, these samples should have been placed on ice in an attempt to cool them to the proper temperature. This exception is only applicable if the samples were collected the same day as the laboratory receives them. It should be noted if samples are "Received On Ice" (ROI).

f. Samples that are received on ice and it is evident that the client made a good faith attempt to properly cool the samples.

F. If several coolers are received at once, they must be inspected to determine the order in which the samples should be unpacked and logged in. The following priorities should be given:

1. Any analyses, which have a 24-72 hour holding, time. It is the log-in person's responsibility to notify the department manager or section group leader of such samples via e-mail and verbally.

2. Any sample which has almost exceeded its' holding time. (Especially watch for this with waters organic extractions, Solids and Sulfides, all of which have only 7 days). A list of parameters and holding times is posted in the log-in room.

   a. If a sample is received already out of holding time, the project manager must be contacted. The sample can be analyzed at the client's request, but it will be qualified on the final report as being analyzed out of holding time. The project manager must inform you of the client's need.

   b. If a sample is received with limited holding time remaining for any parameter it may be necessary to contact the project manager so that he/she can contact the client. If the sample has to be analyzed on a rush basis to meet the holding time a rush charge may apply. Also it may not be possible to analyze the sample within the holding time due to sample load, etc. A CAR must be completed.

3. Samples requiring rush turnaround.

   a. If sample(s) require 24-hour turnaround they will take first priority. Other rush requests also have high priority.

   b. The Project Manager and/or Section Manager must be contacted for approval concerning any unscheduled rush requests.

G. Unpack all samples from the cooler. If there are any known or suspected hazards this must be done under a hood. All coolers from USACE projects should be unpacked under a hood. It may be necessary to rinse off the outside of the containers in the sink and/or wipe them off with a paper towel.

   1. Visually inspect them for tampering and custody seals (if applicable). Sort and inventory the samples against the chain of custody by arranging them in the same order as they are listed on the chain of custody. Normally samples are assigned log numbers in the same order as they are listed on the chain of custody but for certain projects or situations it is acceptable to arrange them in a manner which will make them easiest to log in.

   2. Check for leakage as this could compromise the sample integrity. If any spillage occurred in the cooler make sure this is noted. Also list all the other samples in the cooler as cross contamination could occur. A CAR must be completed and the Project Manager and/or the customer may need to be notified in these situations. It may be necessary to resample.

H. Check the chain of custody information against the information recorded on the containers. If these do not agree, contact appropriate person (s) - Project Manager, sampler, client, etc. All problems must be documented with a CAR.

1. If major changes are made on the chain of custody received from an engineering job, then the PE should submit written confirmation of these changes or make the corrections and initial them directly on the chain of custody.

2. Any error found on the chain of custody must be marked through with one line, initialed and dated and the correction written in.

I. Note any unusual requests, methodology, hazards (known or suspected) to the Project Manager and/or Laboratory Section Manager or analysts before the samples are actually logged in. Keep notes of any problems (improper containers, preservatives, temperature, or descriptions, etc.) A CAR must be completed and the analyst or manager should be notified immediately. If ever in doubt, fill one out!

II. Sample Log In

A. After samples have been unpacked, sorted and reviewed, they are then ready to be assigned log numbers and continue through the log in process. Make sure that the parameters for the samples are clearly marked on the chain of custody. If we prepared the sample kits there should be a sample kit work order form. Contact the Project Manager if there are any questions, problems, etc.

B. Assign a work-order and sample number to each individual sample and record it on each sample container and the chain of custody.

1. All containers with the same description must have the same sample number even if they have different preservatives and require different tests. However, each different fraction (bottle type and/or preservative) should be designated with a letter (A, B, C, etc.)

2. Grab and composite samples from the same sample location must be considered as separate samples. It may be necessary to use "grab" or "composite" as part of the sample description to distinguish between the samples. Only assign different log numbers to them if the parameters are clearly marked as grab and as composite. Do not assume that VOC must be analyzed from grab samples so therefore the client must have taken a grab sample.

3. Sample numbers must begin with 001 at the beginning of each year (e.g. 0101001).

C. Check the following items and record this information on the cooler receipt form to further ensure sample integrity. A CAR must be completed if any of the following requirements are not met and it may be necessary to contact the client. We can perform the analyses in most cases and will do so with the client's approval, however the results may be qualified in some manner on the final report.

Preserving sample integrity throughout the log in procedure must be one of our section's top priorities. This includes not only ensuring that the proper chemical preservatives have been added but also that the samples are received and maintained at the proper temperature. ***When samples are unpacked they must be placed in cold storage within two hours even if they have not been through the entire log in procedure.*** All samples for NPDES compliance monitoring from North Carolina will be stored at a temperature range of 1.0 to 4.4°C. All other NPDES samples will be stored at 4.0 ± 2.0°C. On the days we receive a large volume of samples, or are short handed, etc., we may not be able to completely log in all samples until late in the day or even the next day. Samples should not set out at room temperature if there is a delay. The samples must temporarily be placed in cold storage until you are able to complete the log in procedure. This should also be done when we take lunch breaks.

[Make sure the VOC containers are not temporarily stored in a non designated VOC only storage area.]

1. Determine if the samples were received at the proper temperature. (See section IC)

2. The sample descriptions on the bottle should match those on the chain of custody. (See section 1H)

3. Check to determine if the proper chemical preservatives were added to adjust the sample to the correct pH. All regulatory compliance samples received from North Carolina that do not meet the preservation requirement will be segregated and the client will be notified of non-compliance. The samples will not be analyzed until notification to proceed with analyses is received from the client. A list of parameters and the required chemical preservatives is posted in the log-in room. The verification of this preservation will be recorded on the Cooler Receipt Form for all projects. If Empirical Laboratories prepared and shipped out the sample containers they will have been pre-preserved unless instructed otherwise by the client. Complete traceability of the preservatives used to pre-preserve the sample containers and to preserve samples in the log-in area is required. A bound notebook must be used to trace this information and must include the following: Lot #, Type of preservative, Date Prepped, Amount and Analyst Name. This information must also be labeled on each container, re-pipetter, etc. that the preservative is stored in. Each lot of HNO3 used for Metals preservation must be tested prior to using them for preservation. These analyses are kept on file.

   a. The pH of each container (except VOA vials) which requires pH preservation must be checked. Do not open and check the pH of VOA vials in sample receiving/log-in.

   b. The pH of preserved samples is checked and confirmed using pH narrow range indicator paper. When the client request pH analysis on samples and they must be reported and measured for pH using the narrow range paper, rather then a pH meter, the accuracy of each batch of indicator paper must be calibrated to the nearest tenth versus certified pH buffer and recorded into a bound logbook in accordance with SW846 method 9041A pH Paper method.

c. When taking the pH reading, DO NOT PUT THE pH PAPER DIRECTLY INTO THE SAMPLE CONTAINER. Pour up a small aliquot and dispose of this volume after the pH is taken. For some samples (wastes) the indicator paper may not be accurate due to interferences. The observation of the appropriate color change is a strong indication that no interferences have occurred. If it appears as if there is interference, the pH must be measured using the pH meter. [See SOP ATSD-187 pH, Electrometric.]

4. The following guidelines must be followed to check pH preservation:

a. Water samples for Cyanide analyses must be preserved to a pH of >12 with NaOH upon collection. If the pH of these samples is between 11.0-12.0 upon receipt, and the samples are at the proper temperature and not over 48 hours old it will not be necessary to complete a CAR, however the sample should be adjusted to ≥12.0 unless project/client specific requirements are to contact the client first.

b. Water samples for Metals analyses must be preserved to a pH of ≤2.0 with HNO_3 upon collection. If the pH of these samples is between 2.0-.3.0 upon receipt, and the samples are not over 48 hours old it will not be necessary to complete a CAR, however the sample should be adjusted to ≤2.0. unless project/client specific requirements are to contact the client first.

c. Samples requiring analyses which are preserved with H_2SO_4 (i.e., Nitrogen compounds, Total Phenolics, Oil and Grease, Total Phosphorus, etc.) can be accepted up to a pH of 2.5 without a CAR, however the sample should be adjusted ≤2.0 unless project/client specific requirements are to contact the client first. Samples for sulfide analysis must have a pH >9.

d. If a sample is not properly preserved, log-in personnel must either do the following:

- To meet project specific requirements, including all USACE projects, the client must be notified before preserving or adding additional preservative to the sample unless otherwise instructed. If the client instructs us to add chemical preservatives to a sample, complete traceability of the preservatives used is required (See section IIC, #3). A CAR must be completed.

- For other projects it may be acceptable to preserve the sample accordingly before the sample is placed in storage. Complete traceability of the preservatives used is required (See section IIC, #3). A CAR outlining the project and the steps taken must be completed.

- All metals samples preserved upon receipt must be held 24 hours before proceeding with analysis. These samples must be CAR generated and the client notified to see if the lab is to proceed with analysis.

e. In some instances it may not be possible to adjust the sample to the proper pH due to matrix problems which cause excessive foaming or require an unusually large amount of acid. Do not continue to add acid if a few mL's of acid does not lower the pH. Notify the Project Manager, Metals Manager and/or analyst. They will make the decision if the sample will be diluted, not analyzed, etc. A CAR must be completed in these situations. Make sure you note on the container and in the LIMS notes that the sample is not at the proper pH as well as any useful information (i.e., foaming, strong odor, etc.).

f. A CAR may not be required for samples generated in the Aquatic Toxicology Laboratories and brought directly to Sample Receiving after they are collected but before they are preserved. Log-in personnel must preserve the samples accordingly before they are placed in storage. Complete traceability of the preservatives used is required (See section IIC, #3). A CAR outlining the project and the steps taken must be completed.

5. Check to make sure samples are in proper containers and that there is adequate volume for all the parameters requested and no leakage.

6. If VOA vials are present, each vial must be inverted and checked for head space. "Pea-sized" bubbles (i.e. bubbles not exceeding 1/4 inch or 6 mm in diameter) are acceptable and should be noted, however, a CAR is not required. Large bubbles or head space is not acceptable and a CAR must be completed. If this occurs, the client must be contacted. The samples can be analyzed with their approval, however the report will be qualified and the data may be questionable. All VOA vials will be preserved with $Na_2S_2O_3$ (0.2g) when chlorine is known to be, or suspected to be present.

7. All pesticide samples to be analyzed by method 608 will be checked by the sample receiving personnel for the correct pH range of 5.0 to 9.0. The pH of the sample(s) will be communicated via E-mail to the Section Manager and appropriate analyst.

8. All chlorinated effluent samples received for Cyanide must be checked for residual chlorine. The one liter sample container should initially contain 1 to 2g/L of Ascorbic Acid. Potassium Iodide starch indicator paper will be used for detecting the presence of residual chlorine. DO NOT PUT THE TEST PAPER DIRECTLY INTO THE SAMPLE CONTAINER. Pour up a small aliquot, neutralize, test and dispose of this volume after the sample is checked. If the test paper turns blue, the sample must be treated for residual chlorine. Add Ascorbic Acid, approximately 0.6g at a time and recheck the sample until there is no residual chlorine present. If the sample required this treatment this information must be included in the LIMS notes. This must be done by log-in personnel before leaving the receiving area. It may be necessary to notify the Inorganic Manager and/or analyst.

9. Be aware of holding time requirements. (See section 1D)

D. Once sample containers have been numbered, they must be checked by another laboratory individual to ensure that the log number on the container matches the log number and sample ID on the Chain of Custody. A ***Sample Receiving Custody and Disposal Form [Attachment VII]*** must be completed each day. Samples should not leave the log-in area until this has been completed. *[see IIC; it may be necessary to temporarily store samples in cold storage until the samples can be second checked, the amount of time that the samples are at room temperature must be minimized as much as possible.]* The original is to remain in Sample Receiving until the samples are disposed of. Once the document is complete, the original will be kept on file. The following information must be logged onto this form:

1. Client and Log #s
2. Date/Time Unpacked
3. Logged In/Numbered By (Initials)
4. 2nd Checked By (Initials)
5. Date/Time Placed in Cold Storage
6. Storage Area (Walk In, VOC Cooler, Quarantined Soils, Quarantined-VOC, Other)
7. Disposed of By/Date
8. Method of Disposal

E. Notify the proper analyst if samples have been logged in for analyses which have a 24-48 hour holding time or if a 1-2 day turnaround has been requested. The log number and description on sample (s) must be second checked before it is released to the analyst. (The analyst can second check the sample, but must initial the custody form.)

III. Sample Storage

A. After samples have been correctly logged in they are then transferred to one of the following cold storage areas and arranged in numerical order by the assigned log in/LIMS sample number. ***Note that aqueous VOC samples must be segregated from all other samples.***

1. The Hobart refrigerator in the MS Lab: All aqueous VOC's must be stored in this refrigerator. Storage blanks consisting of organic free water from the laboratory may be required for specific projects. These will be analyzed for VOCs only. ***Storage blanks are required for all DOD projects.***

2. Walk In Refrigerator: All aqueous samples for all analyses must be stored in this refrigerator.

3. Soil Walk-In Refrigerator: All quarantined and non-quarantined soil samples for all analyses must be stored in this refrigerator.

B. Quarantined soils are those quarantined by the US Department of Agriculture. These soil samples must be segregated from other soil samples during storage. A separate disposal log must be maintained for these soils including the location, date and quantity of the soil received and processed. Soil residues from quarantined samples must be treated according to regulations after testing (see Sample Disposal SOP). Quarantined soils are defined as:

1. Soil taken from much of the southeastern US and parts of New York and Maryland at a depth of three feet or less. *Soils from three feet or more are not regulated provided they are stored separately.* A map of the regulated areas in the United States entitled ***Soil Movement Regulations [Attachment VIII]*** is posted in the log-in room.

2. All soils taken from foreign sources, US. Territories and Hawaii.

NOTE: All soils are treated as quarantined soils and are disposed of in accordance with USDA regulations. Above for information purposes only.

C. All samples must be stored in one of the three refrigerators detailed above with the following exceptions:

1. Matrices that may be adversely affected by the cold temperature. (e.g. surfactant samples, multi-phase samples)

2. Highly contaminated waste or product type samples that could jeopardize the integrity of other samples in the walk in cooler. Often these can be stored at room temperature. If these require refrigeration see the Project Manager for other options.

D. The temperature of each sample refrigerator must be monitored and recorded each day by Wet Chem personnel by the following method. A Mercury thermometer or digital min/max thermometer with 1° increments must be used. Each thermometer must be calibrated against a NIST certified thermometer once a year **(digital thermometers quarterly)** and this information recorded in a bound notebook. The Certificate of Calibration for the NIST thermometer is kept on file at the QAO's desk. The thermometers must be tagged with a unique identification, the date calibrated and the correction factor.

The tolerance range for all refrigerators is 1 to 6°C. This range and the range using the corrected reading must be posted on the outside of each cooler. If the temperature exceeds this range, corrective action measures must be put in place immediately. A CAR must be completed specifically noting the date and time the problem was discovered. The Project Manager, Laboratory Director and Technical Director will be notified in order to assess the situation. It may be necessary to put a service call in to the refrigeration repair service.

E. All personnel removing samples from any refrigerator must sign them in and out. This is done by completing the ***Sample Custody Form [Attachment IX]*** which is attached to the door of each refrigerator. These completed forms are kept on file [see section III, #4F]

F. The water walk in refrigerator in the sample room is the largest refrigerator and stores a large majority of the samples. A back up compressor is hooked into the system and scheduled to automatically come on if the main compressor fails. There is a digital min/max thermometer, which monitors the temperature 7 days a week. This thermometer will be calibrated quarterly against the NIST thermometer.

G. As stated above the temperatures for all refrigerators that samples are stored are checked each day Monday-Friday and monitored seven days a week with min/max thermometers. Pay close attention to these readings and watch for signs of possible problems.

H. A temperature maintenance record book is kept for each refrigerator.

I. Samples must be held for a minimum of 30 days after the final report unless specified otherwise. For USACE projects, samples must be held for a minimum of 60 days after the final report unless otherwise specified. See SOP ATSD 405 entitled Analytical Laboratory Waste Disposal SOP for guidance on disposal of samples.

IV. Laboratory Information Management System (LIMS)

A. Log the sample information into the LIMS for each sample. Every attempt should be made to get every sample logged into the LIMS by the end of the day. All information entered should be clearly stated and recorded on the COC provided. After opening the main menu of the LIMS, select the 'Work Orders' tab from the 'Sample Control' drop down menu. Now click on the 'Add' button to create a new Work Order. You will see the following:

1. ***Client*:**

   Select the client I.D. by clicking on the pull-down and choosing from the client list. This list is in alphabetical order. If the desired client is not on the list, a new client must be created by the project manager or I.T. director.

2. ***Projects*:**

   Click on 'Projects' and choose the project I.D. The projects will be client specific. After the project is chosen the "project information" areas should fill in. The 'Project Name,' 'Project Number,' 'TAT,' 'Client Project Manager,' 'Lab Project Manager,' and 'Comments' information should also appear. If there are no applicable project choices, a project must be created by the project manager or I.T. director. There are two types of projects:

a. Internal -- Empirical Laboratories projects;

b. External -- direct laboratory clients.

3. ***Comments:***

This area is to be used to note any information from the project manager for all work orders of this project. It can also be used to list any work order specific notes; this includes but is not limited to information concerning rush turnaround, deliverables or other QC requirements, analyte concentrations, safety issues, quarantined soils, CAR #s, preservation or matrix problems, etc.

4. ***Received By:***

Enter the name of the person who received the samples.

5. ***Logged In By:***

Enter the name of the person who logged in the samples.

6. ***Received:***

Enter the date and time received separated by a space and using military time.
Example: *08/02/2008 08:30*

7. ***Project/Package Date Due:***

After the date and time received have been entered, the date due for both of these fields will be calculated. If this information is not correct or needs to be amended later, check with the project manager before doing so.

8. ***Shipping Containers:***

Click on the 'Coolers' button and enter the temperature and condition upon receipt. If more than one cooler was received, each cooler must be assigned a different name. For example, if these came in by dedicated courier, enter the last four numbers of the Tracking Number as the name. After all of a cooler's information has been entered (received on ice, where custody seals present, preservation confirmed, COC/container labels agree, sample containers in-tact) click the 'Save' button. If more than one cooler was received, click the 'Add' button and repeat the process above, then click 'Done' after all the coolers' info has been saved.

9. ***COC Number:***

If an identifiable COC number is listed, record that ID here.

10. ***Shipped By:***

Enter the courier used to deliver the samples. If the samples were picked up by a lab employee or dropped of by the client/representative, enter 'Hand-Delivered.'

After these items have been completed, click 'Save,' then the 'Samples' button to continue. To begin entering information for a sample, click the 'Add' button on the bottom of the Samples screen.

11. ***Sample Name:***

a. Only abbreviate if description is too long for the spaces allotted in the LIMS. This information should come directly from the chain of custody. The sample ID entered into the LIMS will be the sample ID on the final report.

b. If no sample ID is provided, or is indistinguishable from other samples listed, contact the project manager to ascertain distinction in the samples. Include date as part of the description if this is the only way to differentiate the samples.

c. When logging in trip blanks that do not have an ID assigned by the client, list them as "Trip Blank # _____". This information should be on the containers. A log book must be kept in the sample kit room which lists all trip blanks and the date they were filled. This will ensure consistency with the descriptions for trip blanks. Make sure you record the trip blank on the chain of custody if it is not listed.

12. ***Collection Date:***

Enter the date and time the sample was collected. You must use military time and separate by a space. Often the time collected is not given. Although this is a sampling requirement, this information may not be crucial unless a parameter with a short holding time or a data deliverables package is required. In the event that a sample collection time is not listed on the COC or the sample container, a default time of 00:00 can be used temporarily until client verification. Once verified, then the correct sample collection time must be input into LIMS. If the COC and sample containers do not list a collection date and time, a CAR must be generated. All attempts should be made to get all our clients to supply this information.

13. ***Lab/Report Matrix:***

Click on pull down and select matrix. Many times it is difficult to discern the matrix if it is not specified on the COC, and log-in personnel must use their best judgment with

regard to analytes/methods requested. Keep in mind that the detection limits and units on the LIMS reports are linked to the matrix. In some cases it may be necessary to ask the Section Managers about the matrix selection. Log-in may do a dilution test to distinguish water samples from oil samples if the COC does not clarify a sample matrix if need be.

14. ***Sample Type:***

This is used to differentiate between special types of samples (i.e. Field Duplicates, Equipment Blanks, Trip Blanks, etc.). If there is no definite way to determine that a sample should be classified as something else, then "SAMP-Client Sample" will be selected as the sample type. Do not list a sample as anything other than a Client Sample unless noted on the COC of are instructed by the client to do so.

15. ***Container:***

Click on the drop down list and select the appropriate bottle type. If multiple bottles are received for the same sample, then move down to the next line and select all other containers as required. Repeat this process until all containers for the sample are listed. As each container is entered, an individual number is assigned to it by the LIMS system. This number is also listed on the container labels that are printed from the LIMS, and is placed on the corresponding bottle for container tracking purposes.

16. ***pH*** (Container Preservative)***:***

Use this to document the pH check information taken during sample unpacking. If no preservative was used, then nothing is required in this field.

17. ***Comments:***

Enter any information that is applicable at the sample level.

18. ***Field Analysis:***

Click on field analysis tab and enter field information when provided.

19. ***Work Analyses:***

Select all parameters requested for the sample from this list.

a. If the required test code is not listed, and the sample matrix is not a contributing factor, click the Work Analyses tab to open the All Analyses list. When selecting from this expanded list, be careful to select the proper method as all methods available for the current matrix will be selectable.

b. If any analyses are selected from the All Analyses list, the Project Manager in charge should be notified so that the correctness of methods and pricing can be checked and updated as needed.

c. All preparation codes for analytes are entered and stored by the system independently of the test codes selected, except in the cases of Dry Weight analysis, and TCLP/SPLP preparation (tumbling). In the case of the TCLP/SPLP prep codes, these are entered alongside the other required analyses automatically by the LIMS when a TCLP/SPLP analyte is selected. As for Dry Weight, it is required for all solids testing except in the cases of TCLP/SPLP analysis, Explosives only analysis, and/or any pure product/non-soil based sample when specified by the client.

20. ***Analyses Comments:***

These comments should be used for any notes that only apply to that particular test code.

21. ***RTAT:***

If the Rush Turn-Around Time for this sample is known at the time of log-in, this information should be updated here.

22. ***Save:***

Once all applicable information is entered for a sample, click the save button. At this time the LIMS applies the Laboratory Sample ID to the sample. This is a four part ID code composed of the following:

a. A 2-digit numeral of the year. Example (**08**11248-06)

b. A 2-digit numeral of the month. Example (08**11**248-06)

c. A 3-digit numeral of the work order number. This number reset to 001 at the beginning of each month. Example (0811**248**-06)

d. A 2-digit numeral of the sample number separated by a dash. Example (0811248-**06**). This number is different for each sample in a work order, and a single work order cannot contain more than 99 samples. If more sample numbers are needed, a new work order number will have to be assigned to the applicable set of sample.

23. ***Add/Edit/Copy:***

Use these selections to add more samples to the work order, or to change existing information prior to label printing.

Once all the tests have been selected and all samples have been added in the work order, a work order summary and all container labels are printed. Labels are checked for accuracy against the containers while being labeled. At this point log-in of this group of samples is complete.

B. After log-in of a work order is complete, the COC can then be scanned into the system, attached to the work order on the Work Order screen, and the work order can be updated to Available status so as to be seen by the analysts.

V. Daily Follow Up for Sample Receiving/Log In

A. Wipe out the inside of coolers and return all Empirical Laboratories coolers to the sample kit room. Discard any coolers that are cracked, broken or filthy.

B. If any samples were received for RUSH turnaround, then a ***RUSH SHEET [Attachment XII]*** must be completed and distributed to all laboratory personnel via e-mail. If ever in doubt of which analysts should be notified, pass them out to everyone. Always give copies to the Laboratory Director, Administrative Assistant and Section Managers. It may be necessary to send out two RUSH sheets per day (one around mid-day and the other at the end of the day).

C. Complete any required CARs.

D. At the end of the day organize all paperwork received and generated for the day. The following should be given to the Project Manager (section supervisor):

1. The original chains of custody and yellow original or copy of each. The CRF will accompany the COC for the project.

2. Any information (letters, regulatory limits, etc.) from a client which was received with any samples.

3. All CARs.

4. LIMS sample receiving logs.

5. Copies of any RUSH sheets which have been distributed

6. Sample Receiving Custody and Disposal Form.

7. Cooler receipt form.

E. All the above information from the day will be reviewed as soon as possible.

1. All LIMS logs must be 2nd checked by a different person than the person entering the information into the LIMS. Each set of logs must be initialed dated by the person 2nd checking. These will be kept on file at the Project Manager desk.

2. If any corrections or changes are required, all laboratory personnel will be notified by distributing a ***Sample Log Change Form [Attachment XIII]*** through email distribution. A ***Sample Log Change Form*** by the project manager will also be sent out if a client adds or deletes any parameters, changes sample IDs, etc.

F. The Testing Coordinator will distribute the following after they have been through the 2nd QA check:

1. Copies of the LIMS receiving reports to necessary laboratory personnel.

2. Original (white copy) chains of custody are given to the Project Manager. These will be sent with the final report to the client.

3. Finalized/approved CARs must be sent to the:

a. Organic Manager

b. Inorganic Manager

c. Laboratory Manager

d. Laboratory Director {optional}

e. Quality Assurance Officer

f. Administrative Assistant

g. Client {optional}

4. Copies of any project/sample specific information to the Section Manager and analysts.

G. Information will be filed as follows:

1. Chains of custody:

a. Original (white copy) is returned to the customer with the final report along with the CRF.

b. Pink copies should be retained by the sampler.

2. CARs

a. CARs can be found at V:\LAB\log-in\login (year)\logcar (year).

3. Sample Change Forms and RUSH Sheets

a. Sample Change Forms are distributed by email.

b. RUSH Sheets are found at V:\LAB\login\Rushsheets

4. At the end of each year, files for that year are boxed and archived. Make sure files are labeled properly and place them in banker's boxes. Complete a storage box file form with as much detailed information as possible. The Laboratory Administrative Assistant will label and number the boxes and incorporate the storage boxes into the laboratory file archive system. Boxes containing files from Sample Receiving are kept on site for 1-2 years and then may be moved to off site storage upon release from the Project Manager.

VI. Miscellaneous

A. All projects which require deliverables or other QC requirements should be listed in the notes section of the LIMS.

B. If samples are received from a new client or a new job number that is not in the LIMS, a new client code must be set up. This information should be on the chain of custody or it may be necessary to contact the customer if the information is incomplete.

C. Samples from the Aquatic Toxicity Laboratory (ATL) are logged into the LIMS for billing and long-term tracking purposes. The receiving information and proper assignment of tests are reviewed by the ATL Manager. The samples are then logged in by ATL personnel.

D. A flow chart outlining sample receiving and the flow of data, reporting and invoicing is attached as ***Attachment XIV.***

E. A ***Telephone Conversation Log [Attachment XV]*** may be required to document information and may be attached to or used as a CAR.

F. All log books used in the Sample Receiving and Sample Storage Areas are numbered. The following log books are presently maintained. All log books must be "Z"ed out. The Testing Coordinator will review the log books each week to check for completeness.

Log Book ID	**Log Book Description**
LI014	Trip Blank Prep Log Book
LI009	Tracking of VOC Trip Blanks Shipped
LI011	Quarantined Soil Treatment Log Book
LI012	Acid Neutralization Log Book
LI013	Sample Receiving and Disposal Log Book
LI010	Kit Room Preservation Preparation Log Book

Attachments to SOP 404

II	Chain of Custody Record
III	Corrective Action Report for Sample Receiving/Log In
IV	Cooler Receipt Form
V	List of Short Holding Time (Immediate-72 hrs.) Parameters
VII	Sample Receiving Custody and Disposal Form
VIII	Map of Quarantined Soil Areas in the US.
IX	Laboratory Sample Custody Form for Walk In Refrigerator
X	Container Codes for the LIMS
XI	Routine NPDES Clients
XII	RUSH Sheet
XIII	Sample Log Change Form (Green Sheet)
XIV	Flow Chart, Laboratory Sample Tracking System

[Attachments I and VI were removed during the editing process and not added to the SOP.]

EMPIRICAL LABORATORIES, LLC - CHAIN OF CUSTODY RECORD

SHIP TO: 227 French Landing Drive, Suite 550 ♦ Nashville, TN 37228 ♦ 615-345-1115 ♦ (fax) 615-846-5426

Send Results to:	Send Invoice to:	Analysis Requirements:	Lab Use Only:
Name _____	Name _____		VOA Headspace Y N NA
Company _____	Company _____		Field Filtered Y N NA
Address _____	Address _____		Correct Containers Y N NA
City _____	City _____		Discrepancies Y N NA
State, Zip _____	State, Zip _____		Cust. Seals Intact Y N NA
Phone _____	Phone _____		Containers Intact Y N NA
Fax _____	Fax _____		
E-mail _____	E-mail _____		Airbill #: _____
Project No./Name:	**Sampler's (Signature):**		CAR #: _____

Lab Use Only Lab #	Date/Time Sampled	Sample Description	Sample Matrix	Analysis Requirements	Comments	No. of Bottles	*Lab Use Only* Containers/Pres.

Sample Kit Prep'd by: (Signature)	Date/Time	Received By: (Signature)	REMARKS:
Relinquished by: (Signature)	Date/Time	Received By: (Signature)	
Relinquished by: (Signature)	Date/Time	Received By: (Signature)	
Received for Laboratory by: (Signature)	Date/Time	*Temperature*	

Details:

Page _____ of _____

Cooler No. ____ of _____

Date Shipped _____

Shipped By _____

Turnaround _____

Distribution: Original and yellow copies accompany sample shipment to laboratory; Pink retained by samplers.

Attachment III

CAR 09-

EMPIRICAL LABORATORIES

CORRECTIVE ACTION REPORT FOR SAMPLE RECEIVING/LOG-IN

Date Completed:

Form Completed By:

Date Samples Received:

Parameter(s):

Client/Job #:

Samples:

Problem(s):

Action Taken:

Action Taken to Prevent Reoccurrence of this Problem:

Approval of Section Leader: _____

Distributed to:

EMPIRICAL LABORATORIES
COOLER RECEIPT FORM

LIMS Number: _____ Number of Coolers: _____ of _____

Client: _____ Project: _____

Date/Time Received: Date cooler(s) opened:

Opened By (print): (signature): _____

Circle response below as appropriate

1. How did the samples arrive?: FedEx UPS DHL Hand Delivered

EL Courier Other: _____

If applicable, enter airbill number here: _____

2. Were custody seals on outside of cooler(s)? ..... Yes No

How many: _____ Seal date: _____ Seal Initials: _____

3. Were custody seals unbroken and intact at the date and time of arrival? ..... Yes No N/A

4. Were custody papers sealed in a plastic bag included in the sample cooler? ..... Yes No N/A

5. Were custody papers filled out properly (ink, signed, etc.)? ..... Yes No N/A

6. Did you sign custody papers in the appropriate place for acceptance? ..... Yes No N/A

7. Was project identifiable from custody papers? ..... Yes No N/A

8. If required, was enough ice present in the cooler(s)? ..... Yes No N/A

Type of Coolant: WET DRY BLUE NONE Temperature of Samples upon Receipt: _____

Dates samples were logged-in:

9. Initial this form to acknowledge login of sample(s): (Name): **WILLIAM SCHWAB** (Initial):_____

10. Were all bottle lids intact and sealed tightly? ..... Yes No N/A

11. Did all bottles arrive unbroken? ..... Yes No N/A

12. Was all required bottle label information complete? ..... Yes No N/A

13. Did all bottle labels agree with custody papers? ..... Yes No N/A

14. Were correct containers used for the analyses indicated? ..... Yes No N/A

15. Were preservative levels correct in all applicable sample containers? ..... Yes No N/A

16. Was residual chlorine present in any applicable sample containers? ..... Yes No N/A

17. Was sufficient amount of sample sent for the analyses required? ..... Yes No N/A

18. Was headspace present in any included VOA vials? ..... Yes No N/A

If Non-Conformance issues were present, list by sample ID: _____

_____ CAR#: _____

Short Holding Time Parameters

(Immediate-72 hours)

Parameter	Holding Time
pH	Immediate [a]
Sulfite	Immediate [a]
Temperature	Immediate [a]
Residual Chlorine	Immediate [a]
Coliform (Fecal and Total) RCRA/WW	6 hours
Hexavalent Chromium (Cr +6)	24 hours
Odor	24 hours
Coliform (Fecal and Total) *Drinking Water only*	30 hours
BOD	48 hours
Color	48 hours
Settleable Solids	48 hours
MBAS	48 hours
Orthophosphate	48 hours
Turbidity	48 hours
Nitrite	48 hours
Flashpoint	72 hours [b]

[a] Immediate generally means within 15 minutes of sample collection.

[b] This is an internal holding time. The method does not specify a holding time.

Attachment VII

Empirical Laboratories, LLC

SAMPLE RECEIVING CUSTODY AND DISPOSAL FORM

Date Samples Received _____

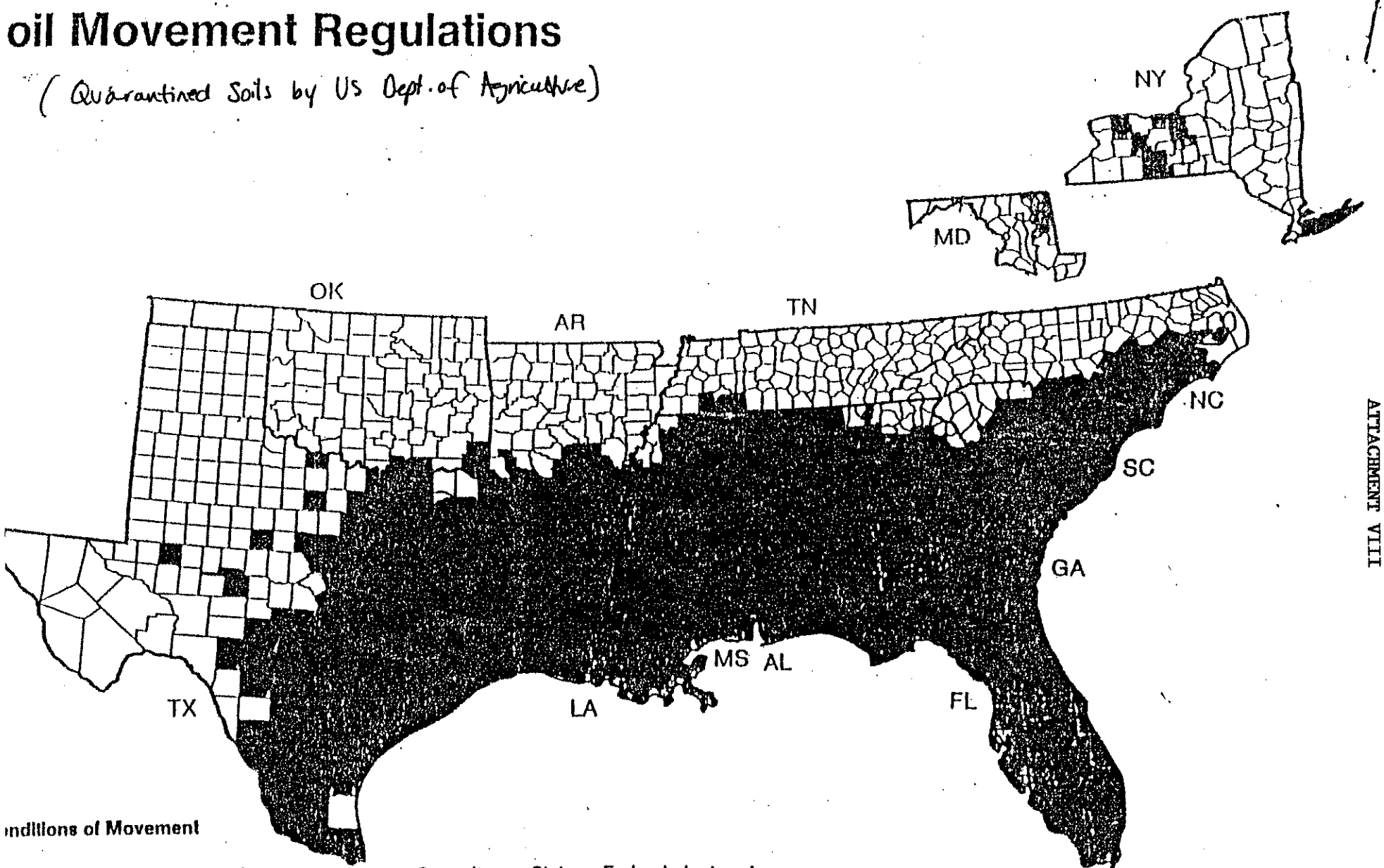
Client	Log #'s	Date Unpacked	Logged In/ Numbered By	2nd Checked By *	Placed in Storage By	Date Placed in Storage	Storage Area (1)	Disposed of By/Date	Method of Disposal

(1) W=Walk in Refrigerator
HV= Hobart Refrigerator, VOC samples only
Q= Refrigerator for Quarantined Soil Samples
QV= Refrigerator for Quarantined Soil, VOC samples only
O=Other (Must Specify)

***= MUST HAVE INITIALS OF THE PERSON WHO SECOND CHECKED AND MUST BE FILLED IN BY THAT PERSON IN INK.**

oil Movement Regulations

(Quarantined Soils by US Dept. of Agriculture)



ınditions of Movement

ıstrictions are imposed on the move-
ınt of regulated articles from a regulated
ɜa as follows:
ɔm red areas into or through white
ɜas. Movement within red areas may be
gulated.

Consult your State or Federal plant protection inspector or your county agent for assistance regarding exact areas under regulation and requirements for moving regulated articles.

Regulated Area

ATTACHMENT VIII

Empirical Laboratories

EMPIRICAL LABORATORIES, LLC
LABORATORY SAMPLE CUSTODY FORM
WALK-IN REFRIGERATOR

Sample Log # (s)	Time/Date/Initials Removed	Time/Date/Initials Returned (Note if all Sample Used)	Notes/ Comments	Task Performed

Preservatives		Types of Container	
NI	*HNO3*	**A**	*1 LITER - PLASTIC*
NF	*HNO3 (Filtered)*	**B**	*500 mL - PLASTIC*
SU	*H2SO4*	**C**	*250 mL - PLASTIC*
SH	*NaOH*	**D**	*120 mL - PLASTIC*
ZN	*ZnAC / NaOH*	**EN**	*ENCORE PAK*
HY	*HCl*	**F**	*1 LITER - GLASS CLEAR WIDE MOUTH*
		G	*1 LITER - GLASS CLEAR BOSTON ROUND*
		H	*1 LITER - GLASS AMBER*
		I	*250 ml. - AMBER*
		J	*VOA VIALS - (40 ml.)*
		K	*500 ml. - (16 oz)*
		L	*250 ml. - (8 oz)*
		M	*125 ml. - (4 oz)*
		N	*60 ml. - (2 oz)*
		O	*OTHER*
		P	*PLASTIC BAG -1 Gallon*

ROUTINE NPDES CLIENTS (Page 1 of 2)

ALCAN Ingot and Recycling
Amoco Oil
Armstrong (Pirelli)
Elf Atochem-Carrollton, KY
Auburn Hosiery Mill
Autostyle

Bando Manufacturing
Bowers Ink
Bowling Green Municipalities (City of)
BP Oil
Bremner, Inc.
Brentwood, City of
Brown Printing Central

Cargill Steel and Wire
Clarksville Products

E.I. Dupont
Eaton and Olsen
Emhart Pop Rivets

Fleet Design
Franklin, City of

Gatlinburg

Hennessey Co. (Coats)
H.I.S. Laundry
H.K. Bell (City of Hopkinsville Landfill Monthly Monitoring)
Hoover

International Paper
J. S. Technos

Ken Koat
King Industries

Lannom Tannery
Leonard Plating

al Plate, Inc.
Morflex, Inc.

Nashville Wire
Norandal USA Inc.

Oak Ridge, City of

Plymouth Tube
Prime Colorants

RMI

Shared Hospital Services
Snap On Tools
Springfield, City of
Special Metals
te Industries

Tennessee Dickel Distillery
Tullahoma, City of

UCAR, Clarksville

Valmore Leather

Westvaco (Mayfield Creek Up/Down)
Woodbury

Revised 9/10/96

Date Distributed 1/01/02

RUSH

DATE RECEIVED	CLIENT	LOG # (S)	PARAMETERS	E-MAIL COPY DUE (DATE / TO)	FAX COPY DUE (DATE / TO)	*FINAL COPY DUE (DATE / TO)

*ALL FINAL REPORTS SHOULD BE DELIVERED TO TERESA WILLIAMS OR HERBIE JOHNSON THREE DAYS PRIOR TO FINAL DUE DATE TO CLIENT.

ATTACHMENT XII

ATTACHMENT XIII

96-0001

SAMPLE LOG CHANGE FORM

DATE:

TO:

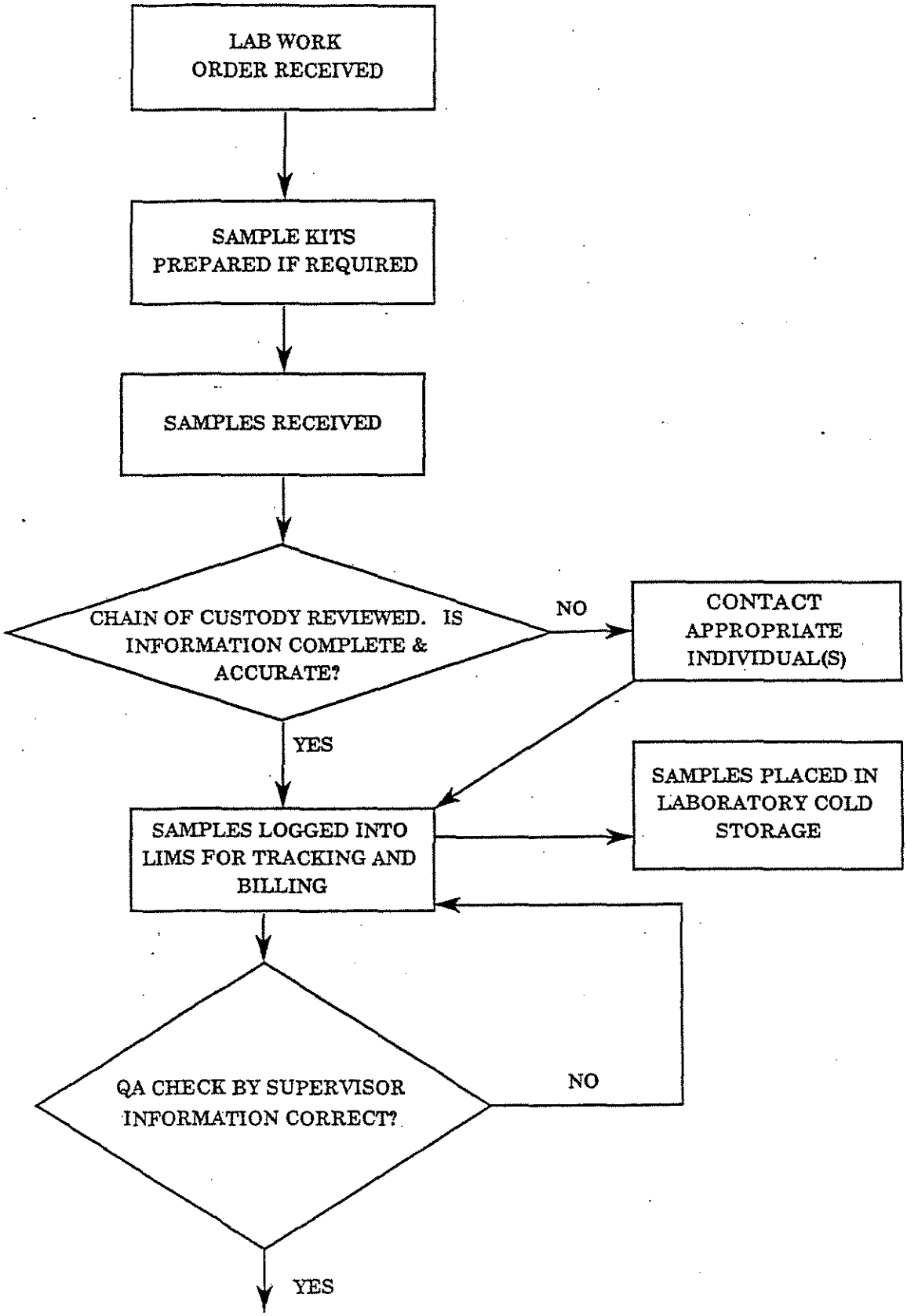
SAMPLE #(S):

CLIENT:

Changes:

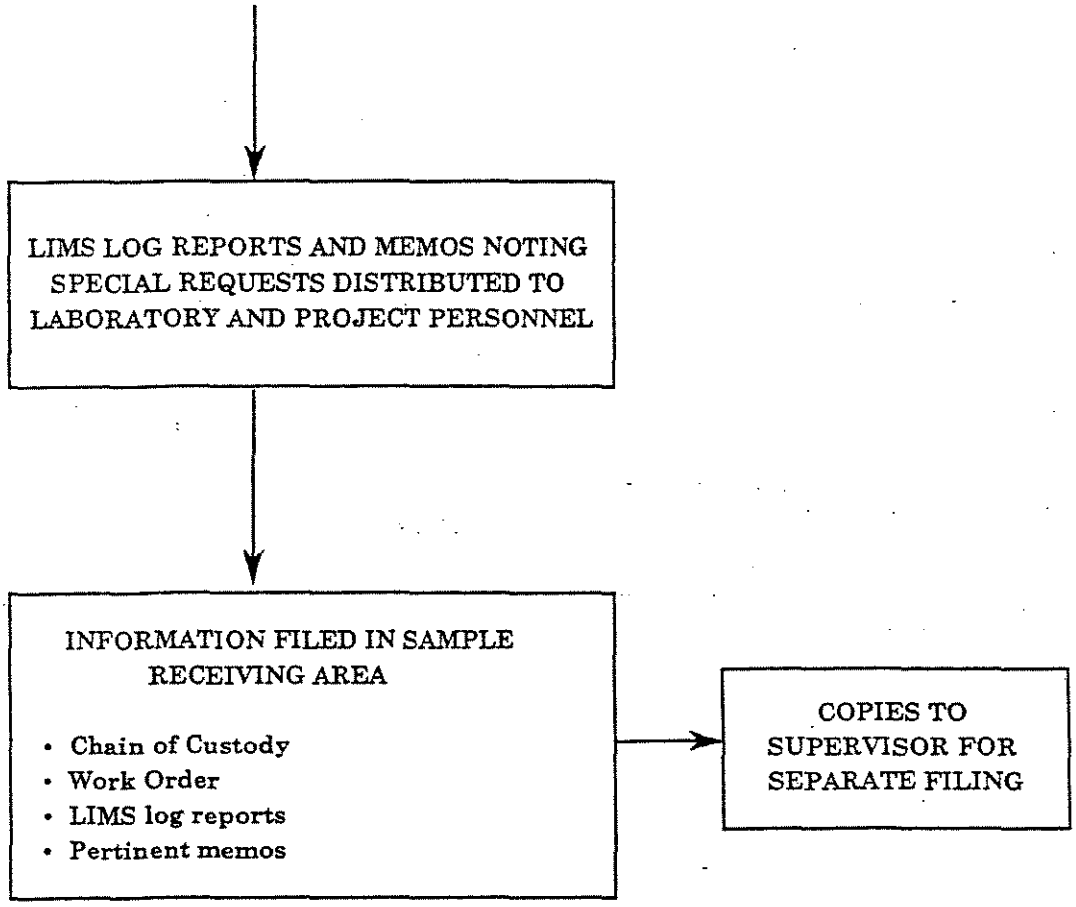
ATTACHMENT XIV

LABORATORY SAMPLE TRACKING SYSTEM
SAMPLE RECEIVING



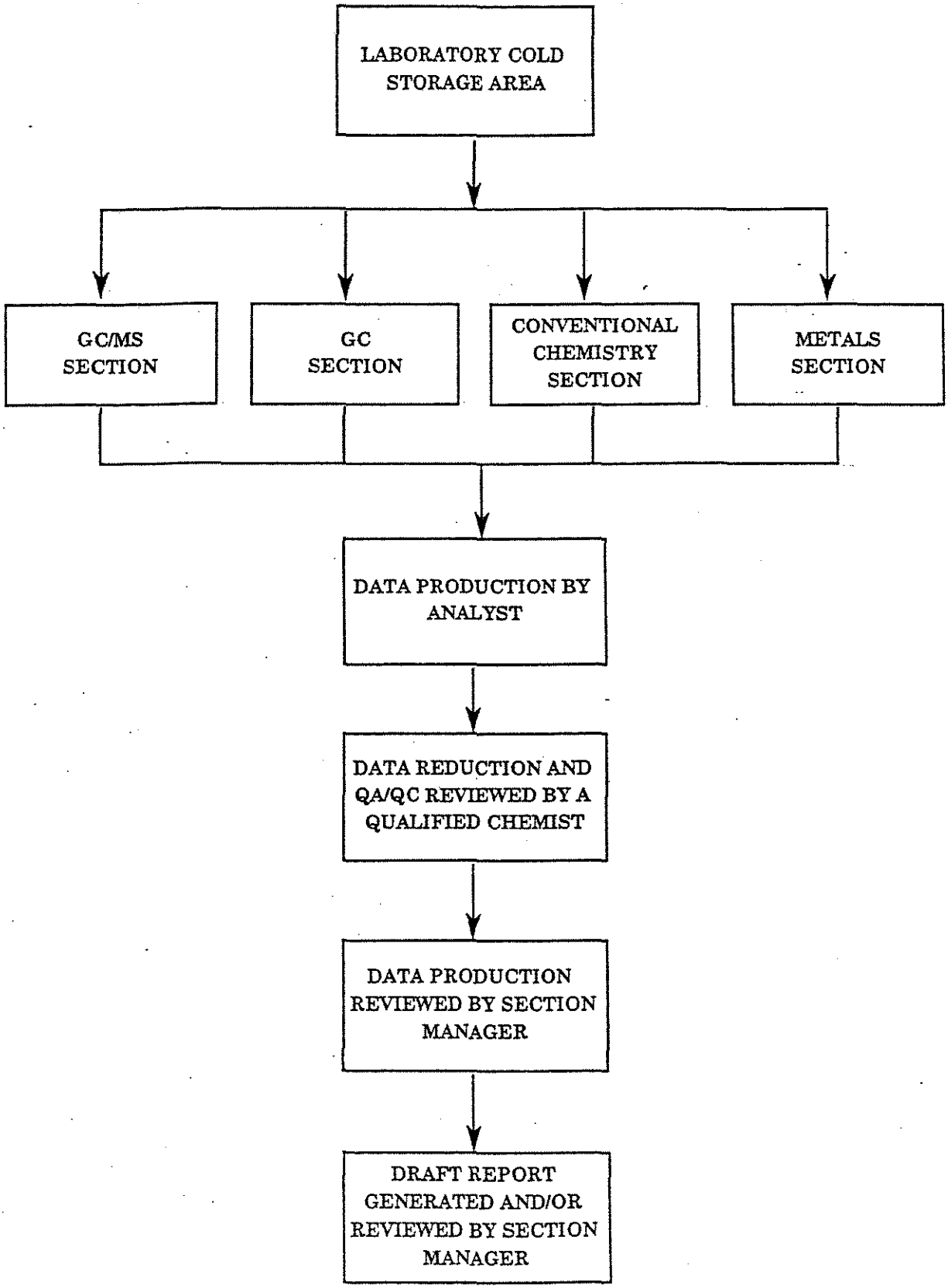
L:\QAM\SAMPTRAK.AF2

LABORATORY SAMPLE TRACKING SYSTEM
SAMPLE RECEIVING (continued)

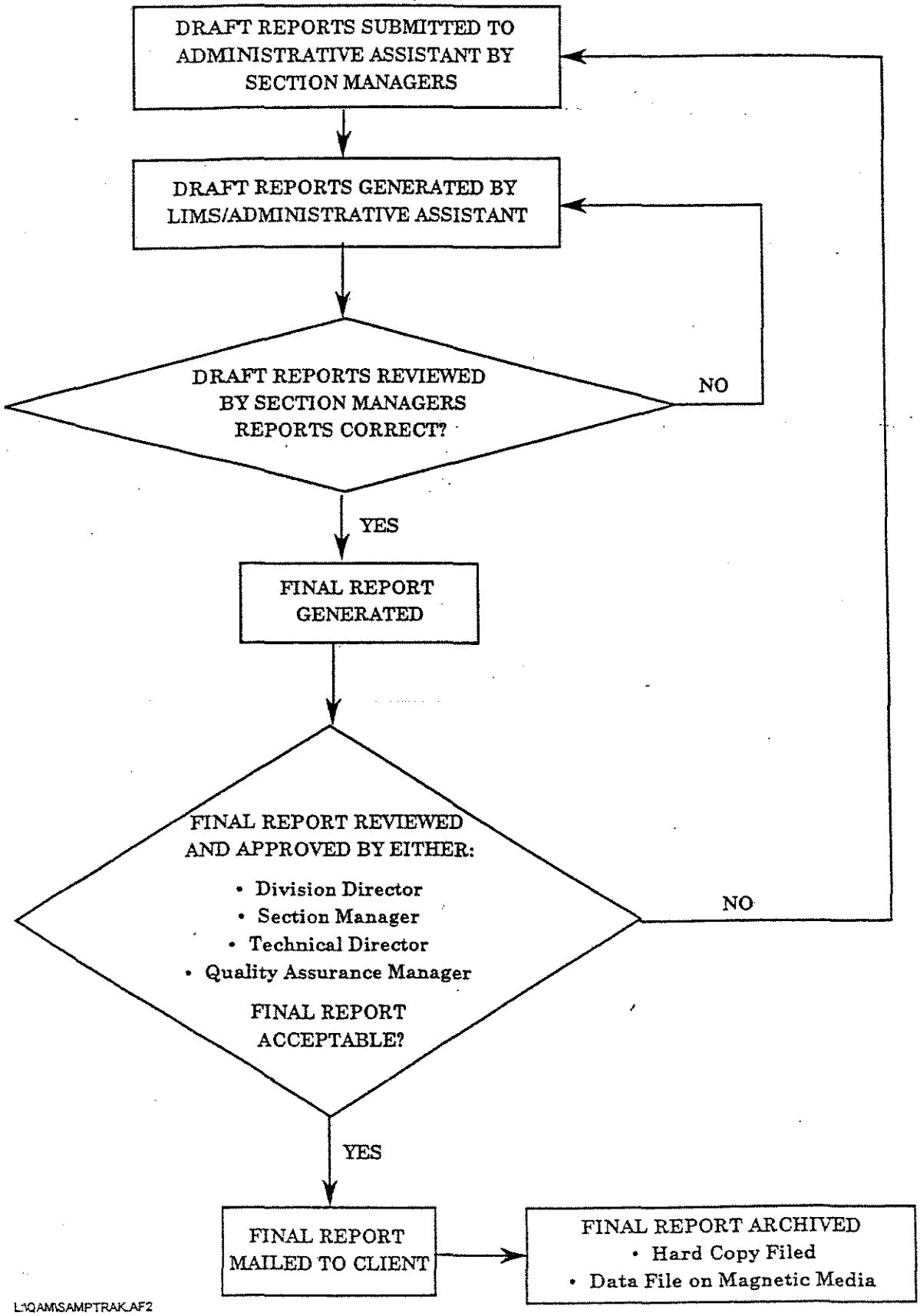


ATTACHMENT XIV (Continued)

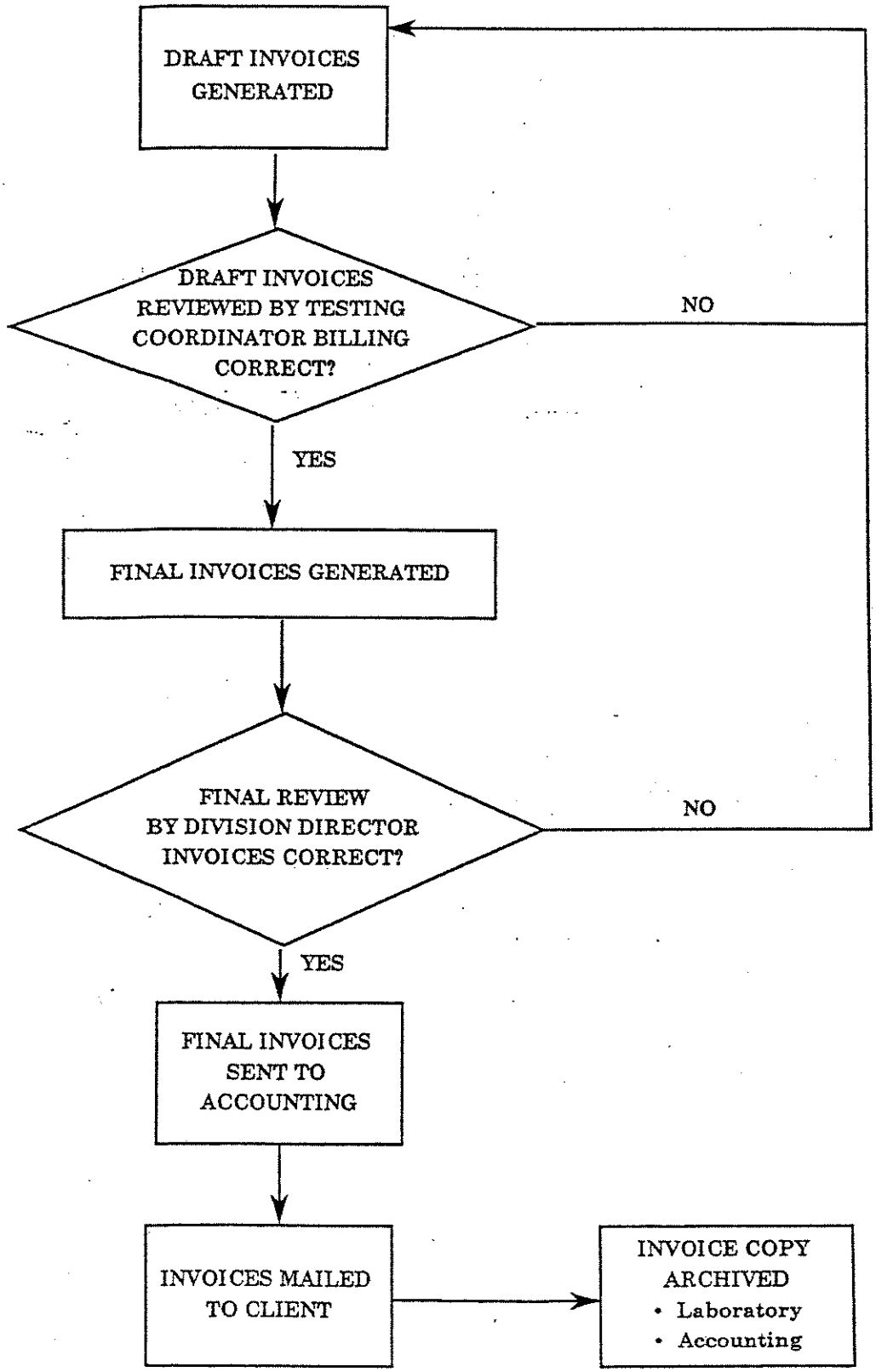
LABORATORY SAMPLE TRACKING SYSTEM
DATA PRODUCTION AND REVIEW



LABORATORY SAMPLE TRACKING SYSTEM
DRAFT AND FINAL REPORT



LABORATORY SAMPLE TRACKING SYSTEM
INVOICING



DISTRIBUTION/TRAINING LOG

LABORATORY SAMPLE RECEIVING, LOGIN AND STORAGE STANDARD OPERATING PROCEDURES

SOP NUMBER: **SOP-404**

REVISION NUMBER: **13**

RECEIVED BY/DATE:

W. Schwab

F. Rivers

~~R. Townsend~~

Signature above signifies acknowledgement of responsibility to know and follow the contents of this document. It also signifies receipt of training covering all new aspects of the SOP.

TRAINED BY:

EFFECTIVE DATE: **06/29/09**

PLEASE COLLECT OLD SOPs AND RETURN WITH SIGNED FORM TO QAO

ANALYTICAL LABORATORY WASTE DISPOSAL

SOP NUMBER: **SOP-405**

REVISION NUMBER: **5**

APPROVED BY:

LAB DIRECTOR

QUALITY ASSURANCE OFFICER

EFFECTIVE DATE: **06/23/09**

DATE OF LAST REVIEW: **06/23/09**

Analytical Laboratory Waste Disposal
Standard Operating Procedure

I. SCOPE AND APPLICATION:

Empirical Laboratories, LLC laboratory waste includes excess client sample waste and waste that are generated while performing an array of analytical services, some of which are hazardous. These wastes must be disposed of in a manner that is safe, cost efficient and in accordance with hazardous waste regulations.

A. Wastes can be broken down into the following categories:

1. Unused portions of actual samples received from outside clients.

   a. Unused aliquots of completed water samples.

   b. Unused aliquots of completed non-aqueous samples.

2. Soils from quarantined areas

3. All other soils, sediments, building debris, wipes etc.

4. Hazardous waste generated within the laboratory as part of numerous analytical procedures.

II. SUMMARY OF PROCEDURES:

A. There are four options for disposing of unused sample portions:

1. Return completed samples and any generated waste from these samples to the client.

2. Throw the sample away after confirming that it is non-hazardous.

3. Disposal through a waste vendor in either a sealed drum or lab pack. This is normally done twice a year.

4. Treat the sample to make it non-hazardous and dispose of it as such. (Aqueous pH neutralization only.)

B. There are two options for disposing of laboratory generated waste:

1. Disposal through a waste vendor in either a sealed drum or lab pack. This is normally done twice a year. The waste must be stored properly until the waste is transported off site.

For example: Solvent waste must be stored in the vented flammable cabinet.

2. Treat the waste to make it non-hazardous and dispose of it as such. (Aqueous pH neutralization only.)

III. EQUIPMENT/APPARATUS:

A. Proper safety equipment in good working condition. This includes gloves, lab coat and safety glasses/goggles (voluntary use of cartridge respirator allowed see area manager or QAO).

B. USDOT approved drums for storing and shipping hazardous waste.

C. Fume hood vented outside the building.

D. Flammable storage cabinet which is vented to the outside

IV. PROCEDURE

Waste disposal is done under the management and coordination of the Sample Receiving Manager, Section Managers and the Health and Safety Officer.

A. Disposal of completed aqueous samples:

Completed samples are kept in cold storage for approximately three weeks after the final report has been mailed. Engineering support projects involving CLP work, litigation cases etc. may be saved for longer than three weeks at the request of the project manager.

No samples should be disposed of without approval from the responsible area manager or analyst. **At this point the area manager and/or analyst will communicate information about samples deemed as hazardous.**

1. The majority of the water samples (ground, surface and drinking) is non-hazardous and is disposed of by pouring them down the sink.

a. This must be done under the hooded area located near the sink in sample receiving. Make sure that the sash is closed far enough to produce sufficient ventilation. The tap water should be turned on to supply copious wash for sample disposal.

b. Proper safety equipment **must** be used including safety glasses (face shield if necessary), lab coat and gloves.

c. **be alert to potential problems: for example, separate Cyanide waste from acid waste. Neutralize acid waste that will be poured down the drain and don't mix waste/samples thought to contain Cyanide with samples that are acidified. Also, look for things such as phase separation, odd color, odor etc. Check with the area manager or Health and Safety Officer before disposing of any questionable samples.**

d. Tap water must be running during the time samples are poured out and for approximately 10 minutes after so sufficient flushing and dilution takes place.

e. All containers must be rinsed out, all identifying markings defaced or removed, and thrown into the trash.

f. All samples disposed of in this manner must be documented in the bound disposal log.

2. If water samples are hazardous (known or suspected), one of the following steps must be taken.

a. Samples may be returned to the client. If you plan to ship the unused portion back to the client check with shipping and receiving to make sure that the material can be shipped in accordance with USDOT regulations. **If the samples are not returned to the client they must be stored properly until picked up by a waste vender.**

b. Treat the sample to make it non-hazardous. One example of this is if the sample is highly corrosive, the pH may be adjusted.

c. Store the sample properly until either a sealed drum or lab pack is sent out.

d. All samples disposed of in this manner must be documented in the bound disposal log.

B. Disposal of completed non-aqueous samples:

The majority of non-aqueous samples are soils or sediments, although there may also be building debris, wipes, oils, and occasionally product type samples.

1. If samples are non-hazardous they must have all identifying markings defaced or removed, and thrown into the trash. On specific projects we may also opt to return the unused portions to the client even if they are non-hazardous.

2. If non-aqueous samples are hazardous (known or suspected), one of the following steps must be taken.

a. Samples may be returned to the client. If you plan to ship the unused portion back to the client check with shipping and receiving to make sure that the material can be shipped in accordance with USDOT regulations. **If the samples are not returned to the client they must be stored properly until picked up by a waste vender.**

b. Store the sample properly until a lab pack is sent out.

3. Soil samples taken at a depth of three feet or less from areas, which have been quarantined by the US Department of Agriculture (USDA), must first be treated at the laboratory to prevent the spread of any plant pests. The USDA has detailed proper treatment procedures of which we use the following:

a. The sample is heated to 180°C(356°F)in a vented oven for two hours.
b. After the heating the samples are placed close to a hood to cool and are marked as being ready for disposal.

4. Once the samples have undergone treatment they can then be disposed of by one of the procedures for non-aqueous samples. **All samples disposed of in this manner must be documented in the bound disposal logbook with the following information:**

a. Client
b. Sample #s

c. Date(s) treated
d. Treatment method used

C. Disposal of laboratory generated waste:

Generated waste is stored outside the building, inside the caged fence until a waste pick up occurs. This area must be maintained properly.

1. Waste handling and disposal within each laboratory section:

Each laboratory analyst and section manager is responsible to assure that **handling** operations within their area are being followed according to the laboratory requirement.

a. General Chemistry/Inorganic

Each analyst performing specific laboratory tests that generates waste is responsible to handle and dispose of the waste in a safe manner and under the guidelines listed below. If you have any questions left unanswered regarding waste disposal within your specific area contact the inorganic manager or the safety officer.

- Concentrated acid waste, **(>2% by volume) and** dilute mercury waste (mercury, chemical oxygen demand, total kjeldahl nitrogen and chloride analyses waste) are poured into the Acid Satellite Waste drum located outside the back of the building inside the caged fence. **Document the type and amount of waste in the acid waste logbook, then initial and date the entry**.
- Dilute acid waste **(<2% by volume or less)** are neutralized using concentrated amounts of sodium hydroxide and poured down a sink drain within hooded ventilation with copious amounts of tap water. The amounts of acid waste treated along with the amount of sodium hydroxide used to neutralize the acid waste, is then recorded into an acid waste neutralization log book that is kept in sample receiving.
- **All other non-hazardous sample waste, reagents and standards are poured down the drain with copious amounts of tap water.**

b. Metals

Each analyst performing specific laboratory tests that generates waste is responsible to handle and dispose of the waste in a safe manner and under the guidelines listed

below. If you have any questions left unanswered regarding waste disposal within your specific area contact the inorganic manager or the safety officer.

- Concentrated acid waste, aqueous sample waste digestates and old unused calibration standards **(>2% by volume)** are poured into the Acid Satellite Waste drum located outside the back of the building inside the caged fence.
- Non-aqueous sample digestate wastes are decanted off the soil/solid samples into the Acid Satellite Waste drum located outside the back of the building inside the caged fence. **Rinse the soil/solid with tap water several times and discard the first rinsate into the Acid Satellite Waste drum and the sequential rinsates decant down an acid drain with copious amounts of tap-water.**
- **Throw the soil/solids in the trash once the acid has been rinsed free.**
- **Cr6 digestates as with all concentrated metal/acid waste are poured into the Acid Satellite Waste drum.**

c. Organic Extraction Laboratory Area

Each analyst performing specific laboratory tests that generates waste is responsible to handle and dispose of the waste in a safe manner and under the guidelines listed below. If you have any questions left unanswered regarding waste disposal within your specific area contact the organic manager or the safety officer.

- Concentrated acid waste is discarded into the Acid Satellite Waste located outside the back of the building inside the caged fence.
- Non-chlorinated solvent waste (Acetone, Ether, Hexane, and Methanol ....etc...) pour into the Non-Chlorinated Waste labeled bottle located in the hood in the Organic Extraction Laboratory.
- Chlorinated solvent waste (Methylene Chloride, Chloroform, chlorinated standard and spike waste) pour into the Chlorinated Waste labeled bottle located in the hood in the Organic Extraction Laboratory.

****Note: Laboratory generated solvent waste is transferred to the appropriate Satellite Solvent Waste Drum (chlorinated or non-chlorinated) weekly or as deemed necessary. Disposal of solvent waste is done under the direction of the organic laboratory manager. These drums are located outside the back of the building inside the caged fence and only authorized laboratory staff are allowed to add waste solvent to these drums. The date of addition to the drum, type and quantity of solvent is entered into the '*Organic Solvent Waste Logbook*' located on the shelf next to the drums.**

- **Aqueous sample waste from extracted samples (once the extraction solvent has been removed) is poured down the drain and flush with copious amount of tap water.**
- Non-aqueous sample waste and sodium sulfate waste is dumped into a waste container under an extraction laboratory hood and left overnight or until the solvent is evaporated and then the waste is discarded into the trash.

d. Gas Chromatography (GC)/High Performance Liquid Chromatography (HPLC) Laboratory

- Autosampler vials are discarded into the appropriately labeled box located in the GC/HPLC Laboratory.

PCB Box – all samples/standards
Pesticide Box – all samples/standards
Herbicide Box – all samples/standards
8330 Box – all samples/standards
Methylene Chloride Box- all samples/standards that contain methylene chloride (Diesel Range Organics, DRO)

- Sample and spike extract vials are separated according to the contents in the vial. **Acid cleaned extracts** are combined into a separatory funnel and the acid layer separated from the solvent. The acid portion is discarded into the Acid Satellite Waste drum located outside the back of the building inside the caged fence. The solvent waste is discarded into the appropriate solvent waste bottle (chlorinated/non-chlorinated waste) located in the hood in the organic extraction laboratory.

Unused stock and working standards are discarded into the chlorinated solvent waste bottle located in the organic extraction laboratory. The empty vials are rinsed several (3) times with solvent and the solvent rinsate poured into the solvent waste and the vials with labels removed are discarded into the glassware waste container.

e. Gas Chromatography/Mass Spectrometry

- Volatile sample, standard and reagent waste

Waste from the instrument - Aqueous sample waste is collected in waste bottles via waste lines from the instrument. The bottles are emptied into buckets and poured down the drain(pH is < 2% by volume). A small amount of methanol used to clean glassware is also dumped into the bucket and poured down the drain. While disposing of sample waste always run the cold tap water 10-15 minutes. Non-aqueous waste from sample analyses is retained and dispose of in the same manner as the unused sample. Unused sample is held for sample disposal by the sample receiving area, see A and B listed above.

Standards - Unused stock and working standards are discarded into the chlorinated solvent waste bottle located in the organic extraction laboratory. The empty vials are rinsed several (3) times with solvent and the solvent rinsate poured into the solvent waste and the vials with labels removed are discarded into the glassware waste container.

In conjunction with section managers, the sample receiving area disposes of solid sample waste and unused aqueous and solid samples see procedures A and B listed above.

- Semivolatile sample and standard waste disposal

Methylene chloride waste solvent and standard waste in vials are poured into the chlorinated waste bottle in the hood in the organic extraction laboratory. The empty vials are rinsed with solvent and the solvent poured into the waste solvent bottle. The vials with labels removed are discarded into the glassware waste disposal container.

Auto sampler vials are collected in buckets and stored under the hood in the organic extraction laboratory. **Periodically the vials are consolidated in lab packs for disposal by a licensed waste disposal company**.

f. Bioassay Laboratory

- Aqueous sample waste and a small amount of methanol are poured down the drain with copious amounts of tap water. Larger amounts of methanol used for glassware cleaning are collected in beakers and evaporated at room temperature.

- Hazardous or product samples are returned to the client.

D. Consolidation of satellite waste for contractor disposal:

In conjunction with the Safety Officer, the sample receiving supervisor is responsible to coordinate waste disposal operations with outside waste disposal contractors.

1. Solvent waste from the areas discussed above is periodically consolidated into two drums located outside the back of the building inside the caged fence (c. *Organic Extraction Laboratory Area*, * **Note**). A drum designated either chlorinated or non-chlorinated solvent waste is available to receive the appropriate solvent waste. When the drums become full (fluid surface six inches below the top of the drum), an authorized hazardous waste contractor will be scheduled to remove them to proper waste disposal.

2. The Acid Satellite Waste drum is also disposed through the authorized hazardous waste contractor once the drum is full to the level of six inches below the top of the drum.

3. Consolidated autosampler and standard vials are periodically Lab-Packed in drums and disposed through the authorized hazardous waste contractor.

4. The Laboratory Health and Safety Officer will administer the Waste Disposal Program and maintain current information to track quantities of waste generated and stored on-site.

It is the continuous objective of our laboratory to find ways to decrease the amount of waste generated.

DISTRIBUTION/TRAINING LOG

ANALYTICAL LABORATORY WASTE DISPOSAL

SOP NUMBER: **SOP-405**

REVISION NUMBER: **5**

RECEIVED BY/DATE:

W. Schwab	WS
R. Townsend	Russell Townsend RET
F. Rivers	FR
J. Holliman	J.H.
B. DeVille	Betty DeVille
A. Monteiro	
B. Richard	

Signature above signifies acknowledgement of responsibility to know and follow the contents of this document. It also signifies receipt of training covering all new aspects of the SOP.

TRAINED BY: Randy H. Wood

EFFECTIVE DATE: **06/23/09**

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STANDARD OPERATING PROCEDURE (SOP) FOR LABORATORY SAMPLE STORAGE, SECURE AREAS AND SAMPLE CUSTODY

SOP NUMBER: **SOP-410**

REVISION NUMBER: **7**

APPROVED BY:

SECTION MANAGER

TECHNICAL DIRECTOR

EFFECTIVE DATE: **06/23/09**

DATE OF LAST REVIEW: **06/23/09**

STANDARD OPERATING PROCEDURE (SOP) FOR LABORATORY SAMPLE STORAGE, SECURE AREAS AND SAMPLE CUSTODY

Empirical Laboratories, LLC is located at 621 Mainstream Dr. suite 270 Nashville, TN 37228 on the first floor. This building is locked and monitored by an alarm system after normal business hours. No unauthorized personnel are permitted within the facility without a proper escort and a visitor's badge. During non business hours, all doors to the building are locked and secured by an alarm system. All front and back doors are locked and only Empirical Laboratories, LLC personnel have a key to access the building. Upon unlocking the door and entering into the laboratory, then the employee is to deactivate the alarm system using the assigned 4 digit alarm code assigned to them by Human Resources. Each employee is assigned their own designated alarm code, with no code being assigned twice. There is a buzzer at the door to Login to allow entry for sample and supply deliveries.

The majority of samples are shipped in coolers by couriers such as Federal Express and UPS. All couriers are generally received in the Shipping/Sample Receiving (SR) area in back of the building. The laboratory is located close to Federal Express (FedEx) distribution station; therefore we pick up our coolers at the FedEx location daily and transport them directly to the laboratory. Some coolers and/or samples are delivered directly to the SR area by the sampler and/or client. The SR personnel must not leave any packages/cooler without authorized receipt from laboratory personnel. Samples must be accompanied by some type of chain of custody record. Sample receiving personnel sign, and list the date and time received on the chain of custody. The time received must reflect the actual time or validation date and time of receipt for the samples although they may be placed in cold storage and logged into the system at a later time. The method of delivery is listed on the cooler receipt form(CRF). The tracking # (if available) is attached to the chain of custody.

Once sample containers have been assigned a laboratory ID number, they must be checked by another laboratory individual to ensure that the log number on the container matches the log number and sample ID on the Chain of Custody. A Cooler Receipt Form also must be completed to accompany the cohesive Chain of Custody. Samples should not leave the log-in area until this has been completed. Log-in is also responsible for maintaining a Sample Receiving Custody and Disposal Form for samples received. This form is to be filled out before the actual disposing of any

sample in house. Once the document is complete, the original will be kept on file. The following information must be logged onto this form:

- Client and Log #s
- Date/Time Unpacked
- Logged In/Numbered By (Initials)
- 2nd Checked By (Initials)
- Date/Time Placed in Cold Storage
- Storage Area (Walk In, Blue Air-VOCs, Quarantined Soils, Quarantined-VOC, Other)
- Disposed of By/Date
- Method of Disposal

Original samples are stored in following areas of the laboratory.

1. Hobart Refrigerator in the VOC lab: All water VOCs must be stored in this refrigerator.

2. Water Walk In Refrigerator: All waters for all analyses except VOCs must be stored in this refrigerator.

3. Soil Walk in Refrigerator for all soils.

4. VOC Dry Storage Rack: All water VOCs that have exceeded double holding time can be stored on this rack. These samples are stored here segregated alone to ensure no cross contamination occurs between VOC samples and other non-VOC aqueous samples.

All soils are treated as quarantined.

All samples must be stored in one of the four locations detailed above with the following exceptions:

1. Matrices that may be adversely affected by the cold temperature. (e.g. surfactant samples, multi-phase samples)

2. Highly contaminated waste or product type samples which could jeopardize the integrity of other samples in the walk in cooler. Often these can be stored at room temperature. If these require refrigeration see the Testing Coordinator for other options.

Any person removing samples from the storage areas listed above, must sign them out on a laboratory custody sheet (attached). The individual performing the processing becomes responsible for the samples at this point. The samples are maintained in the secure possession of the individual processing the samples. When the processing is completed, the samples are returned and signed back into the appropriate storage area. It must be noted if the entire sample volume was used and that the container was discarded.

Sample extracts and digestates are stored in the following areas:

1. All metals digestates are stored in the metals instrument laboratory. The transfer from the digestion analysts to the ICAP analysts is documented in the metals digestion log book.

2. Non - ZHE TCLP extracts are returned to the refrigerator in which the original samples are stored. For ZHE samples, the extract is returned to the refrigerator in which the original VOC sample containers are stored.

3. Extracts from medium level VOC analyses are also stored in the Soil Walk – in or VOC sample freezer in the VOC Lab.

4. All Organic extracts are stored in a Beverage Air side by side refrigerator in the organic extraction laboratory.

The generation of all sample extracts/digests and their movement through the laboratory will also be tracked on a laboratory custody sheet or in a log book. The individual performing the processing becomes responsible for the samples at this point. The samples are maintained in the secure possession of the individual processing the samples. When the processing is completed, the extracts are returned and signed back into the appropriate storage area. The metals digestates are not removed from the metals instrument laboratory.

After the analytical results have been reported, the original samples, sample extracts, and digestates will remain in secure storage until they are disposed of in accordance with the Waste Disposal Standard Operating Procedure. Samples will be held for a minimum of 30 days after the final report unless specified otherwise. Sample extracts and digestates are held for a minimum of 60 days after the final report unless project specific requirements state otherwise. See SOP No. 405 entitled Laboratory Waste Disposal SOP for guidance on disposal of samples.

The following personnel as of June 23rd, 2009 have access to all sample storage areas:

James Dalton	Herbie Johnson
Ashley Bester	Dahae Kim
Roger Burr	Dustin Lynch
Janice Shilling	Marcia McGinnity
Rick Davis	Badeen Mekael
Jessica Sales	Antonio Montiero
Betty DeVille	Kelienne Verdier
Amanda Fei	Gino Moore
Kendra Gentry	Lorraine Norohna
Jason Goodman	Melanie Sams
Sonya Gordon	Brian Richard
Gwen Hallquist	Franklin Rivers
Veronica Mullen	William Schwab
William Lancaster	Russell Townsend
Jade Holliman	Christy Thompson
John Hughes	Renee Vogel
Karu Huka	Randy Ward
Randy Ward	Marcia McGinnity

In the event that an employee is terminated, the supervisor is responsible for collecting the employee's keys.

For additional information see SOP No. 404 entitled Laboratory Sample Receiving, Log-In and Storage.

DISTRIBUTION/TRAINING LOG

STANDARD OPERATING PROCEDURE (SOP) FOR LABORATORY SAMPLE STORAGE, SECURE AREAS AND SAMPLE CUSTODY

SOP NUMBER: **SOP-410**

REVISION NUMBER: 7

RECEIVED BY/DATE:

W. Schwab WS

F. Rivers FR

R. Townsend Russell Townsend RET

Signature above signifies acknowledgement of responsibility to know and follow the contents of this document. It also signifies receipt of training covering all new aspects of the SOP.

TRAINED BY: Randy H. Ward

EFFECTIVE DATE: 06/23/09

PLEASE COLLECT OLD SOPs AND RETURN WITH SIGNED FORM TO QAO

APPENDIX E

FIELD STANDARD OPERATING PROCEDURES

TtNUS SOP List

CT-04	Sample Nomenclature
CT-05	Database Records and Quality Assurance
GH-1.2	Evalutation of Existing Monitoring Wells and Water Level Measurement
GH-1.3	Soil and Rock Drilling Methods
GH-1.5	Borehole and Sample Logging
GH-2.4	In-Situ Hydraulic Conductivity Testing
GH-2.8	Groundwater Monitoring Well Installation
HS-1.0	Utility Location and Excavation Clearance
SA-1.3	Soil Sampling
SA-1.1	Groundwater Sample Acquisition and Onsite Water Quality Testing
SA-2.5	Direct Push Technology (Geoprobe/Hydropunch)
SA-6.1	Non-Radiological Sample Handling
SA-6.3	Field Documentation
SA-7.1	Decontamination of Field Equipment

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6.0 DEVIATIONS **6**

1.0 PURPOSE

The purpose of this document is to specify a consistent sample nomenclature system that will facilitate subsequent data management in a cost-effective manner. The sample nomenclature system has been devised such that the following objectives can be attained:

- Sorting of data by matrix.
- Sorting of data by depth.
- Maintenance of consistency (field, laboratory, and data base sample numbers).
- Accommodation of all project-specific requirements.
- Accommodation of laboratory sample number length constraints (maximum of 20 characters).

2.0 SCOPE

The methods described in this procedure shall be used consistently for all projects requiring electronic data.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Program Manager - It shall be the responsibility of the Program Manager (or designee) to inform contract-specific Project Managers of the existence and requirements of this Standard Operating Procedure.

Project Manager - It shall be the responsibility of the Project Manager to determine the applicability of this Standard Operating Procedure based on: (1) program-specific requirements, and (2) project size and objectives. It shall be the responsibility of the Project Manager (or designee) to ensure that the sample nomenclature is thoroughly specified in the relevant project planning document (e.g., sampling and analysis plan) and is consistent with this Standard Operating Procedure if relevant. It shall be the responsibility of the project manager to ensure that the Field Operations Leader is familiar with the sample nomenclature system.

Field Operations Leader - It shall be the responsibility of the Field Operations Leader to ensure that all field technicians or sampling personnel are thoroughly familiar with this Standard Operating Procedure and the project-specific sample nomenclature system. It shall be the responsibility of the Field Operations Leader to ensure that the sample nomenclature system is used during all project-specific sampling efforts.

5.0 PROCEDURES

5.1 Introduction

The sample identification (ID) system can consist of as few as 8 but not more than 20 distinct alpha-numeric characters. The sample ID will be provided to the laboratory on the sample labels and chain-of-custody forms. The basic sample ID provided to the lab has three segments and shall be as follows where "A" indicates "alpha," and "N" indicates "numeric":

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters
Site Identifier	Sample Type	Sample Location

Additional segments may be added as needed. For example:

(1) Soil and Sediment Sample ID

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters	NNNN 4-Characters
Site Identifier	Sample Type	Sample Location	Sample Depth

(2) Aqueous (groundwater or surface water) Sample ID

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters	NN 2-Characters	-A
Site Identifier	Sample type	Sample Location	Round Number	Filtered Sample only

~~(3) Biota Sample ID~~

~~A or N~~ ~~3- or 4-Characters~~	~~AAA~~ ~~2- or 3-Characters~~	~~A or N~~ ~~3- to 6-Characters~~	~~AA~~ ~~2-Characters~~	~~NNN~~ ~~3-Characters~~
Site Identifier	Sample Type	Sample Location	Species Identifier	Sample Group Number

5.2 Sample Identification Field Requirements

The various fields in the sample ID will include but are not limited to the following:

- Site Identifier
- Sample Type
- Sample Location
- Sample Depth
- ~~Sampling Round Number~~
- Filtered
- ~~Species Identifier~~
- ~~Sample Group Number~~

The site identifier must be a three- or four-character field (numeric characters, alpha characters, or a mixture of alpha and numeric characters may be used). A site number is necessary since many facilities/sites have multiple individual sites, SWMUs, operable units, etc. Several examples are presented in Section 5.3 of this SOP.

The sample type must be a two- or three-character alpha field. Suggested codes are provided in Section 5.3 of this SOP.

The sample location must be at least a three-character field but may have up to six-characters (alpha, numeric, or a mixture). The six-characters may be useful in identifying a monitoring well to be sampled or describing a grid location.

The sample depth field is used to note the depth below ground surface (bgs) at which a soil or sediment sample is collected. The first two numbers of the four-number code specify the top interval, and the third and fourth specify the bottom interval in feet bgs of the sample. If the sample depth is equal to or greater than 100, then only the top interval would be represented and the sampling depth would be truncated to

three-characters. The depths will be noted in whole numbers only; further detail, if needed, will be recorded on the sample log sheet, boring log, logbook, etc.

A two-digit round number will be used to track the number of aqueous samples taken from a particular aqueous sample location. The first sample collected from a location will be assigned the round identifier 01, the second 02, etc. This applies to both existing and proposed monitoring wells and surface water locations.

Aqueous samples that are field filtered (dissolved analysis) will be identified with an "-F" in the last field segment. No entry in this segment signifies an unfiltered (total) sample.

~~The species identifier must be a two-character alpha field. Several suggested codes are provided in Section 5.3 of this SOP.~~

~~The three digit sample group number will be used to track the number of biota sample groups (a particular group size may be determined by sample technique, media type, the number of individual caught, weight issues, time, etc.) by species and location. The first sample group of a particular species collected from a given location will be assigned the sample group number 001 and the second sample group of the same species collected from the same location will be assigned the sample group number 002.~~

5.3 Example Sample Field Designations

Examples of each of the fields are as follows:

Site Identifier - Examples of site numbers/designations are as follows:

A01 - Area of Concern Number 1
125 - Solid Waste Management Unit Number 125
000 - Base or Facility Wide Sample (e.g., upgradient well)
BBG - Base Background

The examples cited are only suggestions. Each Project Manager (or designee) must designate appropriate (and consistent) site designations for their individual project.

Sample Type - Examples of sample types are as follows:

~~AH - Ash Sample~~
~~AS - Air Sample~~
~~BM - Building Material Sample~~
~~BSB - Biota Sample Full Body~~
~~BSF - Biota Sample Fillet~~
~~CP - Composite Sample~~
~~CS - Chip Sample~~
~~DS - Drum Sample~~
~~DU - Dust Sample~~
~~FP - Free Product~~
IDW - Investigation Derived Waste Sample
~~LT - Leachate Sample~~
MW - Monitoring Well Groundwater Sample
~~OF - Outfall Sample~~
~~RW - Residential Well Sample~~
SB - Soil Boring Sample
SD - Sediment Sample
~~SC - Scrape Sample~~

~~SG - Soil Gas Sample~~
~~SL - Sludge Sample~~
~~SP - Seep Sample~~
SS - Surface Soil Sample
~~ST - Storm Sewer Water Sample~~
~~SW - Surface Water Sample~~
~~TP - Test Pit Sample~~
~~TW - Temporary Well Sample~~
~~WC - Well Construction Material Sample~~
~~WP - Wipe Sample~~
~~WS - Waste/Solid Sample~~
~~WW - Wastewater Sample~~

Sample Location - Examples of the location field are as follows:

001 - Monitoring Well 1
N32E92 - Grid location 32 North and 92 East
D096 - Investigation derived waste drum number 96

~~Species Identifier - Examples of species identifier are as follows:~~

~~BC - Blue Crab~~
~~GB - Blue Gill~~
~~CO - Corn~~
~~SB - Soybean~~

5.4 Examples of Sample Nomenclature

The first round monitoring well groundwater sample collected from existing monitoring well 001 at SWMU 16 for a filtered sample would be designated as 016MW00101-F.

The second round monitoring well groundwater sample collected from existing monitoring well C20P2 at Site 23 for an unfiltered sample would be designated as 023MWC20P202.

~~The second surface water sample collected from point 01 at SWMU 130 for an unfiltered sample would be designated as 130SW00102.~~

A surface soil sample collected from grid location 32 North and 92 East at Site 32 at the 0- to 2-foot interval would be designated as 032SSN32E920002.

A subsurface soil sample from soil boring 03 at SWMU 32 at an interval of 4 to 5 feet bgs would be designated as 032SB0030405.

A sediment sample collected at SWMU 19 from 0 to 6 inches at location 14 would be designated as 019SD0140001. The sample data sheet would reflect the precise depth at which this sample was collected.

~~During biota sampling for full body analysis the first time a minnow trap was checked at grid location A25 of SWMU 1415 three small blue gills were captured, collected and designated with the sample ID of 1415BSBA25BG001. The second time blue gill were collected at the same location (grid location A25 at SWMU 1415) the sample ID designation given was 1415BSBA25BG002.~~

Note: No dash (-) or spacing is used between the segments with the exception of the filtered segment. The "F" used for a filtered aqueous sample is preceded by a dash "-F".

5.5 Field Quality Assurance/Quality Control (QA/QC) Sample Nomenclature)

Field QA/QC will be designated using a different coding system. The QC code will consist of a three- to four-segment alpha-numeric code that identifies the sample QC type, the date the sample was collected, and the number of this type of QC sample collected on that date.

AA	NNNNNN	NN	-F
QC Type	Date	Sequence Number (per day)	Filtered (aqueous only, if needed)

The QC types are identified as:

TB = Trip Blank
~~RB = Rinsate Blank (Equipment Blank)~~
FD = Field Duplicate
AB = Ambient Conditions Blank
WB = Source Water Blank

The sampling time recorded on the Chain-of-Custody Form, labels, and tags for duplicate samples will be 0000 so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the routine sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory). Documentation for all other QC types (TB, RB, AB, and WB) will be recorded on the QC Sample Log sheet (see SOP on Field Documentation).

5.6 Examples of Field QA/QC Sample Nomenclature

The first duplicate of the day for a filtered ground water sample collected on June 3, 2000 would be designated as FD06030001-F.

The third duplicate of the day taken of a subsurface soil sample collected on November 17, 2003 would be designated as FD11170303.

The first trip blank associated with samples collected on October 12, 2000 would be designated as TB10120001.

The only rinsate blank collected on November 17, 2001 would be designated as RB11170101.

6.0 DEVIATIONS

Any deviation from this SOP must be addressed in detail in the site specific planning documents.

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A MIS REQUEST FORM **7**

1.0 PURPOSE

The purpose of this document is to specify a consistent procedure for the quality assurance review of electronic and hard copy databases. This SOP outlines the requirements for establishment of a Database Record File, Quality Assurance review procedures, and documentation of the Quality Assurance Review Process.

2.0 SCOPE

The methods described in this Standard Operating Procedure (SOP) shall be used consistently for all projects managed by Tetra Tech NUS (TtNUS).

3.0 GLOSSARY

Chain-of-Custody Form - A Chain-of-Custody Form is a printed form that accompanies a sample or a group of samples from the time of sample collection to the laboratory. The Chain-of-Custody Form is retained with the samples during transfer of samples from one custodian to another. The Chain-of-Custody Form is a controlled document that becomes part of the permanent project file. Chain-of-Custody and field documentation requirements are addressed in SOP SA-6.1.

Electronic Database - A database provided on a compact laser disk (CD). Such electronic databases will generally be prepared using public domain software such as DBase, RBase, Oracle, Visual FoxPro, Microsoft Access, Paradox, etc.

Hardcopy Database - A printed copy of a database prepared using the software discussed under the definition of an electronic database.

Form I - A printed copy of the analytical results for each sample.

Sample Tracking Summary - A printed record of sample information including the date the samples were collected, the number of samples collected, the sample matrix, the laboratory to which the samples were shipped, the associated analytical requirements for the samples, the date the analytical data were received from the laboratory, and the date that validation of the sample data was completed.

4.0 RESPONSIBILITIES

Database Records Custodian - It shall be the responsibility of the Database Records Custodian to update and file the Sample Tracking Summaries for all active projects on a weekly basis. It shall be the responsibility of the Database Records Custodian to ensure that the most recent copies of the Sample Tracking Summaries are placed in the Database Records file. It shall be the responsibility of the Database Records Custodian to ensure that a copy of all validation deliverables is provided to the Project Manager (for placement in the project file). It shall be the responsibility of the Database Records Custodian to ensure that photocopies of all validation deliverables and historical data and reports (as applicable) are placed in the Database Records file.

Data Validation Coordinator - It shall be the responsibility of the Data Validation Coordinator (or designee) to ensure that the Sample Tracking Summaries are maintained by the Database Records Custodian. It shall be the responsibility of the Data Validation Coordinator (or designee) to ensure that photocopies of all data validation deliverables are placed in the applicable Database Records file by the Database Records Custodian.

Earth Sciences Department Manager - It shall be the responsibility of the Earth Sciences Department Manager (or equivalent) to ensure that all field personnel are familiar with the requirements of this Standard Operating Procedure (specifically Section 5.5).

FOL - It shall be the responsibility of the FOL (FOL) of each project to ensure that all field technicians or sampling personnel are thoroughly familiar with this SOP, specifically regarding provision of the Chain-of-Custody Forms to the Database Records Custodian. Other responsibilities of the FOL are described in Sections 5.4 and 5.5.

Management Information Systems (MIS) Manager - It shall be the responsibility of the MIS Manager to ensure that copies of original electronic deliverables (CDs) are placed in both the project files and the Database Records File. It shall be the responsibility of the MIS Manager (or designee) to verify the completeness of the database (presence of all samples) in both electronic and hardcopy form in the Database Records File. It shall be the responsibility of the MIS Manager to ensure that Quality Assurance Reviews are completed and are attested to by Quality Assurance Reviewers. It shall be the responsibility of the MIS Manager to ensure that records of the Quality Assurance review process are placed in the Database Records File. It shall be the responsibility of the MIS Manager to ensure that both electronic and hardcopy forms of the final database are placed in both the project and the Database Record File. It shall be the responsibility of the MIS Manager to ensure that data validation qualifiers are entered in the database.

Furthermore, it shall be the responsibility of the MIS Manager to participate in project planning at the request of the Project Manager, specifically with respect to the generation of level of effort and schedule estimates. To support the project planning effort, the MIS Manager shall provide a copy of the MIS Request From included as Attachment A to the project manager. It shall be the responsibility of the MIS Manager to generate level of effort and budget estimates at the time database support is requested if a budget does not exist at the time of the request. The MIS Request Form shall be provided to the Project Manager at the time of any such requests. It shall be the responsibility of the MIS Manager to notify the Project Manager of any anticipated level of effort overruns or schedule noncompliances as soon as such problems arise along with full justification for any deviations from the budget estimates (provided they were generated by the MIS Manager). It shall be the responsibility of the MIS Manager to document any changes to the scope of work dictated by the Project Manager, along with an estimate of the impact of the change on the level of effort and the schedule.

Program/Department Managers - It shall be the responsibility of the Department and/or Program Managers (or designees) to inform their respective department's Project Managers of the existence and requirements of this SOP.

Project Manager - It shall be the responsibility of each Project Manager to determine the applicability of this SOP based on: (1) program-specific requirements, and (2) project size and objectives. It shall be the responsibility of the Project Manager (or designee) to ensure that the FOL is familiar with the requirements regarding Chain-of-Custody Form provision to the Database Records Custodian. It shall be the responsibility of the Project Manager (or designee) to determine which, if any, historical data are relevant and to ensure that such data (including all relevant information such as originating entity, sample locations, sampling dates, etc.) are provided to the Database Records Custodian for inclusion in the Database Records File. It shall be the responsibility of the Project Manager to obtain project planning input regarding the level of effort and schedule from the MIS Manager. It shall be the responsibility of the Project Manager to complete the database checklist (Attachment A) to support the level of effort and schedule estimate and to facilitate database preparation and subroutine execution.

Risk Assessment Department Manager - It shall be the responsibility of the Risk Assessment Department Manager to monitor compliance with this Standard Operating Procedure, to modify this SOP as necessary, and to take corrective action if necessary. Monitoring of the process shall be completed on a quarterly basis.

Quality Assurance Reviewers - It shall be the responsibility of the Quality Assurance Reviewers to verify the completeness of the sample results via review of the Chain-of-Custody Forms and Sample Tracking Summaries. It shall be the responsibility of the Quality Assurance Reviewers to ensure the correctness of the database via direct comparison of the hardcopy printout of the database and the hardcopy summaries of the original analytical data (e.g., Form Is provided in data validation deliverables). Correctness includes the presence of all relevant sample information (all sample information fields), agreement of the laboratory and database analytical results, and the presence of data validation qualifiers.

Quality Manager - It shall be the responsibility of the Quality Manager to monitor compliance with this Standard Operating Procedure via routine audits.

5.0 PROCEDURES

5.1 Introduction

Verification of the accuracy and completeness of an electronic database can only be accomplished via comparison of a hardcopy of the database with hardcopy of all relevant sample information. The primary purposes of this SOP are to ensure that 1) all necessary hardcopy information is readily available to Quality Assurance Reviewers; 2) ensure that the Quality Assurance review is completed in a consistent and comprehensive manner, and; 3) ensure that documentation of the Quality Assurance review process is maintained in the project file.

5.2 File Establishment

A Database Record file shall be established for a specific project at the discretion of the Project Manager. Initiation of the filing procedure will commence upon receipt of the first set of Chain-of-Custody documents from a FOL or sampling technician. The Database Record Custodian shall establish a project-specific file for placement in the Database Record File. Each file in the Database Record File shall consist of standard components placed in the file as the project progresses. Each file shall be clearly labeled with the project number, which shall be placed on the front of the file drawer and on each and every hanging file folder relevant to the project. The following constitute the minimum components of a completed file:

- Electronic Deliverables
- Sample Tracking Forms
- Chain-of-Custody Forms
- Data Validation Letters
- Quality Assurance Records

5.3 Electronic Deliverables

The format of electronic deliverables shall be specified in the laboratory procurement specification and shall be provided by the laboratory. The integrity of all original electronic data deliverables shall be maintained. This shall be accomplished via the generation of copies of each electronic deliverable provided by the laboratory. The original electronic deliverable shall be provided to the project manager for inclusion in the project file. A copy of the original electronic deliverable shall be placed in the Database Record File. The second copy shall be maintained by the MIS Manager (or designee) to be used as a working copy.

5.4 Sample Tracking Forms

Updated versions of the sample tracking form for each relevant project shall be maintained by the Database Record Custodian. The Sample Tracking Forms shall be updated any time additional Chain-of-Custody Forms are received from a FOL or sampling technician, or at any time that data are received from a laboratory, or at any time that validation of a given data package (sample delivery group) is completed. The Data Validation Coordinator shall inform the Database Record Custodian of the receipt of any data packages from the laboratory and of completion of validation of a given data package to facilitate updating of the Sample Tracking Form. The Database Record Custodian shall place a revised copy of the Sample Tracking Form in the Database Record File anytime it has been updated. Copies of the updated Sample Tracking Form shall also be provided to the project manager to apprise the project manager of sample package receipt, completion of validation, etc.

5.5 Chain-of-Custody Forms

The Chain-of-Custody Forms for all sampling efforts will be used as the basis for (1) updating the Sample Tracking Form, and (2) confirming that all required samples and associated analyses have been completed. It shall be the responsibility of the FOL (or sample technician) to provide a photocopy of all Chain-of-Custody Forms to the Database Record Custodian immediately upon completion of a sampling effort. The Database Record Custodian shall then place the copies of the Chain-of-Custody Form(s) in the Database Record File. Upon receipt of a sample data package from an analytical laboratory, the Data Validation Coordinator shall provide a copy of the laboratory Chain-of-Custody Form to the Database Record Custodian. The Database Record Custodian shall use this copy to update the Sample Tracking Summary and shall place the copy of the laboratory-provided Chain-of-Custody Form in the Database Record File. The photocopy of the laboratory-provided Chain-of Custody Form shall be stapled to the previously filed field copy. Upon receipt of all analytical data, two copies of the Chain-of-Custody will therefore be in the file. Review of the Chain-of-Custody Forms will therefore be a simple mechanism to determine if all data have been received. Chain-of-Custody is addressed in SOP SA-6.1.

5.6 Data Validation Letters

All data validation deliverables (or raw data summaries if validation is not conducted) shall be provided for inclusion in both the Database Record File and the project file. If USEPA regional- or client-specific requirements are such that Form Is (or similar analytical results) need not be provided with the validation deliverable, copies of such results must be appended to the deliverable. It is preferable, although not essential that the validation qualifiers be hand-written directly on the data summary forms. The data validation deliverables (and attendant analytical summaries) will provide the basis for direct comparison of the database printout and the raw data and qualifiers.

5.7 Historical Data

At the direction of the Project Manager, historical data may also be included in a project-specific analytical database. In the event that historical data are germane to the project, hardcopy of the historical data must be included in the Database Record File. Historical data may be maintained in the form of final reports or as raw data. The information contained in the historical data file must be sufficient to identify its origin, its collection date, the sample location, the matrix, and any and all other pertinent information. All available analytical data, Chain-of-Custody Forms, boring logs, well construction logs, sample location maps, shall be photocopied by the Project Manager (or designee) and placed in one or more 3-ring binders. All information shall be organized chronologically by matrix. It shall be the responsibility of the Project Manager (or designee) to ensure that all inconsistencies between analytical data, Chain-of-Custody Forms, boring logs, sample log sheets, and field logbooks are identified and corrected. The Project Manager (or designee) shall decide which nomenclature is appropriate and edit, initial and date all relevant forms. Data entry may only be performed on information that has undergone the aforementioned

editing process, thereby having a direct correlation between hardcopy information and what will become the electronic database.

6.0 RECORDS

Records regarding database preparation and quality assurance review include all those identified in the previous section. Upon completion of the database task, records from the file will be forwarded to the Project Manager for inclusion in the project file, or will be placed in bankers boxes (or equivalent) for storage. The final records for storage shall include the following minimum information on placards placed on both the top and end of the storage box:

Database Record File
PROJECT NUMBER: ____
SITE NAME: _____
DATE FILED: __/__/__
SUMMARY OF CONTENTS ENCLOSED
BOX _ OF _

Project- or program-specific record keeping requirements shall take precedence over the record keeping requirements of this SOP.

ATTACHMENT A

MIS REQUEST FORM

Tetra Tech NUS, Inc.

Project Name:
CTO:
Project Manager:
Requestor:
Program/Client:
State/EPA Region:

Request Date:
Date Data Available for Production:
Request in Support of:
Database Lead:
GIS Lead:
Statistics Lead:
Risk Lead:

Site Name(s) (Area, OU, etc.):
Sampling Date(s):
Matrix: ☐ GW ☐ SO ☐ SD ☐ SW ☐ Other:

Labels: ☐ Labels needed for an upcoming sampling event _____ Total # of Samples
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
_____ FOL
Additional Instructions:

Data Entry:
☐ Chemical data needs to be entered from hardcopy _____ Estimated # of Samples
☐ Chemical data needs to be formated electronically
☐ Field analytical data needs to be entered from hardcopy
☐ Geologic data needs to be entered from hardcopy
☐ Hydrology data needs to be entered from hardcopy
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
Additional Instructions:

Tables:
☐ Full Data Printout
☐ Summary of Positive Hits
☐ Occurance and Distribution ☐ with criteria
☐ Sampling Analytical Summary
☐ Other:
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
Additional Instructions:

GIS:
☐ General Facility Location
☐ Site Location
☐ Potentiometric Contours/Groundwater Flow
☐ Sample Location Proposed
☐ Sample Location Existing
☐ Tag Map Single Round
☐ Tag Map Multiple Round
☐ Isoconcentrations
☐ Chart Map
☐ 3D Visualization
☐ EGIS CD
☐ Other:
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
Additional Instructions:

Statistics: ☐ Yes
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
Additional Instructions:

Geostatistics: ☐ Yes
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
Additional Instructions:

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1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating the physical condition and project utility of existing monitoring wells and determining water levels.

2.0 SCOPE

The procedures described herein are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

Water Table - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

4.0 RESPONSIBILITIES

Site Geologist/Hydrogeologist - Has overall responsibility for the evaluation of existing wells, obtaining water level measurements and developing groundwater contour maps. The site geologist/hydrogeologist (in concurrence with the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number and location of data points which shall be used for constructing a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - Must have a basic familiarity with the equipment and procedures involved in obtaining water levels and must be aware of any project-specific requirements or objectives.

5.0 PROCEDURES

Accurate, valid and useful groundwater monitoring requires that four important conditions be met:

- Proper characterization of site hydrogeology.
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths.
- Satisfactory methods of groundwater sampling and analysis to meet the project data quality objectives (DQOs).
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To insure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

~~5.1 Preliminary Evaluation~~

~~A necessary first step in evaluating existing monitoring well data is the study and review of the original work plan for monitoring well installation (if available). This helps to familiarize the site geologist/hydrogeologist with site-specific condition, and will promote an understanding of the original purpose of the monitoring wells.~~

~~The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology, and will help to establish consistency between hydraulic properties of the well and physical features of the well or formation. The physical features which should be identified and detailed, if available, include:~~

- ~~The well identification number, permit number and location by referenced coordinates, the distance from prominent site features, or the location of the well on a map.~~
- ~~The installation dates, drilling methods, well development methods, past sampling dates, and drilling contractors.~~
- ~~The depth to bedrock – where rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split barrel sampling) may be used to estimate bedrock interface.~~
- ~~The soil profile and stratigraphy.~~
- ~~The borehole depth and diameter.~~
- ~~The elevation of the top of the protective casing, the top of the well riser, and the ground surface.~~
- ~~The total depth of the well.~~
- ~~The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval.~~
- ~~The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size.~~

~~5.2 Field Inspection~~

~~During the onsite inspection of existing monitoring wells, features to be noted include:~~

- ~~The condition of the protective casing, cap and lock.~~
- ~~The condition of the cement seal surrounding the protective casing.~~
- ~~The presence of depressions or standing water around the casing.~~
- ~~The presence of and condition of dedicated sampling equipment.~~
- ~~The presence of a survey mark on the inner well casing.~~

~~If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have infiltrated into the well. This may invalidate previous sampling results unless the time when leakage started can be precisely determined.~~

~~The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these occurrences may invalidate~~

~~previously collected water quality data. If the monitoring well is to be used in the future, considerations shown in the steps described above should be rectified to rehabilitate the well.~~

~~After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a photoionization detector (PID) or flame ionization detector (FID) to determine the appropriate worker safety level. The following information should be noted:~~

- ~~Cap function.~~
- ~~Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space.~~
- ~~Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing.~~
- ~~Presence of a riser cap, method of attachment to casing, and venting of the riser.~~
- ~~Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.~~

~~The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. This includes the determination of static water levels, total well depth and well obstruction. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present and/or the well has not been sampled in 12 or more months, it should be redeveloped before sampling.~~

~~Lastly, as a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.~~

~~See Attachment A, Monitoring Well Inspection Sheet.~~

5.3 Water Level (Hydraulic Head) Measurements

5.3.1 General

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well purging or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the site geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and barometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells, if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater, if required.

Water level readings shall be taken regularly, as required by the site geologist/hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize affects due to weather changes.

5.3.2 Water Level Measuring Techniques

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the site geologist/hydrogeologist.

In most instances, preparation of accurate potentiometric surface maps require that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, electrical water level indicator methods have been found to be best, and thus should be utilized. Other, less precise methods, such as the popper or bell sound, or bailer line methods, should be avoided. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use a pressure transducer.

5.3.3 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment, as required. Never remove an air-tight lock (such as a J-plug) with your face over the well. Pressure changes within the well may explosively force the cap off once loosened.

2. Record all information specified below in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B):

   - Well number.
   - Water level (to the nearest 0.01 foot). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing. If the J-plug was on the well very tightly, it may take several minutes for the water level to stabilize.
   - Time and day of the measurement.
   - Thickness of free product if present.

Water level measuring devices with permanently marked intervals shall be used. The devices shall be free of kinks or folds which will affect the ability of the equipment to hang straight in the well pipe.

5.3.4 Water Level Measuring Devices

Electric Water Level Indicators

These are the most commonly used devices and consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well adjacent to the survey mark on the inner well casing. The electric tape is read (to the nearest 0.01 ft.) at the measuring point and recorded where contact with the water surface was indicated.

~~**Popper or Bell Sounder**~~

~~A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.~~

~~**Pressure Transducer**~~

~~Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.~~

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

5.3.5 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

5.3.6 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells. Manufacturer's instructions for cleaning the device shall be strictly followed. Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy and any adjustments/corrections shall be recorded in the field logbook/notebook. After the corrections/adjustments are made to the measuring device and entered in the field logbook/notebook, the corrected readings shall be entered onto the Groundwater Level Measurement Sheet (Attachment B). Elevations will be entered on the sheet when they become available.

5.4 Equipment Decontamination

Equipment used for water level measurements provide a mechanism for potentially cross contaminating wells. Therefore, all portions of a device which project down the well casing must be decontaminated prior to advancing to the next well. Decontamination procedures vary based on the project objectives but must be defined prior to conducting any field activities including the collection of water level data. Consult the project planning documents and SA-7.1 Decontamination of Field Equipment.

5.5 Health and Safety Considerations

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a health/safety hazard which must be considered. Initial monitoring of the well headspace and breathing zone concentrations using a PID or FID shall be performed to determine required levels of protection. Under certain conditions, air-tight well caps may explosively fly off the well when the pressure is relieved. Never stand directly over a well when uncapping it.

6.0 RECORDS

A record of all field procedures, tests and observations must be recorded in the site logbook or designated field notebook. Entries in the log/notebook should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation.

~~ATTACHMENT A~~
~~MONITORING WELL INSPECTION SHEET~~

Monitoring Well Inspection Sheet

Project Name: _____ Date: _____
Location: _____ Time: _____
Tidally Influenced: Y / N Personnel: _____

Field Measurements				
Well ID	PID Reading PPM	Depth to Water *	Total Depth *	Flush Mt./ Stick-up

Well Construction Details (Taken from construction logs)		
Total Depth *	Ground Elev.	Top/Btm Screen *

Check List:

Riser Pipe Material:
Riser Notched for Surveyors:
Well ID Tag In-place:
Well security:
Photo taken:

Condition of Well:

Protective Case:
Riser:
Well Pad:
Other:

Presence/Evidence of:

Standing Water Around Well:
Existing Sampling Equipment:
Sediment build-up in Well Btm:

Comments:

** = Measurements are from the top of the inner case to the nearest 0.01'*

ATTACHMENT B
GROUNDWATER LEVEL MESUREMENT SHEET

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: _____ **Project No.:** _____
Location: _____ **Personnel:** _____
Weather Conditions: _____ **Measuring Device:** _____
Tidally Influenced: Yes ___ No ___ **Remarks:** _____

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Comments

* All measurements to the nearest 0.01 foot, from surveyed mark (unless noted)

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A DRILLING EQUIPMENT SIZES 25

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1.0 PURPOSE

The purpose of this procedure is to describe the methods and equipment necessary to perform soil and rock borings and identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits, and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

The sampling methods described within this procedure are applicable to collecting surface and subsurface soil samples, and obtaining rock core samples for lithologic and hydrogeologic evaluation, excavation/foundation design, remedial alternative design and related civil engineering purposes.

3.0 GLOSSARY

Rock Coring - A method in which a continuous solid cylindrical sample of rock or compact rock-like soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

~~Wire-Line Coring - As an alternative to conventional coring, this technique is valuable in deep hole drilling, since this method eliminates trips in and out of the hole with the coring equipment. With this technique, the core barrel becomes an integral part of the drill rod string. The drill rod serves as both a coring device and casing.~~

4.0 RESPONSIBILITIES

Project Manager - In consultation with the project geologist, the Project Manager is responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and the known or suspected geologic conditions at the site. The Project Manager also determines the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Field Operations Leader (FOL) - The FOL is responsible for the overall supervision and scheduling of drilling activities, and is strongly supported by the project geologist.

Project Geologist - The project geologist is responsible for ensuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see SOPs SA-6.3 and GH-1.5). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan and/or Sampling and Analysis Plan.

Drilling Subcontractor - Operates under the supervision of the FOL. Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the FOL within 24 hours of determination, and must provide advance written notification of any changes in field procedures, describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the FOL (with the concurrence of the Project Manager). Depending on the subcontract, the Project Manager may need to obtain written authorization from appropriate administrative personnel before approving any changes.

The drilling subcontractor is responsible for following decontamination procedures specified in the project plan documents. Upon completion of the work, the driller is responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 General

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site.
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned between samples and borings using appropriate decontamination procedures as outlined in SOP SA-7.1. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the site geologist as they proceed (see SOPs SA-6.3 and GH-1.5). Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the site geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

5.2 Drilling Methods

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, the waste conditions at the site, and reviewing the purpose of drilling and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of rotating augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations requires the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.
- No drilling fluids are required.
- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.

- The inside diameter of hollow stem augers used for well installation should be at least 4 inches greater than the well casing. Use of such large-diameter hollow-stem augers is more expensive than the use of small-diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.

- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.

- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet.

Hollow-stem auger drilling is the preferred method of drilling. Most alternative methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods, great care must be taken to ensure that the method does not interfere with the collection of a representative sample (which may be the prime objective of the borehole construction). With this in mind, the preferred order of choice of drilling method after hollow-stem augering (HSA) is:

- Cable tool
- Casing drive (air)
- Air rotary
- Mud rotary
- Rotosonic
- Drive and wash
- Jetting

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow-stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The guidelines established in SOP SA-1.3 shall

also be followed. The hollow-stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation. However, when drilling below the water table, specially designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This drilling configuration method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see SOP GH-2.8 for well development procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

At the option of the Field Operations Leader (in communication with the Project Manager), when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations, it may be prudent to also grout borings which penetrate only the water table aquifer, since loose soil backfill in the boring may still provide a preferred pathway for surface liquids to reach the water table. Backfilling requirements may also be driven by state or local regulations.

~~**5.2.2 Continuous-Flight Solid-Stem Auger Drilling**~~

~~This drilling method is similar to hollow-stem augering. Practical application of this method is severely restricted compared to use of hollow-stem augers. Split-barrel (split-spoon) sampling cannot be performed without pulling the augers out, which may allow the hole to collapse. The continuous-flight solid-stem auger drilling method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable, and depth to water may be difficult to determine while drilling.~~

~~There would be very few situations where use of a solid-stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to remain open after the augers are withdrawn. Alternatively, this technique can be used to find depth to bedrock in an area when no other information is required from drilling.~~

~~**5.2.3 Rotary Drilling**~~

~~Direct rotary drilling includes air-rotary and fluid-rotary drilling. For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque~~

~~and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.~~

~~Air rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:~~

- ~~The drilling rate is high (even in rock).~~
- ~~The cost per foot of drilling is relatively low.~~
- ~~Air rotary rigs are common in most areas.~~
- ~~No drilling fluid is required (except when water is injected to keep down dust).~~
- ~~The borehole diameter is large, to allow room for proper well installation procedures.~~

~~Disadvantages to using this method include:~~

- ~~Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.~~
- ~~Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.~~
- ~~In situ samples cannot be taken, unless the hole is cased.~~
- ~~Casing must generally be used in unconsolidated materials.~~
- ~~Air rotary drill rigs are large and heavy.~~
- ~~Large amounts of Investigation Derived Waste (IDW) may be generated which may require containerization, sampling, and off-site disposal.~~

~~A variation of the typical air rotary drill bit is a down hole hammer which hammers the drill bit down as it drills. This makes drilling in hard rock faster. Air-rotary drills can also be adapted to use for rock coring although they are generally slower than other types of core drills. A major application of the air-rotary drilling method would be to drill holes in rock for well installation.~~

~~Fluid Rotary drilling operates in a similar manner to air rotary drilling except that a drilling fluid ("mud") or clean water is used in place of air to cool the drill bit and remove cuttings. There are a variety of fluids that can be used with this drilling method, including bentonite slurry and synthetic slurries. If a drilling fluid other than water/cuttings is used, it must be a natural clay (i.e., bentonite) and a "background" sample of the fluid should be taken for analysis of possible organic or inorganic contaminants.~~

~~Advantages to the fluid rotary drilling method include:~~

- ~~The ability to drill in many types of formations.~~
- ~~Relatively quick and inexpensive.~~
- ~~Split barrel (split spoon) or thin wall (Shelby) tube samples can be obtained without removing drill rods if the appropriate size drill rods and bits (i.e., fish tail or drag bit) are used.~~

- ~~In some borings temporary casing may not be needed as the drilling fluids may keep the borehole open.~~
- ~~Drill rigs are readily available in most areas.~~

~~Disadvantages to this method include:~~

- ~~Formation logging is not as accurate as with hollow-stem auger method if split-barrel (split-spoon) samples are not taken (i.e., the depths of materials logged from cuttings delivered to the surface are approximate).~~
- ~~Drilling fluids reduce permeability of the formation adjacent to the boring to some degree, and require more extensive well development than "dry" techniques (augering, air rotary).~~
- ~~No information on depth to water is obtainable while drilling.~~
- ~~Fluids are needed for drilling, and there is some question about the effects of the drilling fluids on subsequent water samples obtained. For this reason as well, extensive well development may be required.~~
- ~~In very porous materials (i.e., rubble fill, boulders, coarse gravel) drilling fluids may be continuously lost into the formation. This requires either constant replenishment of the drilling fluid, or the use of casing through this formation.~~
- ~~Drill rigs are large and heavy, and must be supported with supplied water.~~
- ~~Groundwater samples can be potentially diluted with drilling fluid.~~

~~The procedures for performing direct rotary soil investigations and sampling shall conform with the applicable ASTM standards: D2113-83, D1587-83, and D1586-84.~~

~~Soil samples shall be taken as specified by project plan documents, or more frequently, if requested by the project geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.~~

~~When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the project geologist.~~

~~5.2.4 Rotosonic Drilling~~

~~The Rotosonic drilling method employs a high frequency vibrational and low speed rotational motion coupled with down pressure to advance the cutting edge of a drill string. This produces a uniform borehole while providing a continuous, undisturbed core sample of both unconsolidated and most bedrock formations. Rotosonic drilling advances a 4-inch diameter to 12-inch diameter core barrel for sampling and can advance up to a 12-inch diameter outer casing for the construction of standard and telescoped monitoring wells. During drilling, the core barrel is advanced ahead of the outer barrel in increments as determined by the site geologist and depending upon type of material, degree of subsurface contamination and sampling objectives.~~

~~The outer casing can be advanced at the same time as the inner drill string and core barrel, or advanced down over the inner drill rods and core barrel, or after the core barrel has moved ahead to collect the undisturbed sample and has been pulled out of the borehole. The outer casing can be advanced dry in most cases, or can be advanced with water or air depending upon the formations being drilled, the depth and diameter of the hole, or requirements of the project.~~

~~Advantages of this method include:~~

- ~~Sampling and well installation are faster as compared to other drilling methods.~~
- ~~Continuous sampling, with larger sample volume as compared to split-spoon sampling.~~
- ~~The ability to drill through difficult formations such as cobbles or boulders, hard till and bedrock.~~
- ~~Reduction of IDW by an average of 70 to 80 percent.~~
- ~~Well installations are quick and controlled by elimination of potential bridging of annular materials during well installation, due to the ability to vibrate the outer casing during removal.~~

~~Disadvantages include:~~

- ~~The cost for Rotosonic drilling as compared to other methods are generally higher. However, the net result can be a significant savings considering reduced IDW and shortened project duration.~~
- ~~Rotosonic drill rigs are large and need ample room to drill, however, Rotosonic units can be placed on the ground or placed on an ATV.~~
- ~~There are a limited number of Rotosonic drilling contractors at the present time.~~

~~5.2.5 Reverse Circulation Rotary Drilling~~

~~The common reverse circulation rig is a water or mud-rotary rig with a large-diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud-rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water quality sampling wells because of the use of drilling muds and the large-diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.~~

~~Advantages of the latter method include:~~

- ~~The formation water is not contaminated by the drilling water.~~
- ~~Formation samples can be obtained, from known depths.~~
- ~~When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.~~
- ~~Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air-rotary rig.~~

~~Disadvantages include:~~

- ~~Double-wall, reverse-circulation drill rigs are rare and expensive to operate.~~
- ~~Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.~~

~~**5.2.6 Drill through Casing Driver**~~

~~The driven casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig (or an air-hammer) and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage); a continuous record is kept of the blows per foot in driving the casing (see SOP GH-1.5). The casing is normally advanced by a 300-pound hammer falling freely through a height of 30 inches. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations within which wash water is used and in which the casing is driven must be clearly recorded.~~

~~The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least 4 inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:~~

- ~~Split barrel (split spoon) sampling can be conducted while drilling.~~
- ~~Well installation is easily accomplished.~~
- ~~Drill rigs used are relatively small and mobile.~~
- ~~The use of casing minimizes flow into the hole from upper water-bearing layers; therefore, multiple aquifers can be penetrated and sampled for rough field determinations of some water quality parameters.~~

~~Some of the disadvantages include:~~

- ~~This method can only be used in unconsolidated formations.~~
- ~~The method is slower than other methods (average drilling progress is 30 to 50 feet per day).~~
- ~~Maximum depth of the borehole varies with the size of the drill rig and casing diameter used, and the nature of the formations drilled.~~
- ~~The cost per hour or per foot of drilling may be substantially higher than other drilling methods.~~
- ~~It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).~~

~~**5.2.7 Cable Tool Drilling**~~

~~A cable tool rig uses a heavy, solid-steel, chisel-type drill bit ("tool") suspended on a steel cable, which when raised and dropped, chisels or pounds a hole through the soils and rock. Drilling progress may be~~

~~expedited by the use of "slip-jars" which serve as a cable-activated down-hole percussion device to hammer the bit ahead.~~

~~When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. Below the water table, after sufficient ground water enters the borehole to replace the water removed by bailing, no further water needs to be added. When soft caving formations are encountered, it is usually necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole (see Section 5.2.5 of this guideline).~~

~~Advantages of the cable tool method include the following:~~

- ~~Information regarding water bearing zones is readily available during the drilling. Even relative permeabilities and rough water quality data from different zones penetrated can be obtained by skilled operators.~~
- ~~The cable tool rig can operate satisfactorily in all formations, but is best suited for caving, boulder, cobble or coarse gravel type formations (e.g., glacial till) or formations with large cavities above the water table (such as limestones).~~
- ~~When casing is used, the casing seals formation water out of the hole, preventing down-hole contamination and allowing sampling of deeper aquifers for field-measurable water quality parameters.~~
- ~~Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be collected through the casing.~~

~~Disadvantages include~~:

- ~~Drilling is slow compared with rotary rigs.~~
- ~~The necessity of driving the casing in unconsolidated formations requires that the casing be pulled back if exposure of selected water-bearing zones is desired. This process complicates the well completion process and often increases costs. There is also a chance that the casing may become stuck in the hole.~~
- ~~The relatively large diameters required (minimum of 4-inch casing) plus the cost of steel casing result in higher costs compared to rotary drilling methods where casing is not required (e.g., such use of a hollow-stem auger).~~
- ~~Cable tool rigs have largely been replaced by rotary rigs. In some parts of the U.S., availability may be difficult.~~

~~5.2.8 Jet Drilling (Washing)~~

~~Jet drilling, which should be used only for piezometer or vadose zone sampler installation, consists of pumping water or drilling mud down through a small diameter (1/2- to 2-inch) standard pipe (steel or PVC). The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.~~

~~Jet percussion is a variation of the jetting method, in which the casing is driven with a drive weight. Normally, this method is used to place 2-inch diameter casing in shallow, unconsolidated sand formations, but this method has also been used to install 3- to 4-inch-diameter casings to a depth of 200 feet.~~

~~Jetting is acceptable in very soft formations, usually for shallow sampling, and when introduction of drilling water to the formation is acceptable. Such conditions would occur during rough stratigraphic investigation or installation of piezometers for water level measurement. Advantages of this method include:~~

- ~~Jetting is fast and inexpensive.~~
- ~~Because of the small amount of equipment required, jetting can be accomplished in locations where access by a normal drilling rig would be very difficult. For example, it would be possible to jet down a well point in the center of a lagoon at a fraction of the cost of using a drill rig.~~
- ~~Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.~~

~~Disadvantages include the following:~~

- ~~A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.~~
- ~~Jetting is usually done in very soft formations which are subject to caving. Because of this caving, it is often not possible to place a grout seal above the screen to assure that water in the well is only from the screened interval.~~
- ~~The diameter of the casing is usually limited to 2 inches.~~
- ~~Jetting is only possible in very soft formations that do not contain boulders or coarse gravel, and the depth limitation is shallow (about 30 feet without jet percussion equipment).~~
- ~~Large quantities of water are often needed.~~

~~5.2.9 Drilling with a Hand Auger~~

~~This method is applicable wherever the formation, total depth of sampling, and the site and groundwater conditions are such as to allow hand auger drilling. Hand augering can also be considered at locations where drill rig access is not possible. All hand auger borings will be performed according to ASTM D1452-80.~~

~~Samples should be taken continuously unless otherwise specified by the project plan documents. Any required sampling is performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. Typical equipment used for sampling and advancing shallow "hand auger" holes are Iwan samplers (which are rotated) or post hole diggers (which are operated like tongs). These techniques are slow but effective where larger pieces of equipment do not have access, and where very shallow holes are desired (less than 15 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.~~

~~5.2.10 Rock Drilling and Coring~~

~~When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.~~

~~Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond studded bit attached to the outer core barrel in a double tube core barrel. The use of single tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation of this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.~~

~~Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see Section 5.3 of this guideline). A double tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the project plans. The most common core barrel diameters are listed in Attachment A.~~

~~Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.~~

~~When coring rock, including shale and claystone, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole causing unsatisfactory coring, the hole should be reamed and a flush-joint casing installed to a point below the broken formation. The size of the flush-joint casing must permit securing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.~~

~~Advantages of core drilling include:~~

- ~~Undisturbed rock cores can be recovered for examination and/or testing.~~
- ~~In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.~~
- ~~Formation logging is extremely accurate.~~
- ~~Drill rigs are relatively small and mobile.~~

~~Disadvantages include:~~

- ~~Water or air is needed for drilling.~~
- ~~Coring is slower than rotary drilling (and more expensive).~~
- ~~Depth to water cannot accurately be determined if water is used for drilling.~~
- ~~The size of the borehole is limited.~~

~~This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods~~.

5.2.11 Drilling & Support Vehicles

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight, size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand carried to the borehole site. Drilling/sampling methods used with such equipment include:

  - Hand augers and lightweight motorized augers.
  - Retractable plug samplers--driven by hand (hammer).
  - Motorized cathead - a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small-diameter cased borings. This rig is sometimes called a "monkey on a stick."

- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismounted tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.

- Small truck-mounted drilling equipment using a Jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs, the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.

- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel" rigs.

- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the drill, derrick, winches, and pumps or compressors. The drill may be provided with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on vehicles having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.

- ~~Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles include:~~

  - ~~Barrel-float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallon drums or similar flotation units.~~

  - ~~Barge-mounted drill rigs.~~

- ~~Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.~~

- ~~Drill ships - for deep ocean drilling.~~

~~In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.~~

5.2.12 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

~~For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8-inch or 7-7/8-inch bits will nominally drill 6-inch and 8-inch holes, respectively).~~

For obtaining split-barrel samples of a formation, samplers are commonly manufactured in sizes ranging from 2 inches to 3-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used and driven by a 140-pound (± 2-pound) hammer dropping 30 inches (± 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow-stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the project plan documents.

5.2.13 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site, the following must be considered:

- The speed of the drilling method employed.

- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).

- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30 feet to 50 feet) boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
Hollow-stem augers	75'
~~Solid-stem augers~~	~~50'~~
~~Mud-Rotary Drilling~~	~~100' (cuttings samples)~~
~~Rotosonic Drilling~~	~~100'-160' (continuous core)~~
~~Reverse-Circulation Rotary~~	~~100' (cuttings samples)~~
~~Skid-Rig with driven casing~~	~~30'~~
~~Rotary with driven casing~~	~~50'~~
~~Cable Tool~~	~~30'~~
~~Hand Auger~~	~~Varies~~
~~Continuous Rock Coring~~	~~50'~~

5.3 Prevention of Cross-Contamination

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe (a method similar to the rock coring method described in Section 5.2.10, except that larger casing is used) or by using a driven-casing method (see Section 5.2.6 of this guideline) and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing (usually of 8-inch diameter) is installed followed by installation of the well casing (6-inch-diameter is common for 2-inch wells). This well casing is driven into the confining layer to ensure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end, is installed to the surface.

Clean sand is placed in the annulus around and to a point of about 2 feet above the screen prior to withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressure-grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

5.4 Cleanout of Casing Prior to Sampling

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from the advancement of the casing. Loss of wash water during cleaning should be recorded.

For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the cleaning operation is usually performed by washing the material out of the casing with water; however, the cleaning should never be accomplished with a strong, downward-directed jet which will disturb the underlying soil. When clean out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the hole, to surge these large particles upward out of the hole. As a time saver, the drilling contractor may be permitted to use a split-barrel (split-spoon) sampler with the ball check valve removed as the clean-out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split-spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hard-cemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner, there is a minimum of disturbance at the top of the material to be sampled. If any gravel material washes down into the casing and cannot be removed by the clean out auger, a split-barrel sample can be taken to remove it; bailers and sandpumps should not be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry manner.

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler may become filled with the cuttings. This limits the amount of sample from the underlying formation which can enter and be retained in the sampler, and also raises questions as to the validity of the sample.

- If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.

- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.

- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the site geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string, then measuring the height of this reference point above the ground surface. The difference of these measurements is the

depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches of cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

5.5 Materials of Construction

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in SOP GH-2.8. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long-term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods and procedures for their use must be provided by the site geologist and approved by the Project Manager. The specific slurry composition and the concentration of suspected contaminants for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field by the judgment of the site geologist and noted in the site logbook, and only after approval by the Project Manager, a vegetable oil or silicone-based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

5.6 Subsurface Soil Samples

Subsurface soil samples are used to characterize subsurface stratigraphy. This characterization can indicate the potential for migration of chemical contaminants in the subsurface. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

Surface protocols for various soil sampling techniques are discussed in SOP SA-1.3. Continuous-core soil sampling and rock coring are discussed below. The procedures described here are representative of

a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

The CME continuous sample tube system provides a method of sampling soil continuously during hollow-stem augering. The 5-foot sample barrel fits within the lead auger of a hollow-auger column. The sampling system can be used with a wide range of I.D. hollow-stem augers (from 3-1/4-inch to 8-1/4-inch I.D.). This method has been used to sample many different materials such as glacial drift, hard clays and shales, mine tailings, etc. This method is particularly used when SPT samples are not required and a large volume of material is needed. Also, this method is useful when a visual description of the subsurface lithology is required. Rotosonic drilling methods also provide a continuous soil sample.

~~5.7 Rock Sampling (Coring) (ASTM D2113-83)~~

~~Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. Rock coring can, however, proceed for thousands of feet continuously, depending on the size of the drill rig, and yields better quality data than air-rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Average output in a 10 hour day ranges from 40 to over 200 feet. Down hole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.~~

~~Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Figure 1.~~

~~Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross-contamination of aquifers.~~

~~Drilling through bedrock is initiated by using a diamond-tipped core bit threaded to a drill rod (outer core barrel) with a rate of drilling determined by the downward pressure, rotation speed of drill rods, drilling fluid pressure in the borehole, and the characteristics of the rock (mineralogy, cementation, weathering).~~

FIGURE 1

STANDARD SIZES OF CORE BARRELS AND CASING

Coring Bit Size	Nominal*		Set Size*	
	O.D.	I.D.	O.D.	I.D.
RWT	1 5/32	3/4	1.160	0.735
EWT	1 1/2	29/32	1.470	0.905
EX, EXL, EWG, EWM	1 1/2	13/16	1.470	0.845
AWT	1 7/8	1 9/32	1.875	1.281
AX, AXL, AWG, AWM	1 7/8	1 3/16	1.875	1.185
BWT	2 3/8	1 3/4	2.345	1.750
BX, BXL, BWG, BWM	2 3/8	1 5/8	2.345	1.655
NWT	3	2 5/16	2.965	2.313
NX, NXL, NWG, NWM	3	2 1/8	2.965	2.155
HWT	3 29/32	3 3/16	3.889	3.187
HWG	3 29/32	3	3.889	3.000
2 3/4 x 3 7/8	3 7/8	2 3/4	3.840	2.690
4 x 5 1/2	5 1/2	4	5.435	3.970
6 x 7 3/4	7 3/4	6	7.655	5.970
AX Wire line ___|___/	1 7/8	1	1.875	1.000
BX Wire line ___|___/	2 3/8	1 7/16	2.345	1.437
NX Wire line ___|___/	3	1 15/16	2.965	1.937

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.

___|___/ Wire line dimensions and designations may vary according to manufacturer.

FIGURE 1
STANDARD SIZES OF CORE BARRELS AND CASING
PAGE TWO

Size Designations		Casing O.D., Inches	Casing Coupling		Casing bit O.D., Inches	Core barrel bit O.D., Inches*	Drill rod O.D., Inches	Approximate Core Diameter	
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; rod couplings		O.D., Inches	I.D., Inches				Normal, Inches	Thinwall, Inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	—	0.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	0.845	0.905
AX	A	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
BX	B	2.875	2.875	2.375	2.965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1.437	Flush Joint	No Coupling	1.485	1.160	1.094	—	0.735
EW	EW	1.812			1.875	1.470	1.375	0.845	0.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4.625	3.890	3.500	3.000	3.187
PW	—	5.500			5.650	—	—	—	—
SW	—	6.625			6.790	—	—	—	—
UW	—	7.625			7.800	—	—	—	—
ZW	—	8.625			8.810	—	—	—	—
—	AX __|__\	—	—	—	—	1.875	1.750	1.000	—
—	BX __|__\	—	—	—	—	2.345	2.250	1.437	—
—	NX __|__\	—	—	—	—	2.965	2.813	1.937	—

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.

__\|__/ *Wire line dimensions and designations may vary according to manufacturer.*

NOMINAL DIMENSIONS FOR DRILL CASINGS AND ACCESSORIES. (DIAMOND CORE DRILL MANUFACTURERS ASSOCIATION). 288-D-2889

~~5.7.1 Diamond Core Drilling~~

~~A penetration of typically less than 6 inches per 50 blows using a 140-lb. hammer dropping 30 inches with a 2-inch split-barrel sampler shall be considered an indication that soil sampling methods may not be applicable and that coring may be necessary to obtain samples.~~

~~When formations are encountered that are too hard to be sampled by soil sampling methods, the following diamond core drilling procedure may be used:~~

- ~~Firmly seat a casing into the bedrock or the hard material to prevent loose materials from entering the hole and to prevent the loss of drilling fluid return. Level the surface of the rock or hard material when necessary by the use of a fishtail or other bits. If the drill hole can be retained open without the casing and if cross-contamination of aquifers in the unconsolidated materials is unlikely, leveling may be omitted.~~

- ~~Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3 m), remove the core barrel from the hole and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately. In soft materials, a large starting size may be specified for the coring tools; where local experience indicates satisfactory core recovery or where hard, sound materials are anticipated, a smaller size or the single-tube type may be specified and longer runs may be drilled. NX/NW size coring equipment is the most commonly used size.~~

- ~~When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split-barrel Sampling) or in Method D 1587 (Thin Walled Tube Sampling); sample soils per SOP SA-1.3. Resume diamond core drilling when refusal materials are again encountered.~~

- ~~Since rock structures and the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as conditions warrant.~~

- ~~In soft, seamy, or otherwise unsound rock, where core recovery may be difficult, M-design core barrels may be used. In hard, sound rock where a high percentage of core recovery is anticipated, the single-tube core barrel may be employed.~~

~~5.7.2 Rock Sample Preparation and Documentation~~

~~Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in SOP GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as designating the top and bottom of the core run.~~

~~After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Project Geologist. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows.~~

~~The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer, the top of the cored interval contained within the box is in the upper left corner of the box, and the bottom of the cored interval is in the lower right corner of the box. The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.~~

~~The inside and outside of the core box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:~~

- ~~Project name.~~
- ~~Project number.~~
- ~~Boring number.~~
- ~~Run numbers.~~
- ~~Footage (depths).~~
- ~~Recovery.~~
- ~~RQD (%).~~
- ~~Box number and total number of boxes for that boring (Example: Box 5 of 7).~~

~~For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number.~~

~~Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).~~

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ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Hollow-stem augers (Ref. 7)	6 1/4	5	2 1/4	
	6 3/4	5 3/4	2 3/4	—
	7 1/4	6 1/4	3 1/4	—
	13 1/4	12	6	—
Thin Wall Tube Samplers (Ref. 7)	—	2	1 7/8	—
	—	2 1/2	2 3/8	—
	—	3	2 7/8	—
	—	3 1/2	3 3/8	—
	—	4 1/2	4 3/8	—
	—	5	4 3/4	—
Drill Rods (Ref. 7)	RW	1 3/32	23/32	13/32
	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	A	1 5/8	1 1/8	9/16
	B	1 7/8	1 1/4	5/8
	N	2 3/8	2	1
				Wall Thickness (Inches)
Driven External Coupled Extra Strong Steel* Casing (Ref. 8)	2 1/2	2.875	2.323	0.276
	3	3.5	2.9	0.300
	3 1/2	4.0	3.364	0.318
	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
	12	12.750	11.750	0.500

* Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

ATTACHMENT A
DRILLING EQUIPMENT SIZES
PAGE TWO

Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Flush Coupled Casing (Ref. 7)	RX	1 7/16	1 3/16	1 3/16
	EX	1 13/16	1 5/8	1 1/2
	AX	2 1/4	2	1 29/32
	BX	2 7/8	2 9/16	2 3/8
	NX	3 1/2	3 3/16	3
	HX	4 1/2	4 1/8	3 15/16
Flush Joint Casing (Ref. 7)	RW	1 7/16	1 3/16	
	EW	1 13/16	1 1/2	
	AW	2 1/4	1 29/32	
	BW	2 7/8	2 3/8	
	NW	3 1/2	3	
	HW	4 1/2	4	
	PW	5 1/2	5	
	SW	6 5/8	6	
	UW	7 5/8	7	
	ZW	8 5/8	8	
Diamond Core Barrels (Ref. 7)	EWM	1 1/2	7/8**	
	AWM	1 7/8	1 1/8**	
	BWM	2 3/8	1 5/8**	
	NWM	3	2 1/8	
	HWG	3 7/8	3	
	2 3/4 x 3 7/8	3 7/8	2 11/16	
	4 x 5 1/2	5 1/2	3 15/16	
	6 x 7 3/4	7 3/4	5 15/16	
	AQ (wireline)	1 57/64	1 1/16**	
	BQ (wireline)	2 23/64	1 7/16**	
	NQ (wireline)	2 63/64	1 7/8	
	HQ (wireline)	3 25/32	2 1/2	

** Because of the fragile nature of the core and the difficulty to identify rock details, use of small-diameter core (1 3/8") is not recommended.

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1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist. Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used on site, the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 Materials Needed

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute hydrochloric acid (HCl)
- Ruler (marked in tenths and hundredths of feet)
- Hand Lens

5.2 Classification of Soils

All data shall be written directly on the boring log (Figure 1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

FIGURE 1

BORING LOG (EXAMPLE)

BORING LOG

Page ___ of ___

PROJECT NAME: _____ BORING NUMBER: _____
PROJECT NUMBER: _____ DATE: _____
DRILLING COMPANY: _____ GEOLOGIST: _____
DRILLING RIG: _____ DRILLER: _____

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**

* When rock coring, enter rock brokeness.

** Include monitor reading in 5 foot intervals @ borehole. Increase reading frequency if elevated response-read.

Drilling Area Background (ppm): [ ]

Remarks: _____

Converted to Well: Yes _____ No _____ Well I.D. #: _____

FIGURE 1 (CONTINUED)

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE-GRAINED SOILS More Than Half of Material is LARGER Than No. 200 Sieve Size				
FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)			GROUP SYMBOL	TYPICAL NAMES
GRAVELS (More than half of coarse fraction is larger than No. 4 sieve size)	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
	GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures, see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.
SANDS (More than half of coarse fraction is smaller than No. 4 sieve size)	CLEAN SANDS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sands, gravelly sands, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures, see ML)	SM	Silty sands, poorly graded sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.

FINE-GRAINED SOILS More Than Half of Material is SMALLER Than No. 200 Sieve Size						
FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)					GROUP SYMBOL	TYPICAL NAMES
	Identification Procedures on Fraction Smaller Than No. 40 Sieve Size					
		DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)		
SILTS AND CLAYS (Liquid Limit < 50)		None to Slight	Quick to Slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.
		Medium to High	None to Very Slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		Slight to Medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity.
SILTS AND CLAYS (Liquid Limit > 50)		Slight to Medium	Slow to None	Slight to Medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		High to Very High	None	High	CH	Inorganic clays of high plasticity, fat clays.
		Medium to High	None to Very Slow	Slight to Medium	OH	Organic clays of medium to high plasticity.
HIGHLY ORGANIC SOILS		Readily identified by color, odor, spongy feel and frequently by fibrous structure.			Pt	Peat and other organic soils

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example, GW-GC, well graded gravel-sand mixture, with clay binder.
All sieve sizes on this chart are U.S. Standard.

DENSITY OF GRANULAR SOILS

DESCRIPTION	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT
Very Loose	0-4
Loose	5-9
Medium Loose	10-14
Dense	15-30
Very Dense	Over 30

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (TONS/SQ.FT.)	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION CRITERIA
Very Soft	Less than 0.25	0 to 1	Easily penetrated several inches by fist.
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb.
Medium Stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb.
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb.
Very Stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail.
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail.

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)		
Descriptive Terms	Scratches or Knife Blade	Hammer Effects
Soft	Easily Gouged	Crushes when pressed with hammer
Medium Soft	Can be Gouged	Breaks (one blow); crumbly edges
Medium Hard	Can be scratched	Breaks (one blow); sharp edges
Hard	Cannot be scratched	Breaks conchoidally (several blows), sharp edges

ROCK BROKENNESS		
Descriptive Terms	Abbreviation	Spacing
Very Broken	(V. Br.)	< 2"
Broken	(Br.)	2"-6"
Blocky	(Bl.)	6"-12"
Massive	(Ma)	> 12"

LEGEND :

SOIL SAMPLES - TYPES	ROCK SAMPLES - TYPES		OTHER SYMBOLS	
3-4" Split Spoon Sample	X-NX (Conventional) Core (1.1-1.5" O.D.)	8/9	▼ 8.0'	Initial Level w/Date & Depth
3.5-5" O.D. Undisturbed Sample	GNX (Diamond) Core (1.5-1.9" O.D.)			
O - Other Samples, Specify in Remarks	Z - Other Core Sizes, Specify in Remarks	8/9	▼ 8.0'	Stabilized Level w/Date & Depth

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Figure 1 (Continued).
This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse-grained soils shall be divided into rock fragments, sand, or gravel. The terms sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as "(1/4 inchΦ-1/2 inchΦ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer-grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split-barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.3. Those designations are:

Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140-pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, or SC (see Figure 1).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Figure 2.

Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Figure 1).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength), or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are shown in Figure 2.

5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
Trace	0 - 10 percent
Some	11 - 30 percent
Adjective form of the soil type (e.g., "sandy")	31 - 50 percent

FIGURE 2

CONSISTENCY FOR COHESIVE SOILS

Consistency	Standard Penetration Resistance (Blows per Foot)	Unconfined Compressive Strength (Tons/Sq. Foot by pocket penetration)	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented with difficulty by thumbnail

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Figure 3.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

FIGURE 3

BEDDING THICKNESS CLASSIFICATION

Thickness (metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	<1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

5.3 Classification of Rocks

Rocks are grouped into three main divisions: sedimentary, igneous and metamorphic. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.
- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.
- Claystone - Very fine-grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- Shale - A fissile very fine-grained rock. Fractures along bedding planes.
- Limestone - Rock made up predominantly of calcite ($CaCO_3$). Effervesces strongly upon the application of dilute hydrochloric acid.
- Coal - Rock consisting mainly of organic remains.
- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. Conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

5.3.1 Rock Type

As described above, there are numerous types of sedimentary rocks. In most cases, a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Figure 4 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a hand lens, the rock is a siltstone. If the grains are not distinguishable with a hand lens, the rock is a claystone.

FIGURE 4

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4 - 64 mm
Granules	2 - 4 mm
Very Coarse Sand	1 - 2 mm
Coarse Sand	0.5 - 1 mm
Medium Sand	0.25 - 0.5 mm
Fine Sand	0.125 - 0.25 mm
Very Fine Sand	0.0625 - 0.125 mm
Silt	0.0039 - 0.0625 mm

After Wentworth, 1922

5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock color charts shall not be used unless specified by the Project Manager.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification (see Figure 3) will also be used for rock classification.

5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).

- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.

- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.

- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the works "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

5.3.5 Fracturing

The degree of fracturing or brokenness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) - Less than 2-inch spacing between fractures
- Broken (BR.) - 2-inch to 1-foot spacing between fractures
- Blocky (BL.) - 1- to 3-foot spacing between fractures
- Massive (M.) - 3 to 10-foot spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

Method of Calculating RQD
(After Deere, 1964)

$$RQD\ \% = r/l \times 100$$

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.
- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified).
- Description of any filled cavities or vugs.
- Cementation (calcareous, siliceous, hematitic).
- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inches or less), probably continuous layer.
- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."
- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."
- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."
- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.
- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.
- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.
- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.
- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse-grained dark igneous rock.

The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite - A fine- to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

5.4 Abbreviations

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C	-	Coarse	Lt	-	Light	Yl	-	Yellow
Med	-	Medium	BR	-	Broken	Or	-	Orange
F	-	Fine	BL	-	Blocky	SS	-	Sandstone
V	-	Very	M	-	Massive	Sh	-	Shale
Sl	-	Slight	Br	-	Brown	LS	-	Limestone
Occ	-	Occasional	Bl	-	Black	Fgr	-	Fine-grained
Tr	-	Trace						

5.5 Boring Logs and Documentation

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceding sections shall be used to complete the logs. A sample boring log has been provided as Figure 5.

The field geologist/engineer shall use this example as a guide in completing each boring log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided either on the back of the boring log or on a separate sheet, for field use.

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.

- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology at 13.7 feet, shall be lined off at the proportional location between the 13- and 14-foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.

- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split-spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.

- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.

- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart on back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

FIGURE 5
COMPLETED BORING LOG (EXAMPLE)

BORING LOG

Page 1 of 1

PROJECT NAME: NSB - SITE
PROJECT NUMBER: 9594
DRILLING COMPANY: SOILTEST CO.
DRILLING RIG: CME-55
BORING NUMBER: SB/MW 1
DATE: 3/8/96
GEOLOGIST: SJ CONTI
DRILLER: R. ROCK

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
S-1 @ 0800	0.0	7/6	1.5/2.0		M DENSE	BRN TO BLK	SILTY SAND - SOME	SM	MOIST SL. ORG. ODOR	5	0	0	0
	2.0	9/10					ROCK FR: TR BRICKS (FILL)		FILL TO 4'±				
	4.0			4.0									
S-2 @ 0810	6.0	5/7	2.9/2.0		M DENSE	BRN	SILTY SAND - TR FINE GRAVEL	SM	MOIST - W ODOR NAT. MATL. TOOK SAMPLE SB01-0406 FOR ANALYSIS	10	0	-	-
	•	9/8		7' ∇									
	8.0			8.0									
S-3 @ 0820	10.0	6/8	1.9/2.0		DENSE	TAN BRN	FINE TO COARSE SAND TR. F. GRAVEL	SW	WET HIT WATER: 7'±	0	0	0	0
	12.0	17/16		12.0									
S-4 @ 0830	14.0	7/6	1.6/2.0		STIFF	GRAY	SILTY CLAY	CL	MOIST → WET	0	.5	-	-
	15.0	5/8		15.0					AUGER REF @ 15'				
				11 LINE 16	M HARD	BRN	SILTSTONE	VBR	WEATHERED				
0/5	①		4.0/5.0						LO ∠ JNTS @ 15.5 WATER STAINS @ 16.5, 17.1, 17.5	0	0	0	0
				19'					LOSING SOME				
	20.0		①		HARD	GRAY	SANDSTONE - SOME SILTSTONE	BR	DRILL H2O @ 17'± SET TEMP 6" CAS TO 15.5				
4.9/5.0	②		5.0/5.0						SET 2" Φ PVC SCREEN 16-25	0	0	0	0
									SAND 14-25				
	25.0			25					PELLETS 12-14				

* When rock coring, enter rock brokeness.
** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

• 1-20Z
1-80Z

Drilling Area Background (ppm): 0

Remarks: CME-55 R16, 4 1/4" ID HSA - 9" OD ±
2" SPLIT SPOONS - 140 LB HAMMER - 30" DROP
NX CORE IN BEDROCK RUN ① = 25 min, RUN ② = 15 min

Converted to Well: Yes ✓ No ____ Well I.D. #: MW-1

- Enter color of the material in the appropriate column.
- Describe material using the USCS. Limit this column for sample description only. The predominant material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:
  - Trace: 0 - 10 percent
  - Some: 11 - 30 percent
  - And/Or: 31 - 50 percent
- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.
- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.
- The following information shall be entered under the "Remarks" column and shall include, but is not limited by, the following:
  - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.
  - Angularity - describe angularity of coarse grained particles using the terms angular, subangular, subrounded, or rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.
  - Particle shape - flat, elongated, or flat and elongated.
  - Maximum particle size or dimension.
  - Water level observations.
  - Reaction with HCl - none, weak, or strong.
- Additional comments:
  - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.
  - Indicate odor and Photoionization Detector (PID) or Flame Ionization Detector (FID) reading if applicable.
  - Indicate any change in lithology by drawing a line through the lithology change column and indicate the depth. This will help when cross-sections are subsequently constructed.
  - At the bottom of the page indicate type of rig, drilling method, hammer size and drop, and any other useful information (i.e., borehole size, casing set, changes in drilling method).

- Vertical lines shall be drawn (as shown in Figure 5) in columns 6 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

- Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent, and core recovery under the appropriate columns.

- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.

- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.

- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.

- Enter brokenness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:

  - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
  - Indicate calcareous zones, description of any cavities or vugs.
  - Indicate any loss or gain of drill water.
  - Indicate drop of drill tools or change in color of drill water.

- Remarks at the bottom of Boring Log shall include:

  - Type and size of core obtained.
  - Depth casing was set.
  - Type of rig used.

- As a final check the boring log shall include the following:

  - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.

  - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5-foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date, etc.). Cuttings shall be closely examined to determine general lithology.
- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.
- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.
- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.
- Record this and any other useful information onto the boring log as provided in Figure 1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split-barrel and rock core sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 Review

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs.
- Checking for conformance to the guideline.
- Checking to see that all information is entered in their respective columns and spaces.

6.0 REFERENCES

Unified Soil Classification System (USCS).

ASTM D2488, 1985.

Earth Manual, U.S. Department of the Interior, 1974.

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.

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A HYDRAULIC CONDUCTIVITY TESTING DATA SHEET 7

1.0 PURPOSE

This guideline is intended to describe procedures for performing in-situ hydraulic conductivity testing (slug testing) in boreholes and monitoring wells, and provide a short description of commonly used evaluation techniques for the data generated. Slug tests are used to provide data regarding the hydraulic properties of the formation tested. A variation of the slug test, called a constant-head test, is also briefly described.

2.0 SCOPE

Slug tests are short-term tests designed to provide approximate hydraulic conductivity values for the portion of a formation immediately surrounding the screened/open interval of a well or boring. These tests are much less accurate than pumping tests, as a much more localized area is involved. Therefore, a number of slug tests are typically performed and averaged to determine a representative hydraulic conductivity value for the formation tested. Performance of slug tests may be preferable to pumping tests in situations where handling of large volumes of contaminated water is a concern or when time/budget constraints preclude the more expensive and time-consuming setup and performance of a pumping test.

Constant-head tests also are used to determine hydraulic conductivity values and are similar to slug tests with regard to the quality of data obtained and time/cost considerations. A disadvantage of constant-head tests is that a significant volume of water may be added to high-permeability formations, potentially affecting short-term water quality.

3.0 GLOSSARY

Hydraulic Conductivity (K) - A quantitative measure of the ability of a porous material to transmit water, defined as the volume of water that will flow through a unit cross-sectional area of porous material per unit time under a head gradient of 1. Hydraulic conductivity is dependent upon properties of the medium and fluid. Common units of expression include centimeters per second (cm/sec), feet per day (ft/day), and gallons per day per foot^2 (gpd/ft^2).

Transmissivity (T) - A quantitative measure of the ability of an aquifer to transmit water. The product of the hydraulic conductivity times the saturated thickness.

Slug Test - A rising head or falling head test used to measure hydraulic conductivity. A slug test consists of instantaneously changing the water level within a well and measuring the rate of recovery of the water level to equilibrium conditions. Slug tests are performed by either withdrawing a slug of water (rising head test) or adding a slug of water (falling head test), then measuring recovery over time. A solid slug of known volume can be used to displace a volume of water, thereby simulating the addition or removal of water.

4.0 RESPONSIBILITIES

Project Hydrogeologist - The project hydrogeologist, in conjunction with the Project Manager, shall evaluate the type(s) and extent of hydraulic testing required for a given project during the planning process, and design the field program accordingly. The project hydrogeologist also shall ensure that field personnel have the necessary training and guidance to properly perform the tests, and shall oversee data reduction activities, including selecting the appropriate evaluation techniques and checking calculations for accuracy.

Field Geologist - The field geologist is responsible for performing the planned field tests as specified in the project planning documents, (or approved modifications thereto). The field geologist also generally assists in the data evaluation process. The field geologist shall be knowledgeable in the testing methodologies used and is responsible for obtaining the necessary support equipment required to perform the field tests. All applicable data regarding testing procedures, equipment used, well construction, and geologic/hydrogeologic conditions shall be recorded by the field geologist. The field geologist shall be familiar enough with testing procedures/requirements to be able to recommend changes in methodology, should unanticipated field conditions be encountered.

5.0 PROCEDURES

5.1 In-situ Hydraulic Conductivity Testing in Wells

Slug tests are commonly performed in completed wells. Prior to testing, the well shall be thoroughly developed and allowed to stabilize, in order to obtain accurate results. Once the water level within the well has stabilized at its static level, it shall be quickly raised or lowered and the rate of recovery measured.

One of the basic assumptions of slug testing is that the initial change in water level is instantaneous; therefore, an effort shall be made to minimize the time involved in raising or lowering the water level initially. Various methods can be used to induce instantaneous (or nearly instantaneous) changes in water level within the well. A rise in water levels can be induced by pouring water into the well. A solid slug of known volume, quickly lowered below the water level within the well, will displace an equivalent volume of water and raise the water level within the well. The slug can be left in place until the water level restabilizes at the static water level, then suddenly removed to create a drop in water level within the well. An advantage of using a solid cylinder of known volume (slug) to change the water level is that no water is removed or added to the monitoring well. This eliminates the need to dispose of contaminated water and/or add water to the system. A bailer or pump can be used to withdraw water from the well. If a pump is used, pumping shall not continue for more than several seconds so that a cone of depression is not created which would adversely impact testing results. The pump hose shall also be removed from the well during the recovery period, as data analysis techniques involve volume of recovery versus time, and leaving the hose within the well would distort the calculated testing results by altering the apparent volume of recovery. Falling head slug tests should only be performed in wells with fully submerged screens, while rising head slug tests can be performed in wells with either partially or fully submerged screens/open intervals.

Other methods that can be used to change water levels within a well include creating a vacuum or a high pressure environment within the well. The vacuum method will raise water levels within the well, while the pressure method will depress the water level in the well. These methods are particularly useful in highly permeable formations where other methods are ineffective in creating measurable changes in water levels. Both of these methods are limited to wells which have completely submerged screens.

Rate of recovery measurements shall be obtained from time zero (maximum change in water level) until water level recovery exceeds 90 percent of the initial change in water level. In low permeability formations, the test may be cut-off short of 90 percent recovery due to time constraints. Time intervals between water level readings will vary according to the rate of recovery of the well. For a moderately fast recovering well, water level readings at 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, 2.5, 3.0, 4.0, . . . minutes may be required. With practice, readings at down to 0.05-minute (3 seconds) time intervals can be obtained with reasonable accuracy, using a pressure transducer and hand held readout. For wells which recover very fast, a pressure transducer and data logger may be required to obtain representative data. Time intervals between measurements can be extended for slow recovering wells. A typical

schedule for measurements for a slow recovering well would be 0, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 15.0, 20.0, 30.0, . . . minutes from the beginning the test. Measurements shall be taken from the top of the well casing.

Water level measurements can be obtained using an electric water level indicator, popper, or pressure transducer. Steel tape coated with chalk or water sensitive paste although very accurate, is a slower method of obtaining water levels and is generally not recommended for use due to the frequency at which water level measurements need to be obtained during the performance of a slug test.

Time/recovery should be field-plotted on semilog graph paper to determine the data quality. The data set should plot along a sloped, straight line. If excessive data scatter is observed, the test should be rerun until acceptable results are obtained.

The following data shall be recorded when performing slug tests in wells or borings:

- Well/boring ID number
- Total depth of well/boring
- Screened/open interval depth and length
- Gravel pack interval depth and length
- Well stickup above ground surface
- Gravel pack radius
- Static water level
- Aquifer thickness
- Depth to confining layer
- Time/recovery data

A variation of the slug test, called a constant-head test, is a test in which water is added to the well at a measured rate sufficient to maintain the water level in the well at a constant height above the static water level. Once a stable elevated water level has been achieved, discharge (pumping) rate measurements are recorded in place of time/recovery data for approximately 10 to 20 minutes. The hydraulic conductivity is then calculated from this information. The constant-head test is generally not recommended for monitoring wells as large volumes of water may be introduced into the screened formation, potentially impacting later sampling events.

5.2 In-situ Hydraulic Conductivity Testing in Borings

Slug tests can be performed in borings while the boring is being advanced. This permits testing of formations at different depths throughout the drilling process. Boreholes to be tested shall be drilled using casing, so that discrete depths may be investigated. Various tests and testing methods are described below. The most appropriate test and testing method to be used in a situation varies and shall be selected after a careful evaluation of drilling, geologic, and general site conditions.

Rising head or falling head slug tests can be performed in saturated and unsaturated formations during drilling. There are two ways that the tests can be performed. One way entails setting the casing flush with the bottom of the boring when the desired testing depth has been reached. The hole is then cleaned out to remove loose materials, the drill bit and rods are carefully withdrawn from the boring, and a few feet of sand (of higher permeability than the surrounding formation) is added to the bottom of the boring. After the water level in the boring has stabilized (for saturated formations), the static water level is measured and recorded. The water level is then raised (falling head test) or lowered (rising head test) and the change in water level is measured at time intervals determined by the field hydrogeologist. Only falling head tests can be performed for depth intervals within the unsaturated (vadose) zone. As described for

wells, time intervals for water level measurements will vary according to the formation's hydraulic conductivity. The faster the rate of recovery expected, the shorter the time intervals between measurements shall be. The rate of change of water level will be used to calculate hydraulic conductivity. The test is to be conducted until the water level again stabilizes, or for a minimum of 20 minutes. In low permeability formations, it is not always practical to run the test until the water level stabilizes, as it may take a long time to do so. The top of the casing shall be used as the reference point for all water level measurements.

The second method for conducting a slug test during drilling consists of placing a temporary well with a short screen into the cleaned-out boring, pulling the drilling casing back to expose the screen, allowing the formation to collapse around the screen (or placing a sand/gravel pack around the screen), and performing the appropriate hydraulic conductivity test in the well, as described for the first method. Again, the test shall be conducted until the water level stabilizes or for a minimum of 20 minutes. This method allows for testing a larger section of the formation and results in more reliable hydraulic conductivity estimates.

Constant-head tests may also be performed in borings. As described for monitoring wells, once a stable elevated level has been achieved, the discharge rate into the boring is measured for a period of time, usually 10 to 20 minutes, and the hydraulic conductivity is calculated from this. This method is the most accurate method depicted in this section, and shall be given preference over others if the materials are available to perform the test and the addition of water to the boring does not adversely impact project objectives. Once the test is over, additional information can be gathered by measuring the rate of the drop in water level in the boring (for saturated formations). A limitation of the constant-head test is that foreign water is introduced into the formation which must be removed from the well area by natural or artificial means, before a representative groundwater sample can be obtained.

Detailed descriptions regarding the performance of borehole hydraulic conductivity tests and subsequent data analysis techniques are provided in Ground Water Manual (1981).

5.3 Data Analysis

There are a number of data analysis methods available to reduce and evaluate slug testing data. The determination of which method is most appropriate shall be made based on the testing conditions (including physical setup of the well/boring tested, hydrogeologic conditions, and testing methodology) and the limitations of each test analysis method. Well construction details, aquifer type (confined or unconfined), and screened/open interval (fully or partially penetrating the aquifer) shall be taken into account in selecting an analysis method. Cooper, et al. (1967), and Papadapulos, et al. (1973) have developed test interpretation procedures for fully penetrating wells in confined aquifers. Hvorslev (1951) developed a relatively simple analytical procedure for point piezometers in an infinite isotropic medium. In Cedergren (1967), Hvorslev presents a number of analytical procedures which cover a wide variety of hydrogeologic conditions, testing procedures, and well/boring/piezometer configurations. Bouwer and Rice (1976) developed an analytical technique applicable to both unconfined and confined conditions, which factors in partial/full penetration and discusses well screen gravel pack considerations. The Ground Water Manual (1981) presents a number of testing and test analysis procedures for wells and borings open above or below the water table, and for both falling head and constant-head tests. The methods described above do not represent a complete listing of test analysis methods available, but are some of the more commonly used and accepted methods. Other methods can be used, at the discretion of the project hydrogeologist and in concurrence with the Project Manager and client.

One consideration to be noted during data analysis is the determination of the screened/open interval of a tested well. If a well with a fully submerged screen is installed in a relatively low permeability formation,

and a gravel pack which is significantly more permeable is installed around the screen, the length of the gravel pack (if longer than the screened interval) should be used as the screened/open length, rather than the screen length itself. In situations where the formation permeability is judged to be comparable to the gravel pack permeability (within about an order of magnitude) this adjustment is not required.

All data analysis applications and calculations shall be reviewed by technical personnel thoroughly familiar with testing and test analysis procedures. Upon approval of the calculations and results, the calculation sheets shall be initialed and dated by the reviewer. Distribution copies shall be supplied to appropriate project personnel and the original copy stored in the project central file.

6.0 REFERENCES

Cedergren, H. R., 1967. Seepage, Drainage, and Flow Nets. John Wiley and Sons Inc., New York, pp. 78-76.

Cooper, H. H., Jr., J. D. Bredehoeft, and I. S. Papadopulos, 1967. Response of a Finite-Diameter Well to an Instantaneous Change of Water. Water Resources Research, V. 3, No. 1, pp. 263-269.

Hvorslev, M. J., 1951. Time Lag and Soil Permeability in Ground Water Observations. U.S. Army Corps of Engineers, Waterways Experiment Station, Washington, D.C., Bull. No. 36.

Papadopulos, I. S., J. D. Bredehoeft, and H. H. Cooper, 1973. On the Analysis of Slug Test Data. Water Resources Research, V. 9, No. 4, pp. 1087-1089.

Bouwer, H. and R. C. Rice, 1976. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells." Water Resources Research, 12:423-28.

United States Department of the Interior, 1981. Ground Water Manual. U.S. Government Printing Office, Denver, Colorado.

7.0 RECORDS

Field data shall be recorded on the data sheet included as Attachment A (or equivalent). 1 Any notes regarding testing procedures, problems encountered, and general observations not included on the data sheet shall be noted in the bound site logbook or field notebook. The boring log and well construction diagrams for each well/boring tested shall be used as references during testing and data analysis activities. Original data sheets shall be placed in the project file, along with the logbook/notebook.

1 If an automated data recorder is used, the data may be displayed using the printer output from the unit. Such printouts should be annoted to include the relevant data form, or attached to the form shown as Attachment A.

ATTACHMENT A
EXAMPLE HYDRAULIC CONDUCTIVITY TESTING DATA SHEET

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET

PROJECT NAME: ..... WELL/BORING NO.: .....

PROJECT NO.: ..... GEOLOGIST: .....

WELL DIAMETER: ..... SCREEN LENGTH/DEPTH: ..... TEST NO.: .....

STATIC WATER LEVEL (Depth/Elevation): ..... DATE: .....

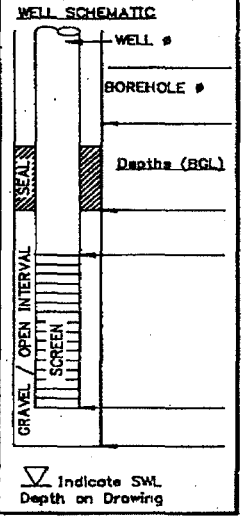
TEST TYPE (Rising/Falling/Constant Head): ..... CHECKED: .....

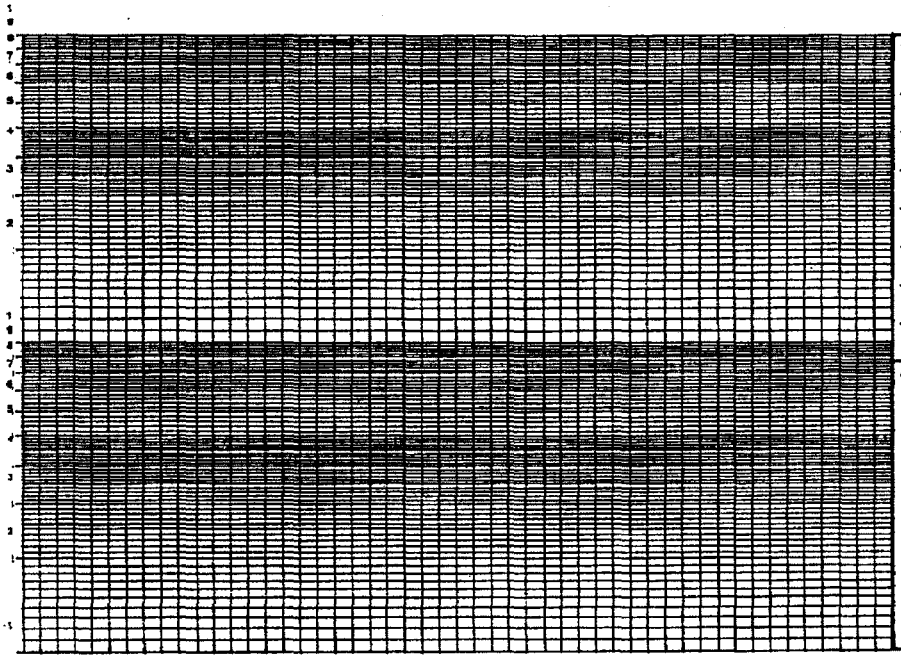
METHOD OF INDUCING WATER LEVEL CHANGE: ..... PAGE ..... OF .....

REFERENCE PT. FOR WL MEAS. (Top of Casing, Transducer, etc.): .....

ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)	ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)

WELL SCHEMATIC





REMARKS:

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CALCS,SKETCH MAPS, ETC.:

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1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of monitoring wells. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be determined during the project planning phases of the investigation, and any required permits must be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is screened, cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored. Some monitoring wells may be constructed as open boreholes.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface representative of the level to which water will rise in a well cased to the screened aquifer.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The driller may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well or piezometer:

- Health and safety equipment (hard hats, safety glasses, etc.) as required by the Site Safety Officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installation tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives and intended use for each monitoring well must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow directions and potential well locations can be determined by an experienced hydrogeologist through the review of geologic data and the site terrain. In addition, data from production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary investigative phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the depths at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant plume, since groundwater samples collected in wells that are screened over the full thickness of the water-bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of contamination in the water-bearing zone. The well diameter desired depends upon the hydraulic characteristics of the water-bearing zone, sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following (and possibly other) information:

- The vertical location of the contaminant source in relation to the water-bearing zone.
- The depth, thickness and uniformity of the water-bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (5 feet or less) are usually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs.

Standard monitoring well diameters are 2, 4, 6, or 8 inches. Drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole bedrock monitoring wells are used. With smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced; however, the sampling devices that can be used are limited.

In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples), particularly if the monitored formation is known to be a low-yielding formation. The unit volume of water contained within a monitoring well is dependent on the well diameter as follows:

Casing Inside Diameter (Inch)	Standing Water Length to Obtain 1 Gallon Water (Feet)
2	6.13
4	1.53
6	0.68

If a well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells (for installation of high capacity pumps); however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "Schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength". Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel. Properties of these two materials are compared in Attachment B. Stainless steel is a good choice where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, ease of manipulation, and widespread acceptance. The crushing strength of PVC may limit the depth of installation, but the use of Schedule 80 materials may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe may corrode and release metal ions or chemically react with organic constituents, but this is considered a minor issue. Galvanized steel is not recommended where samples may be collected for metals analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints. Welded-joint steel casing is also acceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be used if the well is to be sampled for organic constituents.

When the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary, and the annular borehole space around the screened interval is artificially packed with an appropriately sized sand, selected based on formation grain size. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The site geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or No. 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a medium- to coarse-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. The quantity of sand placed in the annular space is dependent upon the length of the screened interval, but should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally (i.e., no artificial sand pack installed). In this case, the natural formation material is allowed to collapse around the well screen after the well is installed. This method has been used where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets, extending to the surface. The grout effectively seals the remaining borehole annulus and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom upward, to prevent bridging, and to provide a better seal. In shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of one or two assemblages of material, (e.g., cement and/or bentonite). A cement-bentonite grout, which is the most common type of grout used in monitoring well completions, normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus 3 to 5 pounds of granular or flake-type bentonite, and 6-7 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6-7 gallons of water. A bentonite slurry (bentonite and water mixed to a thick but pumpable mixture) is sometimes used instead of grout for deep well installations where placement of bentonite pellets is difficult. Bentonite chips are also occasionally used for annular backfill in place of grout.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets/chips or sand. A short (1- to 2-foot) section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is typically placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A protective casing which is level with the ground surface (flush-mounted) is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter, manhole-type protective collar is set into the wet cement around the well with the top set level with or slightly above the pavement. An appropriately-sized id is placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 Monitoring Well Installation

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow-stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineer's rule to ensure proper placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, the sand pack can be installed. A weighted tape measure must be used during the installation procedure to carefully monitor installation progress. The sand is slowly poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur. Centralizers may be used at the geologist's discretion, one above and one below the screen, to assure enough annular space for sand pack placement.

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack. Pellets should be added slowly and their fall monitored closely to ensure that bridging does not occur.

The cement-bentonite grout is then mixed and tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between aquifers. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 5 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting a large-diameter casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for

installation of the monitoring well as detailed for overburden monitoring wells. Sufficient time (determined by the field geologist), must be allowed for setting of the grout prior to drilling through the confined layer.

~~5.3.3 Bedrock Monitoring Wells~~

~~When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 – 10 feet into bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued into bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. If a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be removed when the final well installation is completed.~~

~~5.3.4 Drive Points~~

~~Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen section is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be manually driven to depths exceeding 10 feet.~~

~~Direct push sampling/monitoring point installation methods, using a direct push rig or drilling rig, are described in SOP SA 2.5.~~

~~5.3.5 Innovative Monitoring Well Installation Techniques~~

~~Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only small diameter tubes extending to the surface. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. Four manufacturers of these samplers include Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, BARCAD Systems, Inc., of Concord, Massachusetts, Westbay Instruments Ltd. of Vancouver, British Columbia, Canada and the University of Waterloo at Waterloo, Ontario, Canada.. Each manufacturer offers various construction materials.~~

5.4 Well Development Methods

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity, turbidity, and temperature taken during development may yield information (stabilized values) regarding whether sufficient development has been performed. The selection of the well development method shall be made by the field geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

~~5.4.1 Overpumping and Backwashing~~

~~Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to~~

space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in or bridging of the backfill materials. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

7.0 REFERENCES

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Cosby, and J. Fryberger, 1981. Manual of Groundwater Sampling Procedures. R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989.

~~remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods, including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.~~

5.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is aggressively moved up and down within the well to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

~~5.4.3 Compressed Air~~

~~Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus introducing air into the formation and reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping of the well is subsequently done using the air lift method.~~

~~5.4.4 High Velocity Jetting~~

~~In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.~~

6.0 RECORDS

A critical part of monitoring well installation is recording of all significant details and events in the site logbook or field notebook. The geologist must record the exact depths of significant hydrogeological features, screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed, ensuring the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information shall include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. Documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded, depending on whether the well is completed in overburden (single- or double-cased), as a cased well in bedrock, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have an idea of the quantity of material needed to fill the annular

ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material						
	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Mineral Acid/ High Solids Content	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials:

1 Teflon®
2 Stainless Steel 316
3. Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel

* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material								
	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®*	Silicone	Neoprene	Teflon®*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/ High Solids Content	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials:

~~1 Teflon®~~
~~2 Polypropylene (PP)~~
3. PVC Flexible/PE Linear
~~4 Viton®~~
~~5 PE Conventional~~
~~6 Plexiglas/Lucite (PMM)~~
~~7 Silicone/Neoprene~~

* Trademark of DuPont

Source: Barcelona et al., 1983

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength are not critical.
Weight	Relatively heavier.	Light-weight; floats in water.
Cost	Relatively expensive.	Relatively inexpensive.
Corrosivity	Deteriorates more rapidly in corrosive water.	Non-corrosive -- may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated hydrocarbons.
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work with in the field.
Preparation for Use	Should be steam cleaned if organics will be subsequently sampled.	Never use glue fittings -- pipes should be threaded or pressure fitted. Should be steam cleaned when used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized.	May sorb or release organic substances.

* See also Attachment A.

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1.0 PURPOSE

Utilities such as electric service lines, natural or propane gas lines, water and sewage lines, telecommunications, and steam lines are very often in the immediate vicinity of work locations. Contact with underground or overhead utilities can have serious consequences including employee injury/fatality, property and equipment damage, substantial financial impacts, and loss of utility service to users.

The purpose of this procedure is to provide minimum requirements and technical guidelines regarding the appropriate procedures to be followed when performing subsurface and overhead utility locating services. It is the policy of Tetra Tech NUS, Inc. (TtNUS) to provide a safe and healthful work environment for the protection of our employees. The purpose of this Standard Operating Procedure (SOP) is to aid in achieving the objectives of this policy, to present the acceptable procedures pertaining to utility locating and excavation clearance activities, and to present requirements and restrictions relevant to these types of activities. This SOP must be reviewed by any employee potentially involved with underground or overhead utility locating and avoidance activities.

2.0 SCOPE

This procedure applies to all TtNUS field activities where there may be potential contact with underground or overhead utilities. This procedure provides a description of the principles of operation, instrumentation, applicability, and implementability of typical methods used to determine the presence and avoidance of contact with utility services. This procedure is intended to assist with work planning and scheduling, resource planning, field implementation, and subcontractor procurement. Utility locating and excavation clearance requires site-specific information prior to the initiation of any such activities on a specific project. This SOP is not intended to provide a detailed description of methodology and instrument operation. Specialized expertise during both planning and execution of several of the methods presented may also be required.

3.0 GLOSSARY

Electromagnetic Induction (EMI) Survey - A geophysical exploration method whereby electromagnetic fields are induced in the ground and the resultant secondary electromagnetic fields are detected as a measure of ground conductivity.

Magnetometer – A device used for precise and sensitive measurements of magnetic fields.

Magnetic Survey – A geophysical survey method that depends on detection of magnetic anomalies caused by the presence of buried ferromagnetic objects.

Metal Detection – A geophysical survey method that is based on electromagnetic coupling caused by underground conductive objects.

Vertical Gradiometer – A magnetometer equipped with two sensors that are vertically separated by a fixed distance. It is best suited to map near surface features and is less susceptible to deep geologic features.

Ground Penetrating Radar – Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture.

4.0 RESPONSIBILITIES

Project Manager (PM)/Task Order Manager (TOM) - Responsible for ensuring that all field activities are conducted in accordance with this procedure.

Site Manager (SM)/Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

Site Health & Safety Officer (SHSO) – Responsible to provide technical assistance and verify full compliance with this SOP. The SHSO is also responsible for reporting any deficiencies to the Corporate Health and Safety Manager (HSM) and to the PM/TOM.

Health & Safety Manager (HSM) – Responsible for preparing, implementing, and modifying corporate health and safety policy and this SOP.

Site Personnel – Responsible for performing their work activities in accordance with this SOP and the TtNUS Health and Safety Policy.

5.0 PROCEDURES

This procedure addresses the requirements and technical procedures that must be performed to minimize the potential for contact with underground and overhead utility services. These procedures are addressed individually from a buried and overhead standpoint.

5.1 Buried Utilities

Buried utilities present a heightened concern because their location is not typically obvious by visual observation, and it is common that their presence and/or location is unknown or incorrectly known on client properties. This procedure must be followed prior to beginning any subsurface probing or excavation that might potentially be in the vicinity of underground utility services. In addition, the Utility Clearance Form (Attachment 3) must be completed for every location or cluster of locations where intrusive activities will occur.

Where the positive identification and de-energizing of underground utilities cannot be obtained and confirmed using the following steps, the PM/TOM is responsible for arranging for the procurement of a qualified, experienced, utility locating subcontractor who will accomplish the utility location and demarcation duties specified herein.

1. A comprehensive review must be made of any available property maps, blue lines, or as-builts prior to site activities. Interviews with local personnel familiar with the area should be performed to provide additional information concerning the location of potential underground utilities. Information regarding utility locations shall be added to project maps upon completion of this exercise.

2., A visual site inspection must be performed to compare the site plan information to actual field conditions. Any findings must be documented and the site plan/maps revised. The area(s) of proposed excavation or other subsurface activities must be marked at the site in white paint or pin flags to identify those locations of the proposed intrusive activities. The site inspection should focus on locating surface indications of potential underground utilities. Items of interest include the presence of nearby area lights, telephone service, drainage grates, fire hydrants, electrical service vaults/panels, asphalt/concrete scares and patches, and topographical depressions. Note the location of any emergency shut off switches. Any additional information regarding utility

locations shall be added to project maps upon completion of this exercise and returned to the PM/TOM.

3. If the planned work is to be conducted on private property (e.g., military installations, manufacturing facilities, etc.) the FOL must identify and contact appropriate facility personnel (e.g., public works or facility engineering) before any intrusive work begins to inquire about (and comply with) property owner requirements. It is important to note that private property owners may require several days to several weeks advance notice prior to locating utilities.

4. If the work location is on public property, the state agency that performs utility clearances must be notified (see Attachment 1). State "one-call" services must be notified prior to commencing fieldwork per their requirements. Most one-call services require, by law, 48- to 72-hour advance notice prior to beginning any excavation. Such services typically assign a "ticket" number to the particular site. This ticket number must be recorded for future reference and is valid for a specific period of time, but may be extended by contacting the service again. The utility service will notify utility representatives who then mark their respective lines within the specified time frame. It should be noted that most military installations own their own utilities but may lease service and maintenance from area providers. Given this situation, "one call" systems may still be required to provide location services on military installations.

5. Utilities must be identified and their locations plainly marked using pin flags, spray paint, or other accepted means. The location of all utilities must be noted on a field sketch for future inclusion on project maps. Utility locations are to be identified using the following industry-standard color code scheme, unless the property owner or utility locator service uses a different color code:

white	excavation/subsurface investigation location
red	electrical
yellow	gas, oil, steam
orange	telephone, communications
blue	water, irrigation, slurry
green	sewer, drain

6. Where utility locations are not confirmed with a high degree of confidence through drawings, schematics, location services, etc., the work area must be thoroughly investigated prior to beginning the excavation. In these situations, utilities must be identified using safe and effective methods such as passive and intrusive surveys, or the use of non-conductive hand tools. Also, in situations where such hand tools are used, they should always be used in conjunction with suitable detection equipment, such as the items described in Section 6.0 of this SOP. Each method has advantages and disadvantages including complexity, applicability, and price. It also should be noted that in some states, initial excavation is required by hand to a specified depth.

7. At each location where trenching or excavating will occur using a backhoe or other heavy equipment, and where utility identifications and locations cannot be confirmed prior to groundbreaking, the soil must be probed using a device such as a tile probe which is made of non-conductive material such as fiberglass. If these efforts are not successful in clearing the excavation area of suspect utilities, hand shoveling must be performed for the perimeter of the intended excavation.

8. All utilities uncovered or undermined during excavation must be structurally supported to prevent potential damage. Unless necessary as an emergency corrective measure, TtNUS shall not make any repairs or modifications to existing utility lines without prior permission of the utility owner, property owner, and Corporate HSM. All repairs require that the line be locked-out/tagged-out prior to work.

5.2 Overhead Power Lines

If it is necessary to work within the minimum clearance distance of an overhead power line, the overhead line must be de-energized and grounded, or re-routed by the utility company or a registered electrician. If protective measures such as guarding, isolating, or insulating are provided, these precautions must be adequate to prevent employees from contacting such lines directly with any part of their body or indirectly though conductive materials, tools, or equipment.

The following table provides the required minimum clearances for working in proximity to overhead power lines.

Nominal Voltage	Minimum Clearance
0 -50 kV	10 feet, or one mast length; whichever is greater
50+ kV	10 feet plus 4 inches for every 10 kV over 50 kV or 1.5 mast lengths; whichever is greater

6.0 UNDERGROUND LOCATING TECHNIQUES

A variety of supplemental utility locating approaches are available and can be applied when additional assurance is needed. The selection of the appropriate method(s) to employ is site-specific and should be tailored to the anticipated conditions, site and project constraints, and personnel capabilities.

~~6.1 Geophysical Methods~~

~~Geophysical methods include electromagnetic induction, magnetics, and ground penetrating radar. Additional details concerning the design and implementation of electromagnetic induction, magnetics, and ground penetrating radar surveys can be found in one or more of the TtNUS SOPs included in the References (Section 8.0).~~

~~Electromagnetic Induction~~

~~Electromagnetic Induction (EMI) line locators operate either by locating a background signal or by locating a signal introduced into the utility line using a transmitter. A utility line acts like a radio antenna, producing electrons, which can be picked up with a radiofrequency receiver. Electrical current carrying conductors have a 60HZ signal associated with them. This signal occurs in all power lines regardless of voltage. Utilities in close proximity to power lines or used as grounds may also have a 60HZ signal, which can be picked up with an EM receiver. A typical example of this type of geophysical equipment is an EM-61.~~

~~EMI locators specifically designed for utility locating use a special signal that is either indirectly induced onto a utility line by placing the transmitter above the line or directly induced using an induction clamp. The clamp induces a signal on the specific utility and is the preferred method of tracing since there is little chance of the resulting signals being interfered with. A good example of this type of equipment is the Schonstedt® MAC-51B locator. The MAC-51B performs inductively traced surveys, simple magnetic locating, and traced nonmetallic surveys.~~

~~When access can be gained inside a conduit to be traced, a flexible insulated trace wire can be used. This is very useful for non-metallic conduits but is limited by the availability of gaining access inside the pipe.~~

~~**Magnetics**~~

~~Magnetic locators operate by detecting the relative amounts of buried ferrous metal. They are incapable of locating or identifying nonferrous utility lines but can be very useful for locating underground storage tanks (UST's), steel utility lines, and buried electrical lines. A typical example of this type of equipment is the Schonstedt® GA-52Cx locator. The GA-52Cx is capable of locating 4-inch steel pipe up to 8 feet deep.~~

~~Non ferrous lines are often located by using a typical plumbing tool (snake) fed through the line. A signal is then introduced to the snake that is then traced.~~

~~**Ground Penetrating Radar**~~

~~Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture. In general, an object which is harder than the surrounding soil will reflect a stronger signal. Utilities, tunnels, UST's, and footings will reflect a stronger signal than the surrounding soil. Although this surface detection method may determine the location of a utility, this method does not specifically identify utilities (i.e., water vs. gas, electrical vs. telephone); hence, verification may be necessary using other methods. This method is somewhat limited when used in areas with clay soil types or with a high water table.~~

6.2 Passive Detection Surveys

~~**Acoustic Surveys**~~

~~Acoustic location methods are generally most applicable to waterlines or gas lines. A highly sensitive Acoustic Receiver listens for background sounds of water flowing (at joints, leaks, etc.) or to sounds introduced into the water main using a transducer. Acoustics may also be applicable to determine the location of plastic gas lines.~~

~~**Thermal Imaging**~~

~~Thermal (i.e., infrared) imaging is a passive method for detecting the heat emitted by an object. Electronics in the infrared camera convert subtle heat differentials into a visual image on the viewfinder or a monitor. The operator does not look for an exact temperature; rather they look for heat anomalies (either elevated or suppressed temperatures) characteristic of a potential utility line.~~

~~The thermal fingerprint of underground utilities results from differences in temperature between the atmosphere and the fluid present in a pipe or the heat generated by electrical resistance. In addition, infrared scanners may be capable of detecting differences in the compaction, temperature and moisture content of underground utility trenches. High-performance thermal imagery can detect temperature differences to hundredths of a degree.~~

6.3 Intrusive Detection Surveys

Vacuum Excavation

Vacuum excavation is used to physically expose utility services. The process involves removing the surface material over approximately a 1' x 1' area at the site location. The air-vacuum process proceeds with the simultaneous action of compressed air-jets to loosen soil and vacuum extraction of the resulting

debris. This process ensures the integrity of the utility line during the excavation process, as no hammers, blades, or heavy mechanical equipment comes into contact with the utility line, eliminating the risk of damage to utilities. The process continues until the utility is uncovered. Vacuum excavation can be used at the proposed site location to excavate below the "utility window" which is usually 8 feet.

Hand Excavation

When the identification and location of underground utilities cannot be positively confirmed through document reviews and/or other methods, borings and excavations may be cleared via the use of non-conductive hand tools. This should always be done in conjunction with the use of detection equipment. This would be required for all locations where there is a potential to impact buried utilities. The minimum hand-excavation depth that must be reached is to be determined considering the geographical location of the work site. This approach recognizes that the placement of buried utilities is influenced by frost line depths that vary by geographical region. Attachment 2 presents frost line depths for the regions of the contiguous United States. At a minimum, hand excavation depths must be at least to the frost line depth (see Attachment 2) plus two (2) feet, but never less than 4 feet below ground surface (bgs). For hand excavation, the hole created must be reamed large enough to be at least the diameter of the drill rig auger or bit prior to drilling. For soil gas surveys, the survey probe shall be placed as close as possible to the cleared hand excavation. It is important to note that a post-hole digger must not be used in this type of hand excavation activity.

~~**Tile Probe Surveys**~~

~~For some soil types, site conditions, and excavation requirements, non-conductive tile probes may be used. A tile probe is a "T"-handled rod of varying lengths that can be pushed into the soil to determine if any obstructions exist at that location. Tile probes constructed of fiberglass or other nonconductive material are readily available from numerous vendors. Tile probes must be performed to the same depth requirements as previously specified. As with other types of hand excavating activities, the use of a non-conductive tile probe, should always be in conjunction with suitable utility locating detection equipment.~~

7.0 INTRUSIVE ACTIVITIES SUMMARY

The following list summarizes the activities that must be performed prior to beginning subsurface activities:

1. Map and mark all subsurface locations and excavation boundaries using white paint or markers specified by the client or property owner.

2. Notify the property owner and/or client that the locations are marked. At this point, drawings of locations or excavation boundaries shall be provided to the property owner and/or client so they may initiate (if applicable) utility clearance.

   Note: Drawings with confirmed locations should be provided to the property owner and/or client as soon as possible to reduce potential time delays.

3. Notify "One Call" service. If possible, arrange for an appointment to show the One Call representative the surface locations or excavation boundaries in person. This will provide a better location designation to the utilities they represent. You should have additional drawings should you need to provide plot plans to the One Call service.

4. Implement supplemental utility detection techniques as necessary and appropriate to conform utility locations or the absence thereof.

5. Complete Attachment 3, Utility Clearance Form. This form should be completed for each excavation location. In situations where multiple subsurface locations exist within the close proximity of one another, one form may be used for multiple locations provided those locations are noted on the Utility Clearance Form. Upon completion, the Utility Clearance Form and revised/annotated utility location map becomes part of the project file.

8.0 REFERENCES

OSHA Letter of Interpretation, Mr. Joseph Caldwell, Attachment 4
OSHA 29 CFR 1926(b)(2)
OSHA 29 CFR 1926(b)(3)
TtNUS Utility Locating and Clearance Policy
TtNUS SOP GH-3.1; Resistivity and Electromagnetic Induction
TtNUS SOP GH-3.2; Magnetic and Metal Detection Surveys
TtNUS SOP GH-3.4; Ground-penetrating Radar Surveys

ATTACHMENT 1
LISTING OF UNDERGROUND UTILITY CLEARANCE RESOURCES

American Public Works Association
2345 Grand Boulevard, Suite 500, Kansas City, MO 64108-2625
Phone (816) 472-6100 • Fax (816) 472-1610
Web www.apwa.net • E-mail apwa@apwa.net

ONE-CALL SYSTEMS INTERNATIONAL CONDENSED DIRECTORY

Alabama
Alabama One-Call
1-800-292-8525

Alaska
Locate Call Center of Alaska, Inc.
1-800-478-3121

Arizona
Arizona Blue Stake
1-800-782-5348

Arkansas
Arkansas One Call System, Inc.
1-800-482-8998

California
Underground Service Alert North
1-800-227-2600
Underground Service Alert of Southern California
1-800-227-2600

Colorado
Utility Notification Center of Colorado
1-800-922-1987

Connecticut
Call Before You Dig
1-800-922-4455

Delaware
Miss Utility of Delmarva
1-800-282-8555

Florida
Sunshine State One-Call of Florida, Inc.
1-800-432-4770

Georgia
Underground Protection Center, Inc.
1-800-282-7411

Hawaii
Underground Service Alert North
1-800-227-2600

Idaho
Dig Line Inc.
1-800-342-1585
Kootenai County One-Call
1-800-428-4950
Shoshone - Benewah One-Call
1-800-398-3285

Illinois
JULIE, Inc.
1-800-892-0123
Digger (Chicago Utility Alert Network)
312-744-7000

Indiana
Indiana Underground Plant Protection Service
1-800-382-5544

Iowa
Iowa One-Call
1-800-292-8989

Kansas
Kansas One-Call System, Inc.
1-800-344-7233

Kentucky
Kentucky Underground Protection Inc.
1-800-752-6007

Louisiana
Louisiana One Call System, Inc.
1-800-272-3020

Maine
Dig Safe System, Inc.
1-888-344-7233

Maryland
Miss Utility
1-800-257-7777
Miss Utility of Delmarva
1-800-282-8555

Massachusetts
Dig Safe System, Inc.
1-888-344-7233

Michigan
Miss Dig System, Inc.
1-800-482-7171

Minnesota
Gopher State One Call
1-800-252-1166

Mississippi
Mississippi One-Call System, Inc
1-800-227-6477

Missouri
Missouri One-Call System, Inc.
1-800-344-7483

Montana
Utilities Underground Protection Center
1-800-424-5555
Montana One Call Center
1-800-551-8344

Nebraska
Diggers Hotline of Nebraska
1-800-331-5666

Nevada
Underground Service Alert North
1-800-227-2600

New Hampshire
Dig Safe System, Inc.
1-888-344-7233

New Jersey
New Jersey One Call
1-800-272-1000

New Mexico
New Mexico One Call System, Inc.
1-800-321-2537
Las Cruces- Dona Ana Blue Stakes
1-888-526-0400

New York
Dig Safely New York
1-800-962-7962
New York City- Long Island One Call Center
1-800-272-4480

North Carolina
The North Carolina One-Call Center, Inc.
1-800-632-4949

North Dakota
North Dakota One-Call
1-800-795-0555

Ohio
Ohio Utilities Protection Service
1-800-362-2764
Oil & Gas Producers Underground Protect'n Svc
1-800-925-0988

Oklahoma
Call Okie
1-800-522-6543

Oregon
Oregon Utility Notification Center/One Call Concepts
1-800-332-2344

Pennsylvania
Pennsylvania One Call System, Inc.
1-800-242-1776

Rhode Island
Dig Safe System, Inc.
1-888-344-7233

South Carolina
Palmetto Utility Protection Service Inc.
1-888-721-7877

South Dakota
South Dakota One Call
1-800-781-7474

Tennessee
Tennessee One-Call System, Inc.
1-800-351-1111

ATTACHMENT 1 (Continued)

Texas
Texas One Call System
1-800-245-4545
Texas Excavation Safety System, Inc.
1-800-344-8377
Lone Star Notification Center
1-800-669-8344

Utah
Blue Stakes of Utah
1-800-662-4111

Vermont
Dig Safe System, Inc.
1-888-344-7233

Virginia
Miss Utility of Virginia
1-800-552-7001
Miss Utility (Northern Virginia)
1-800-257-7777

Washington
Utilities Underground Location Center
1-800-424-5555
Northwest Utility Notification Center
1-800-553-4344
Inland Empire Utility Coordinating Council
509-458-8000

West Virginia
Miss Utility of West Virginia, Inc.
1-800-245-4848

Wisconsin
Diggers Hotline, Inc.
1-800-242-8511

Wyoming
Wyoming One-Call System, Inc.
1-800-348-1030
Call Before You Dig of Wyoming
1-800-849-2476

District of Columbia
Miss Utility
1-800-257-7777

Alberta
Alberta One-Call Corporation
1-800-242-3447

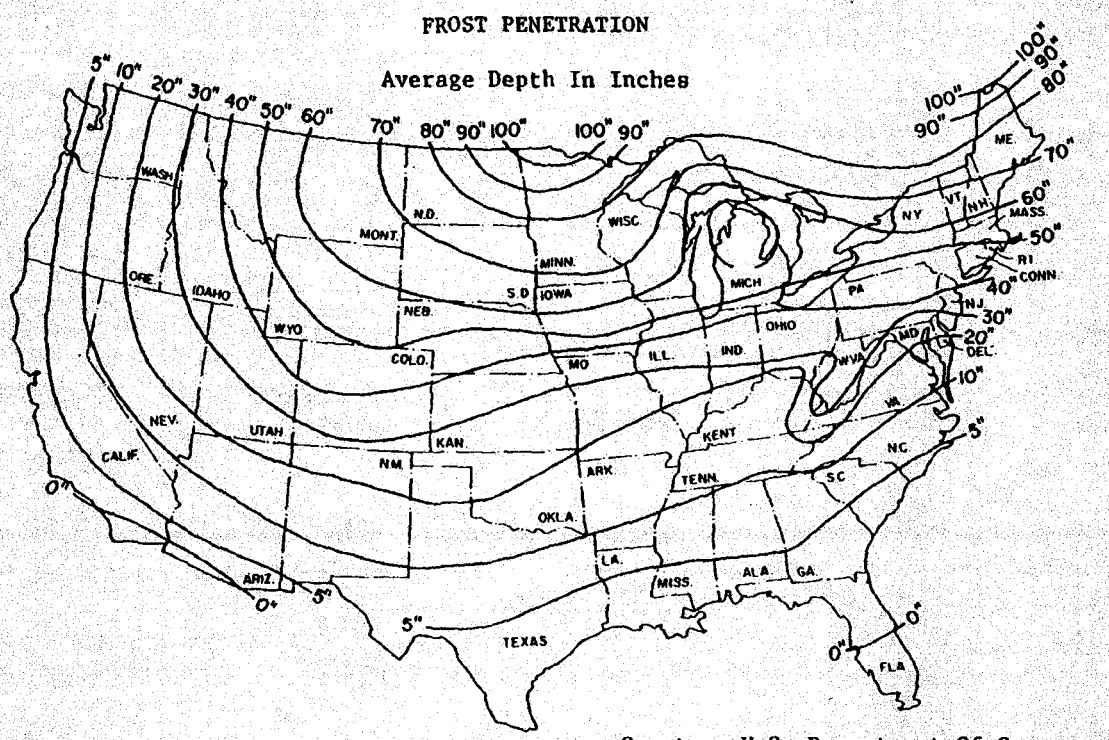
British Columbia
BC One Call
1-800-474-6886

Ontario
Ontario One-Call System
1-800-400-2255

Quebec
Info-Excavation
1-800-663-9228

ATTACHMENT 2

FROST LINE PENETRATION DEPTHS BY GEOGRAPHIC LOCATION



Courtesy U.S. Department Of Commerce

ATTACHMENT 3
UTILITY CLEARANCE FORM

Client: _____ Project Name: _____

Project No.: _____ Completed By: _____

Location Name: _____ Work Date: _____

Excavation Method/Overhead Equipment: _____

1. Underground Utilities — Circle One

a)	Review of existing maps?	yes no N/A
b)	Interview local personnel?	yes no N/A
c)	Site visit and inspection?	yes no N/A
d)	Excavation areas marked in the field?	yes no N/A
e)	Utilities located in the field?	yes no N/A
f)	Located utilities marked/added to site maps?	yes no N/A
g)	Client contact notified Name _____ Telephone: _____ Date: _____	yes no N/A
g)	State One-Call agency called? Caller: _____ Ticket Number: _____ Date: _____	yes no N/A
h)	Geophysical survey performed? Survey performed by: _____ Method: _____ Date: _____	yes no N/A
i)	Hand excavation performed (with concurrent use of utility detection device)? Completed by: _____ Total depth: _____ feet Date: _____	yes no N/A
j)	Trench/excavation probed? Probing completed by: _____ Depth/frequency: _____ Date: _____	yes no N/A

2. Overhead Utilities — Present Absent

a)	Determination of nominal voltage	yes no N/A
b)	Marked on site maps	yes no N/A
c)	Necessary to lockout/insulate/re-route	yes no N/A
d)	Document procedures used to lockout/insulate/re-route	yes no N/A
e)	Minimum acceptable clearance (SOP Section 5.2): _____	

3. Notes:

_____

_____

_____

Approval:

_____ _____

Site Manager/Field Operations Leader Date

c: PM/Project File
Program File

ATTACHMENT 4
OSHA LETTER OF INTERPRETATION

Mr. Joseph Caldwell
Consultant
Governmental Liaison
Pipeline Safety Regulations
211 Wilson Boulevard
Suite 700
Arlington, Virginia 22201

Re: Use of hydro-vacuum or non-conductive hand tools to locate underground utilities.

Dear Mr. Caldwell:

In a letter dated July 7, 2003, we responded to your inquiry of September 18, 2002, regarding the use of hydro-vacuum equipment to locate underground utilities by excavation. After our letter to you was posted on the OSHA website, we received numerous inquiries that make it apparent that aspects of our July 7 letter are being misunderstood. In addition, a number of industry stakeholders, including the National Utility Contractors Association (NUCA), have provided new information regarding equipment that is available for this work.

To clarify these issues, we are withdrawing our July 7 letter and issuing this replacement response to your inquiry.

Question: *Section 1926.651 contains several requirements that relate to the safety of employees engaged in excavation work. Specifically, paragraphs (b)(2) and (b)(3) relate in part to the safety of the means used to locate underground utility installations that, if damaged during an uncovering operation, could pose serious hazards to employees.*

Under these provisions, what constitutes an acceptable method of uncovering underground utility lines, and further, would the use of hydro-vacuum excavation be acceptable under the standard?

Answer

Background

Two sections of 29 CFR 1926 Subpart P (Excavations), 1926.651(Specific excavation requirements), govern methods for uncovering underground utility installations. Specifically, paragraph (b)(2) states:

> When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours * * * or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used. (emphasis added).

Paragraph (b)(3) provides:

ATTACHMENT 4 (Continued)

> When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by safe and acceptable means. (emphasis added).

Therefore, "acceptable means" must be used where the location of the underground utilities have not been identified by the utility companies and detection equipment is not used.

Subpart P does not contain a definition of either "other acceptable means" or "safe and acceptable means." The preambles to both the proposed rule and the final rule discussed the rationale behind the wording at issue. For example, the preamble to the proposed rule, 52 Fed. Reg. 12301 (April 15, 1987), noted that a 1972 version of this standard contained language that specified "careful probing or hand digging" as the means to uncover utilities. The preamble then noted that an amendment to the 1972 standard later deleted that language "to allow other, *equally effective means* of locating such installations." The preamble continued that in the 1987 proposed rule, OSHA again proposed using language in section (b)(3) that would provide another example of an acceptable method of uncovering utilities that could be used *where the utilities have not been marked and detection equipment is not being used* – "probing with hand-held tools." This method was rejected in the final version of 29 CFR 1926. As OSHA explained in the preamble to the final rule, 54 Fed. Reg. 45916 (October 31, 1989):

> OSHA received two comments * * * and input from ACCSH [OSHA's Advisory Committee on Construction Safety and Health] * * * on this provision. All commenters recommended dropping 'such as probing with hand-held tools' from the proposed provision, because this could create a hazard to employees by damaging the installation or its insulation.

In other words, the commenters objected to the use of hand tools being used unless detection equipment was used in conjunction with them. OSHA then concluded its discussion relative to this provision by agreeing with the commentators and ultimately not including any examples of "acceptable means" in the final provision.

Non-conductive hand tools are permitted

This raises the question of whether the standard permits the use of hand tools alone -- without also using detection equipment. NUCA and other industry stakeholders have recently informed us that non-conductive hand tools that are appropriate to be used to locate underground utilities are now commonly available.

Such tools, such as a "shooter" (which has a non-conductive handle and a snub nose) and non-conductive or insulated probes were not discussed in the rulemaking. Since they were not considered at that time, they were not part of the class of equipment that was thought to be unsafe for this purpose. Therefore, we conclude that the use of these types of hand tools, when used with appropriate caution, is an "acceptable means" for locating underground utilities.

ATTACHMENT 4 (Continued)

Hydro-vacuum excavation

It is our understanding that some hydro-vacuum excavation equipment can be adjusted to use a minimum amount of water and suction pressure. When appropriately adjusted so that the equipment will not damage underground utilities (especially utilities that are particularly vulnerable to damage, such as electrical lines), use of such equipment would be considered a "acceptable means" of locating underground utilities. However, if the equipment cannot be sufficiently adjusted, then this method would not be acceptable under the standard.

Other technologies

We are not suggesting that these are the only devices that would be "acceptable means" under the standard. Industry stakeholders have informed us that there are other types of special excavation equipment designed for safely locating utilities as well.

We apologize for any confusion our July 7 letter may have caused. If you have further concerns or questions, please feel free to contact us again by fax at: U.S. Department of Labor, OSHA, Directorate of Construction, Office of Construction Standards and Compliance Assistance, fax # 202-693-1689. You can also contact us by mail at the above office, Room N3468, 200 Constitution Avenue, N.W., Washington, D.C. 20210, although there will be a delay in our receiving correspondence by mail.

Sincerely,

Russell B. Swanson, Director
Directorate of Construction

NOTE: OSHA requirements are set by statute, standards and regulations. Our interpretation letters explain these requirements and how they apply to particular circumstances, but they cannot create additional employer obligations. This letter constitutes OSHA=s interpretation of the requirements discussed. Note that our enforcement guidance may be affected by changes to OSHA rules. Also, from time to time we update our guidance in response to new information. To keep apprised of such developments, you can consult OSHA's website at http://www.osha.gov.

TETRA TECH	STANDARD OPERATING PROCEDURES	Number SA-1.3	Page 1 of 31
		Effective Date 04/072008	Revision 9
		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject SOIL SAMPLING		Approved Tom Johnston T E Johnston	

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures to be used to collect surface, near-surface, and subsurface soil samples. Additionally, it describes the methods for sampling of test pits and trenches to determine subsurface soil and rock conditions and for recovery of small-volume or bulk samples from pits.

2.0 SCOPE

This document applies to the collection of surface, near-surface, and subsurface soil samples exposed through hand digging, hand augering, drilling, or machine excavating at hazardous substance sites for laboratory testing, onsite visual examination, and onsite testing.

3.0 GLOSSARY

Composite Sample - A composite sample is a combination of more than one grab sample from various locations and/or depths and times that is homogenized and treated as one sample. This type of sample is usually collected when determination of an average waste concentration for a specific area is required. Composite samples shall not be collected for volatile organics analysis.

~~Confined Space - As stipulated in 29 Code of Federal Regulations (CFR) 1910.146, a confined space means a space that: (1) is large enough and so configured that an employee can bodily enter and perform assigned work; (2) has limited or restricted means for entry or exit (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, pits, and excavations); and (3) is not designed for continuous employee occupancy. TtNUS considers all confined space as permit-required confined spaces.~~

Grab Sample - One sample collected at one location and at one specific time.

~~Hand Auger - A sampling device used to extract soil from the ground.~~

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

Sample for Non-Volatile Analyses - Includes all chemical parameters other than volatile organics (e.g., semivolatiles, pesticides/PCBs, metals, etc.) and those engineering parameters that do not require undisturbed soil for their analysis.

~~Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split-barrel sampler is typically available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch-long samples, respectively. These split-barrel samplers commonly range in size from 2 to 3.5 inches OD. The larger sizes are commonly used when a larger volume of sample material is required (see Attachment B).~~

~~Test Pit and Trench - Open, shallow excavations, typically rectangular (if a test pit) or longitudinal (if a trench), excavated to determine shallow subsurface conditions for engineering, geological, and soil chemistry exploration and/or sampling purposes. These pits are excavated manually or by machine (e.g., backhoe, clamshell, trencher, excavator, or bulldozer).~~

~~Thin-Walled Tube Sampler - A thin-walled metal tube (also called a Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outside diameter (OD) and from 18 to 54 inches in length.~~

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, selecting proposed sampling locations, and selecting field procedures used in the collection of soil samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager establishes the need for test pits or trenches and determines their approximate locations and dimensions.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan. This will include (but not be limited to) performing air quality monitoring during sampling, boring, and excavation activities and to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO/designee may also be required to advise the FOL on other safety-related matters regarding boring, excavation, and sampling, such as mitigative measures to address potential hazards from unstable trench walls, puncturing of drums or other hazardous objects, etc.

Field Operations Leader (FOL) - This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is responsible for finalizing the locations for collection of surface, near-surface, and subsurface (hand and machine borings, test pits/trenches) soil samples. He/she is ultimately responsible for the sampling and backfilling of boreholes, test pits, and trenches and for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP and/or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, test pit logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

Competent Person - A Competent Person, as defined in 29 CFR 1929.650 of Subpart P - Excavations, means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Health and safety precautions are identified for individual sample collection procedures throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- Knee injuries from kneeling on hard or uneven surfaces
- Slips, trips, and falls
- Cuts and lacerations
- Traffic hazards associated with sampling in parking areas, along roadways and highways.

Methods of avoiding these hazards are provided below.

Knee injuries – If kneeling is required during soil sampling, this could result in knee injuries from stones/foreign objects and general damage due to stress on the joints. To minimize this hazard:

- Clear any foreign objects from the work area.
- Wear hard-sided knee pads.
- Stretch ligaments, tendons and muscles before, during and after. Take breaks as frequently as necessary.
- Report pre-existing conditions to the SSO if you feel this activity will aggravate an existing condition.

Slips, Trips, and Falls – These hazards exist while traversing varying terrains carrying equipment to sample locations. To minimize these hazards:

- Pre-survey sampling locations. Eliminate, barricade, or otherwise mark physical hazards leading to the locations.
- Carry small loads that do not restrict the field of vision.
- Travel the safest and clearest route (not necessarily the shortest).

Cuts and Lacerations - To prevent cuts and lacerations associated with soil sampling, the following provisions are required:

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.
- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.
- Keep cutting surfaces clean and smooth.

- Secure items to be cut – do not hold them against the opposing hand, a leg, or other body part.
- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.
- DO NOT throw broken sample jars or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

Vehicular and Foot Traffic Hazards – When sampling along the roadway or near traffic patterns, follow the following precautions:

- Motorists may be distracted by onsite activities – ASSUME THEY DO NOT SEE YOU OR MEMBERS OF YOUR FIELD CREW.
- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind spot.
- **Provide a required free space of travel**. Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.
- Face Traffic. Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.
- Wear high-visibility vests to increase visual recognition by motorists.
- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver. Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.
- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

The following procedures address surface and subsurface sampling.

CAUTION

Each situation must be evaluated individually to determine the applicability and necessity for obtaining a utility clearance ticket/dig permit. Common sense dictates, prior to digging or boring with power equipment, no matter what the depth, or digging by hand in a manner that could damage unprotected underground utilities, that a dig permit is required. See SOP HS-1.0, Utility Locating and Excavation Clearance, for additional clarification. If you do not know or are unsure as to whether a ticket is necessary – **Get the Ticket**.

6.1 Overview

Soil sampling is an important adjunct to groundwater monitoring. Sampling of the soil horizons above the groundwater table can detect contaminants before they migrate to the water table, and can establish the amount of contamination absorbed or adsorbed on aquifer solids that have the potential of contributing to groundwater contamination.

Soil types can vary considerably on a hazardous waste site. These variations, along with vegetation, can affect the rate of contaminant migration through the soil. It is important, therefore, that a detailed record be maintained during sampling operations, particularly noting sampling locations, depths, and such characteristics as grain size, color, and odor. Subsurface conditions are often stable on a daily basis and may demonstrate only slight seasonal variation especially with respect to temperature, available oxygen and light penetration. Changes in any of these conditions can radically alter the rate of chemical reactions or the associated microbiological community, thus further altering specific site conditions. Certain vegetation species can create degradation products that can alter contaminant concentrations in soil. This is why vegetation types and extent of degradation of this foliage must be recorded. To prevent degradation, samples must be kept at their at-depth temperature or lower, protected from direct light, sealed tightly in approved glass containers, and be analyzed as soon as possible after collection. In addition, to the extent possible, vegetation should be removed from the sample.

The physical properties of the soil, its grain size, cohesiveness, associated moisture, and such factors as depth to bedrock and water table, will limit the depth from which samples can be collected and the method required to collect them. It is the intent of this document to present the most commonly employed soil sampling methods used at hazardous waste sites.

6.2 Soil Sample Collection

6.2.1 Procedure for Preserving and Collecting Soil Samples for Volatile Organic Compound Analysis

Samples collected using traditional methods such as collection in a jar with no preservation have been known to yield non-representative samples due to loss of volatile organic compounds (VOCs). To prevent such losses, preservation of samples with methanol ~~or sodium bisulfate~~ may be used to minimize volatilization and biodegradation. This preservation may be performed either in the field or laboratory, depending on the sampling methodology employed. Because of the large number of sampling methods and associated equipment required, careful coordination between field and laboratory personnel is needed.

Soil samples to be preserved by the laboratory are currently being collected using Method SW-846, 5035. For samples preserved in the field, laboratories are currently performing ~~low-level analyses (sodium bisulfate preservation) and~~ high- to medium-level analyses (methanol preservation) ~~depending on the needs of the end user.~~

The following procedures outline the necessary steps for collecting soil samples to be preserved at the laboratory, and for collecting soil samples to be preserved in the field with methanol ~~or sodium bisulfate.~~

~~6.2.1.1 Soil Samples to be Preserved at the Laboratory~~

~~Soil samples collected for volatile organic analysis that are to be preserved at the laboratory shall be obtained using a hermetically sealed sample vial such as an EnCore™ sampler. Each sample shall be obtained using a reusable sampling handle (T-handle) that can be provided with the EnCore™ sampler when requested and purchased. Collect the sample in the following manner for each EnCore™ sampler:~~

1. ~~Scene Safety - Evaluate the area where sampling will occur. Ensure that the area is safe from physical, chemical, and natural hazards. Clear or barricade those hazards that have been identified.~~

2. ~~Wear the appropriate personal protective equipment (PPE). This will include, at a minimum, safety glasses and nitrile surgeon's gloves. If you must kneel on the ground or place equipment on the surface being sampled, cover the ground surface with plastic to minimize surface contamination of your equipment and clothing. Wear knee pads to protect your knees from kneeling on hard or uneven surfaces.~~

3. ~~Load the Encore™ sampler into the T-handle with the plunger fully depressed.~~

4. ~~Expose the area to be sampled using a hand trowel or similar device to remove surface debris.~~

5. ~~Press the T-handle against the freshly exposed soil surface, forcing soil into the sampler. The plunger will be forced upward as the cavity fills with soil.~~

6. ~~When the sampler is full, rotate the plunger and lock it into place. If the plunger does not lock, the sampler is not full. This method ensures there is no headspace. Soft soil may require several plunges or forcing soil against a hard surface such as a sample trowel to ensure that headspace is eliminated.~~

7. ~~Use a paper towel to remove soil from the side of the sampler so a tight seal can be made between the sample cap and the rubber O-ring.~~

8. ~~With soil slightly piled above the rim of the sampler, force the cap on until the catches hook the side of the sampler.~~

9. ~~Remove any surface soil from the outside of the sampler and place in the foil bag provided with the sampler. Good work hygiene practices and diligent decontamination procedures prevents the spread of contamination even on the outside of the containers.~~

10. ~~Label the bag with appropriate information in accordance with SOP SA-6.3.~~

11. ~~Place the full sampler inside a lined cooler with ice and cool to 4°C ± 2 °C. Make sure any required trip blanks and temperature blanks are also in the cooler. Secure custody of the cooler in accordance with SOP SA-6.3.~~

12. ~~Typically, collect three Encore™ samplers at each location. Consult the SAP or laboratory to determine the required number of Encore™ samplers to be collected.~~

13. ~~The T-handle shall be decontaminated before moving to the next interval or location using a soap and water wash and rinse, and where applicable, the selected solvent as defined in the project planning documents.~~

~~Using this type of sampling device eliminates the need for field preservation and the shipping restrictions associated with preservatives. A complete set of instructions is included with each Encore™ sampler.~~

~~After the Encore™samples are collected, they should be placed on ice immediately and delivered to the laboratory within 48 hours (following the chain-of-custody and documentation procedures outlined in SOP SA-6.1). Samples must be preserved by the laboratory within 48 hours of sample collection.~~

6.2.1.2 Soil Samples to be Preserved in the Field

Soil samples preserved in the field may be prepared for analyses using ~~both the low-level (sodium bisulfate preservation) and~~ high- to medium-level (methanol preservation) methods.

> ***Safety Reminder***
> When using chemicals in the field to preserve samples, the FOL and/or SSO must ensure that Materials Safety Data Sheets (MSDSs) have been provided with the chemicals to be used. They also must ensure that these chemicals have been added to the Chemical Inventory List contained within Section 5.0, Hazard Communication, of your Health and Safety Guidance Manual (HSGM). Lastly, but most importantly, the FOL and/or SSO must review the hazards with personnel using these chemicals and ensure that provisions are available for recommended PPE and emergency measures (e.g., eyewash, etc.).

Methanol Preservation (High to Medium Level):

Bottles may be pre-spiked with methanol in the laboratory or prepared in the field. Soil samples to be preserved in the field with methanol shall utilize 40 to 60 mL glass vials with septum-lined lids. Each sample bottle shall be filled with 25 mL of demonstrated analyte-free purge-and-trap grade methanol. The preferred method for adding methanol to the sample bottle is by removing the lid and using a pipette or scaled syringe to add the methanol directly to the bottle.

> ***CAUTION***
> NEVER attempt to pipette by mouth
>
> In situations where personnel are required to spike the septum using a hypodermic needle, the following provisions for handling sharps must be in place:
>
> - Training of personnel regarding methods for handling of sharps
> - Hard-sided containers for the disposal of sharps
> - Provisions for treatment in cases where persons have received a puncture wound

Soil shall be collected with the use of a decontaminated (or disposable), small-diameter coring device such as a disposable tube/plunger-type syringe with the tip cut off. The outside diameter of the coring device must be smaller than the inside diameter of the sample bottle neck.

A small electronic balance or manual scale will be necessary for measuring the volume of soil to be added to the methanol-preserved sample bottle. Calibration of the scale shall be performed prior to use and intermittently throughout the day according to the manufacturer's requirements.

The sample should be collected as follows:

1. Weigh the unused syringe and plunger to the nearest 0.01 gram.
2. Pull the plunger back and insert the syringe into the soil to be sampled.
3. Collect 8 to 12 grams of soil by pushing the syringe barrel into the soil.
4. Weigh the sample and adjust until obtaining the required amount of sample.
5. Record the sample weight to the nearest 0.01 gram in the field logbook and/or on the sample log sheet.

6. Extrude the weighed soil sample into the methanol-preserved sample bottle taking care not to contact the sample container with the syringe.

7. If dirty, wipe soil particles from the threads of the bottle and cap. Cap the bottle tightly.

8. After capping the bottle, swirl the sample (do not shake) in the methanol and break up the soil such that all of the soil is covered with methanol.

9. Place the sample on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

~~**Sodium Bisulfate Preservation (Low Level):**~~

> ~~***CAUTION***~~
> ~~Care should be taken when adding the soil to the sodium bisulfate solution. A chemical reaction of soil containing carbonates (limestone) may cause the sample to effervesce or the vial to possibly explode. To avoid this hazard or hazards of this type, a small sample aliquot should be subjected to the sample preservative. If it effervesces in an open air environment, utilize an alternative method such as Encore™ or 2-ounce jar.~~

~~Bottles may be prepared in the laboratory or in the field with sodium bisulfate solution. Samples to be preserved in the field using the sodium bisulfate method are to be prepared and collected as follows:~~

~~1. Add 1 gram of sodium bisulfate to 5 mL of laboratory-grade deionized water in a 40 to 60 mL glass vial with septum-lined lid.~~

~~2. Collect the soil sample and record the sample weight to the nearest 0.01 gram in the field logbook or on the sample log sheet as described for methanol preservation~~

~~3. Add the weighed sample to the sample vial.~~

~~4. Collect duplicate samples using the methanol preservation method on a one-for-one sample basis because it is necessary for the laboratory to perform both low-level and medium-level analyses.~~

~~5. Place the samples on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.~~

> ~~***NOTE***~~
> ~~If lower detection limits are necessary, an option to field preserving with sodium bisulfate may be to collect EnCore™ samplers at a given sample location. Consult the planning documents to determine whether this is required. If it is, collect samples in accordance with the Encore™ sampling procedure above and then send all samplers to the laboratory to perform the required preservation and analyses.~~

6.2.2 Procedure for Collecting Soil Samples for Non-Volatile Analyses

Samples collected for non-volatile analyses may be collected as either grab or composite samples as follows:

1. With a stainless steel trowel or other approved tool, transfer a portion of soil to be sampled to a stainless steel bowl or disposable inert plastic tray.

2. Remove roots, vegetation, sticks, and stones larger than the size of a green pea.

3. Thoroughly mix the soil in the bowl or tray to obtain as uniform a texture and color as practicable. The soil type, moisture content, amount of vegetation, and other factors may affect the amount of time required to obtain a properly mixed sample. In some cases, it may be impossible to obtain a uniform sample appearance. Use the field logbook to describe any significant difficulties encountered in obtaining a uniform mixture.

4. Transfer the mixed soil to the appropriate sample containers and close the containers.

5. Label the sample containers in accordance with SOP SA-6.3.

6. Place the containers in a cooler of ice as soon after collection as possible.

7. Prepare the sample shipment and ship the samples in accordance with SOP SA-6.1.

> ***NOTE***
> Cooling may not be required for some samples depending on the scheduled analyses. Consult the planning documents if in doubt regarding correct sample preservation conditions. When in doubt – Cool to 4°C.

> ***NOTE***
> Head space is permitted in soil sample containers for non-volatile analyses to allow for sample expansion.

~~**6.2.3 Procedure for Collecting Undisturbed Soil Samples**~~

> ~~***NOTE***~~
> ~~Use of thin-walled undisturbed tube samplers is restricted by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soil with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Dennison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soil. Using these devices normally increases sampling costs, and therefore their use should be weighed against the need for acquiring an undisturbed sample. These devices are not discussed in this SOP because they are not commonly used.~~

~~When it is necessary to acquire undisturbed samples of soil for purposes of engineering parameter analysis (e.g., permeability), a thin-walled, seamless tube sampler (Shelby tube) shall be employed using the following collection procedure:~~

~~1. In preparation for sampling utilizing a drill rig, field personnel must complete the following activities:~~

- ~~Ensure that all subsurface drilling activities are preceded by a utility clearance for the area to be investigated. This includes activities described in SOP HS-1.0, Utility Location and Excavation Clearance, as well as any location-specific procedures that may apply.~~

~~REMEMBER~~

~~If you are digging near a marked utility (within the diameter of an underground utility that has been marked plus 18 inches), you must first locate the utility through vacuum extraction or hand digging to ensure that your activities will not damage the utility.~~

- ~~Complete an Equipment Inspection Checklist for the drill rig or direct-push technology (DPT) rig. This checklist will be provided in the HASP.~~
- ~~Review the Safe Work Permit prior to conducting the activity.~~
- ~~Review the activity to be conducted.~~

2. ~~Remove all surface debris (e.g., vegetation, roots, twigs, etc.) from the specific sampling location and drill and/or clean out the borehole to the desired sampling depth. Be careful to minimize potential disturbance of the material to be sampled. In saturated material, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and to maintain the water level in the hole at or above groundwater level.~~

~~CAUTION~~

~~The use of bottom-discharge bits or jetting through an open-tube sampler to clean out the borehole shall not be allowed. Only the use of side-discharge bits is permitted.~~

3. ~~Determine whether a stationary piston-type sampler is required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used.~~

4. ~~Prior to inserting the tube sampler into the borehole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out the tube sampler during sample withdrawal. In addition, the check valve maintains a positive suction within the tube to help retain the sample.~~

5. ~~A stainless steel tube sampler is typically used to minimize chemical reaction between the sample and the sampling tube.~~

6. ~~With the sampling tube resting on the bottom of the hole and the water level in the boring at groundwater level or above, push the tube into the soil with a continuous and rapid motion, without impacting or twisting. If the soil is too hard to penetrate by pushing alone, careful hammering may be used by minimizing drop distance (tapping) of the hammer. Before pulling the tube, turn it at least one revolution to shear the sample off at the bottom. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.~~

7. ~~Upon removal of the sampling tube from the hole, measure the length of sample in the tube and also the length penetrated.~~

8. ~~Remove disturbed material in the upper end of the tube and measure the length of sample again.~~

9. ~~After removing at least 1 inch of soil from the lower end, place enough packing material (clean inert material such as paper or cloth) tightly in each end of the Shelby tube and then pour melted wax into each end to make at least a ½-inch wax plug and then add more packing material to fill the voids at both ends.~~

10. ~~Place plastic caps on the ends, tape the caps in place, and dip the ends in wax to prevent loss of soil.~~

~~11. Affix label(s) to the tube as required and record sample number, depth, penetration, and recovery length on the label.~~

~~12. Mark the "up" direction on the side and upper end of the tube with indelible ink.~~

~~13. Complete a chain-of-custody form (see SOP SA-6.3) and other required forms (including Attachment A of this SOP).~~

~~14. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.~~

~~***CAUTION***~~

~~To preserve sample integrity do not allow tubes to freeze, and store the samples vertically with the same orientation they had in the ground, (i.e., top of sample is up) in a cool place out of the sun at all times.~~

~~***CAUTION***~~

~~A primary concern in the preparation of the wax plugs is the potential for the heat source and melted wax to cause a fire and/or burns. Follow the directions below to prevent injury or fire.~~

~~**Electrical Heating**~~

~~Using hot plates to melt the wax is acceptable. In an outdoor setting, make sure a Ground Fault Circuit Interrupter (GFCI) is employed within the electrical circuit. If a portable generator is used, ensure that the generator is an adequate distance from the sampling operation (at least 50 feet). Ensure that the extension cord is rated for the intended load and for outdoor use and is free from recognizable damage. Ensure flammable preservatives are not employed or stored near the hot plate. Although a Hot Work Permit is not required, scene safety evaluation by site personnel of the above elements is. As always, if a fire potential exists, the provisions for extinguishing must be immediately accessible as well as any provisions for first aid measures.~~

~~**Open Flame**~~

~~If an open flame is used, the following provisions are necessary:~~

- ~~Complete a Hot Work Permit and any local permit required for elevated temperature applications. The Hot Work Permit, provided in your HASP, will aid the FOL and/or the SSO in ensuring that fire protection provisions (extinguishers, fire watches, etc.) are in place as well as ensuring that local requirements have been addressed.~~

- ~~Ensure that water is available to address any wax splashes or contact. If possible, immerse the contacted area. Where this is not possible, run water over the area and apply cold compresses. The need for medical attention or first aid shall be determined on site under the direction of the SSO.~~

~~6.3 Surface Soil Sampling~~

~~The simplest, most direct method of collecting surface soil samples for subsequent analysis is by use of a stainless steel shovel, hand auger, soil corer, or stainless steel or disposable plastic trowel.~~

> ~~***NOTE***~~
> ~~Multiple depth intervals are used to describe surface soil. Sometimes surface soil is defined as soil from 0 to 2 inches below ground surface (bgs), and sometimes it is defined as soil from other depths such as 0 to 2 feet bgs. Ensure that the definition of surface soil depth is clear before collecting surface soil samples.~~
>
> ~~For the purposes of instruction, the terms "surface soil" and "near-surface soil" are used in this SOP as follows:~~
>
> ~~- Surface soil - 0 to 6 inches bgs~~
> ~~- Near-surface soil - 6 to 18 inches bgs~~
>
> ~~If these intervals are defined differently in the planning documents, substitute the appropriate depth ranges.~~

~~In general, the following equipment is necessary for obtaining surface soil samples:~~

- ~~Stainless steel or pre-cleaned disposable trowel.~~
- ~~Stainless steel hand auger, soil corer, or shovel.~~
- ~~Real-time air monitoring instrument (e.g., PID, FID) as directed in project planning document.~~
- ~~Required PPE.~~
  - ~~Nitrile surgeon's or latex gloves may be used, layered as necessary.~~
  - ~~Safety glasses~~
  - ~~Other – Items identified on the Safe Work Permit may be required based on location-specific requirements such as hearing protection, steel-toed work boots, and a hard hat when working near a drill rig. These provisions will be listed in the HASP or directed by the FOL and/or SSO.~~

> ~~***Safety Reminder***~~
> ~~The use of latex products may elicit an allergic reaction in some people. Should this occur, remove the latex gloves, treat for an allergic reaction, and seek medical attention as necessary.~~

- ~~Required paperwork (see SOP SA-6.3 and Attachment A of this SOP)~~
- ~~Required decontamination equipment~~
- ~~Required sample container(s)~~
- ~~Wooden stakes or pin flags~~

- ~~Sealable polyethylene bags (e.g., Ziploc® baggies)~~
- ~~Heavy duty cooler~~
- ~~Ice~~
- ~~Chain-of-custody records and custody seals~~

~~When acquiring surface soil samples, use the following procedure:~~

1. ~~Place padding or use knee pads when kneeling near the sample location. If necessary, place plastic sheeting to provide a clean surface for sample equipment to avoid possible cross- contamination.~~
2. ~~Carefully remove vegetation, roots, twigs, litter, etc. to expose an adequate soil surface area to accommodate sample volume requirements.~~
3. ~~Using a precleaned syringe or EnCore™ samplers, follow the procedure in Section 6.2.1 for collecting surface soil samples for volatile analysis. Surface soil samples for volatile organic analysis should be collected deeper than 6 inches bgs because shallower material has usually lost most of the volatiles through evaporation. Ensure that the appropriate surface soil depth is being analyzed in accordance with the planning document.~~
4. ~~Using decontaminated sampling tools, thoroughly mix in place a sufficient amount of soil to fill the remaining sample containers. See Section 6.5 of this procedure for hand auger instruction, as needed.~~
5. ~~Transfer the sample into those containers utilizing a stainless steel trowel.~~
6. ~~Cap and securely tighten all sample containers.~~
7. ~~Affix a sample label to each container. Be sure to fill out each label carefully and clearly, addressing all the categories described in SOP SA-6.3.~~
8. ~~Proceed with the handling and processing of each sample container as described in SOP SA-6.2.~~
9. ~~Site restoration – Whenever removing sample materials, always restore the surface. It is our intent to leave the area better than we found it. Do NOT create trip hazards in areas when pedestrian traffic may exist.~~

~~6.4 Near-Surface Soil Sampling~~

~~Collection of samples from near the surface (depth of 6 to 18 inches) can be accomplished with tools such as shovels, hand auger, soil corers, and stainless steel or pre-cleaned disposable trowels and the equipment listed under Section 6.5 of this procedure.~~

~~To obtain near-surface soil samples, the following protocol shall be used:~~

1. ~~With a clean shovel, make a series of vertical cuts in the soil to the depth required to form a square approximately 1 foot by 1 foot.~~
2. ~~Lever out the formed plug and scrape the bottom of the freshly dug hole with a decontaminated stainless steel or pre-cleaned disposable trowel to remove any loose soil.~~
3. ~~Follow steps 1 through 9 of Section 6.3.~~

~~6.5 Subsurface Soil Sampling With a Hand Auger~~

~~A hand-augering system generally consists of a variety of stainless steel bucket bits (approximately 6.5 inches long and 2, 2.75, 3.25, and 4 inches in diameter), series of extension rods (available in 2-, 3-, 4- and 5-inch lengths), and a T-handle connected to extension rods and to the auger bucket. A larger-diameter bucket bit is commonly used to bore a hole to the desired sampling depth and then it is withdrawn. The larger-diameter bit is then replaced with a smaller-diameter bit, lowered down the hole, and slowly turned into the soil to the completion depth (approximately 6 inches). The apparatus is then withdrawn and the soil sample collected.~~

~~The hand auger can be used in a wide variety of soil conditions. It can be used to sample soil either from the surface, or to depths in excess of 12 feet. However, the presence of subsurface rocks and landfill material and collapse of the borehole normally limit sampling depth.~~

~~To accomplish soil sampling using a hand augering system, the following equipment is required:~~

- ~~Complete hand auger assembly (variety of bucket bit sizes)~~
- ~~Stainless steel mixing bowls~~
- ~~The equipment listed in Section 6.3~~
- ~~Miscellaneous hand tools as required to assemble and disassemble the hand auger units~~

> ~~***CAUTION***~~
> ~~Potential hazards associated with hand augering include:~~
>
> - ~~Muscle strain and sprain due to over twisting and/or over compromising yourself.~~
> - ~~Equipment failure due to excessive stress on the T-handle or rods through twisting. Failure of any of these components will result in a sudden release and potential injury due to that failure.~~
>
> ~~As in all situations, any intrusive activities that could damage underground utilities shall be proceeded by a Dig/Excavation permit/ticket. Call the Utility Locating service in the area or your Project Health and Safety Officer for more information. When in doubt – **Get the Ticket!**~~

~~To obtain soil samples using a hand auger, use the following procedure:~~

1. ~~Wearing designated PPE, attach a properly decontaminated bucket bit to a clean extension rod and attach the T-handle to the extension rod.~~
2. ~~Clear the area to be sampled of any surface debris (vegetation, twigs, rocks, litter, etc.).~~
3. ~~Twist the bucket into the ground while pushing vertically downward on the auger. The cutting shoes fill the bucket as it is advanced into the ground.~~
4. ~~As the auger bucket fills with soil, periodically remove any unneeded soil.~~

5. ~~Add rod extensions as necessary to extend the reach of the auger. Also, note (in a field notebook, boring log, and/or on a standardized data sheet) any changes in the color, texture or odor of the soil as a function of depth. The project-specific planning document (SAP, HASP, etc.) describe requirements for scanning the soil with a real-time air monitoring instrument (e.g., PID, FID, etc.) and recording the measurements.~~

6. ~~After reaching the desired depth (e.g., the top of the interval to be sampled), slowly and carefully withdraw the apparatus from the borehole to prevent or minimize movement of soil from shallower intervals to the bottom of the hole.~~

7. ~~Remove the soiled bucket bit from the rod extension and replace it with another properly decontaminated bucket bit. The bucket bit used for sampling is to be smaller in diameter than the bucket bit employed to initiate the borehole.~~

8. ~~Carefully lower the apparatus down the borehole. Care must be taken to avoid scraping the borehole sides.~~

9. ~~Slowly turn the apparatus until the bucket bit is advanced approximately 6 inches.~~

10. ~~Discard the top of the core (approximately 1 inch), which represents any loose material collected by the bucket bit before penetrating the sample material.~~

11. ~~Using a precleaned syringe or EnCore™ samplers, follow the procedure in Section 6.2.1 for collecting a soil sample for volatile compound analysis directly from the bucket bit.~~
12. ~~Utilizing a properly decontaminated stainless steel trowel or dedicated disposable trowel, remove the remaining sample material from the bucket bit and place into a properly decontaminated stainless steel mixing bowl.~~

13. ~~Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers. Refer to Section 6.2.2.~~

14. ~~Follow steps 4 through 7 listed in Section 6.3.~~

~~6.5.1 Sampling Using Stainless Steel Soil Corers~~

~~A soil corer is a stainless steel tube equipped with a cutting shoe and sample window in the side. The soil corer is advanced into the soil by applying downward pressure (body weight). The soil is unloaded by then forcing a ram towards the cutting shoe, which results in the discharge of the soil core through a window in the sleeve.~~

~~Use, application, and sample protocol is the same as for hand augering provided above, but without necessarily rotating the corer while advancing it.~~

~~SAFETY REMINDER~~

~~Hand augering and soil corer sampling can be physically demanding based on the type of geology and subsurface encumbrances encountered. Soil coring has some added hazards such the corer collapsing under your weight. To reduce the potential for muscle strain and damage, the following measures will be incorporated:~~

- ~~Stretch and limber your muscles before heavy exertion. This hazard becomes more predominant in the early morning hours (prior to muscles becoming limber) and later in the day (as a result of fatigue).~~

- ~~Job rotation – Share the duties so that repetitive actions do not result in fatigue and injury.~~

- ~~Increase break frequencies as needed, especially as ambient conditions of heat and/or cold stress may dictate.~~

- ~~Do not force the hand tools or use cheater pipes or similar devices to bypass an obstruction. Move to another location near the sampling point. Exerting additional forces on the sampling devices can result in damage and/or failure that could potentially injure someone in the immediate vicinity.~~

- ~~Do not over compromise yourself when applying force to the soil corer or hand auger. If there is a sudden release, it could result in a fall or muscle injury due to strain.~~

~~6.6 Subsurface Soil Sampling with a Split-Barrel Sampler~~

~~A split-barrel (split-spoon) sampler consists of a heavy carbon steel or stainless steel sampling tube that can be split into two equal halves to reveal the soil sample (see Attachment B). A drive head is attached to the upper end of the tube and serves as a point of attachment for the drill rod. A removable tapered nosepiece/drive shoe attaches to the lower end of the tube and facilitates cutting. A basket-like sample retainer can be fitted to the lower end of the split tube to hold loose, dry soil samples in the tube when the sampler is removed from the drill hole. This split-barrel sampler is made to be attached to a drill rod and forced into the ground by means of a 140-pound or larger casing driver.~~

> ~~***Safety Reminder***~~
> ~~It is intended through the Equipment Inspection for Drill Rigs form provided in the HASP that the hammer and hemp rope, where applicable, associated with this activity will be inspected (no physical damage is obvious), properly attached to the hammer (suitable knots or sufficient mechanical devices), and is in overall good condition.~~

~~Split-barrel samplers are used to collect soil samples from a wide variety of soil types and from depths greater than those attainable with other soil sampling equipment.~~

~~The following equipment is used for obtaining split-barrel samples:~~

- ~~Drilling equipment (provided by subcontractor).~~

- ~~Split-barrel samplers (2-inch OD, 1-3/8-inch ID, either 20 inches or 26 inches long); Larger OD samplers are available if a larger volume of sample is needed.~~

- ~~Drive weight assembly, 140-pound weight, driving head, and guide permitting free fall of 30 inches.~~

- ~~Stainless steel mixing bowls.~~

- ~~Equipment listed in Section 6.3.~~

~~The following steps shall be followed to obtain split-barrel samples (Steps 1 through 4 are typically performed by the drilling subcontractor):~~

~~1. Attach the split-barrel sampler to the sampling rods.~~

~~2. Lower the sampler into the borehole inside the hollow stem auger bits.~~

~~3. Advance the split-barrel sampler by hammering the length (typically 18 or 24 inches) of the split-barrel sampler into the soil using 140-pound or larger hammer.~~

~~4. When the desired depth is achieved, extract the drill rods and sampler from the augers and/or borehole.~~

~~5. Detach the sampler from the drill rods.~~

~~6. Place the sampler securely in a vise so it can be opened using pipe wrenches.~~

> ~~***CAUTION***~~
> ~~Pipe wrenches are used to separate the split spoon into several components. The driller's helper should not apply excessive force through the use of cheater pipes or push or pull in the direction where, if the wrench slips, hands or fingers will be trapped against an immovable object.~~

~~7. Remove the drive head and nosepiece with the wrenches, and open the sampler to reveal the soil sample.~~

~~8. Immediately scan the sample core with a real-time air monitoring instrument (e.g., FID, PID, etc.) (as project-specific planning documents dictate). Carefully separate (or cut) the soil core, with a decontaminated stainless steel knife or trowel, at about 6-inch intervals while scanning the center of the core for elevated readings. Also scan stained soil, soil lenses, and anomalies (if present), and record readings.~~

~~9. If elevated vapor readings were observed, collect the sample scheduled for volatile analysis from the center of the core where elevated readings occurred. If no elevated readings where encountered, the sample material should be collected from the core's center (this area represents the least disturbed area with minimal atmospheric contact) (refer to Section 6.2.1).~~

~~10. Using the same trowel, remove remaining sample material from the split-barrel sampler (except for the small portion of disturbed soil usually found at the top of the core sample) and place the soil into a decontaminated stainless steel mixing bowl.~~

~~11. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers (refer to Section 6.2.2).~~

~~12. Follow steps 4 through 7 in Section 6.3.~~

6.7 Subsurface Soil Sampling Using Direct-Push Technology

Subsurface soil samples can be collected to depths of 40+ feet using DPT. DPT equipment, responsibilities, and procedures are described in SOP SA-2.5.

~~6.8 Excavation and Sampling of Test Pits and Trenches~~

~~6.8.1 Applicability~~

~~This subsection presents routine test pit or trench excavation techniques and specialized techniques that are applicable under certain conditions.~~

~~CAUTION~~

~~During the excavation of trenches or pits at hazardous waste sites, several health and safety concerns arise from the method of excavation. No personnel shall enter any test pit or excavation over 4 feet deep except as a last resort, and then only under direct supervision of a Competent Person (as defined in 29 CFR 1929.650 of Subpart P - Excavations). Whenever possible, all required chemical and lithological samples should be collected using the excavator bucket or other remote sampling apparatus. If entrance is required, all test pits or excavations must be stabilized by bracing the pit sides using specifically designed wooden, steel, or aluminum support structures or through sloping and benching. Personnel entering the excavation may be exposed to toxic or explosive gases and oxygen-deficient environments; therefore, monitoring will be conducted by the Competent Person to determine if it is safe to enter. Any entry into a trench greater than 4 feet deep will constitute a Confined Space Entry and must be conducted in conformance with OSHA standard 29 CFR 1910.146. In all cases involving entry, substantial air monitoring, before entry, appropriate respiratory gear and protective clothing determination, and rescue provisions are mandatory. There must be at least three people present at the immediate site before entry by one of the field team members. This minimum number of people will increase based on the potential hazards or complexity of the work to be performed. The reader shall refer to OSHA regulations 29 CFR 1926.650, 29 CFR 1910.120, 29 CFR 1910.134, and 29 CFR 1910.146. High-hazard entries such as this will be supported by members of the Health Sciences Group professionally trained in these activities.~~

~~Excavations are generally not practical where a depth of more than about 15 to 20-feet is desired, and they are usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pit, providing that pumped water can be adequately stored or disposed. If soil data at depths greater than 15-feet are required, the data are usually obtained through test borings instead of test pits.~~

~~In addition, hazardous wastes may be brought to the surface by excavation equipment. This material, whether removed from the site or returned to the subsurface, must be properly handled according to any and all applicable federal, state, and local regulations.~~

~~6.8.2 Test Pit and Trench Excavation~~

~~Test pits or trench excavations are constructed with the intent that they will provide an open view of subsurface lithology and/or disposal conditions that a boring will not provide. These procedures describe the methods for excavating and logging test pits and trenches installed to determine subsurface soil and rock conditions. Test pit operations shall be logged and documented (see Attachment C).~~

~~Test pits and trenches may be excavated by hand or power equipment to permit detailed descriptions of the nature and contamination of the in-situ materials. The size of the excavation will depend primarily on the following:~~

- ~~The purpose and extent of the exploration~~
- ~~The space required for efficient excavation~~
- ~~The chemicals of concern~~
- ~~The economics and efficiency of available equipment~~

~~Test pits normally have a cross section that is 4 to 10 feet square; test trenches are usually 3 to 6 feet wide and may be extended for any length required to reveal conditions along a specific line. The following table provides guidelines for design consideration based on equipment efficiencies.~~

~~Equipment~~	~~Typical Widths, in Feet~~
~~Trenching machine~~	~~0.25 to 1.0~~
~~Backhoe/Track Hoe~~	~~2 to 6~~

~~The lateral limits of excavation of trenches and the position of test pits shall be carefully marked on area base maps. If precise positioning is required to indicate the location of highly hazardous materials, nearby utilities, or dangerous conditions, the limits of the excavation shall be surveyed. Also, if precise determination of the depth of buried materials is needed for design or environmental assessment purposes, the elevation of the ground surface at the test pit or trench location shall also be determined by survey. If the test pit/trench will not be surveyed immediately, it shall be backfilled and its position identified with stakes placed in the ground at the margin of the excavation for later surveying.~~

~~The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, the following field conditions may necessitate revisions to the initial plans:~~

- ~~Subsurface utilities~~
- ~~Surface and subsurface encumbrances~~
- ~~Vehicle and pedestrian traffic patterns~~
- ~~Purpose for excavation (e.g., the excavation of potential ordnance items)~~

~~The final depth and construction method shall be collectively determined by the FOL and designated Competent Person. The actual layout of each test pit, temporary staging area, and spoils pile may further be predicated based on site conditions and wind direction at the time the test pit is excavated. Prior to excavation, the area may be surveyed by magnetometer or metal detector or other passive methods specified in SOP HS1.0, Utility Location and Excavation Clearance, to identify the presence of underground utilities or drums. Where possible, the excavator should be positioned upwind and preferably within an enclosed cab.~~

~~No personnel shall enter any test pit or excavation except as a last resort, and then only under direct supervision of a Competent Person. If entrance is required, OSHA requirements must be met (e.g., walls must be braced with wooden or steel braces, ladders must be placed for every 25 feet of lateral travel and extended 3 feet above ground surface). A temporary guard rail or vehicle stop must be placed along the surface of the hole before entry in situations where the excavation may be approached by traffic. Spoils will be stockpiled no closer than 2 feet from the sidewall of the excavation. The excavation equipment operator shall be careful not to undercut sidewalls and will, where necessary, bench back to increase stability. The top cover, when considered clean, will be placed separately from the subsurface materials to permit clean cover. It is emphasized that the project data needs should be structured such that required samples can be collected without requiring entrance into the excavation. For example, samples of leachate, groundwater, or sidewall soil can be collected with telescoping poles or similar equipment.~~

~~Dewatering and watering may be required to ensure the stability of the side walls, to prevent the bottom of the pit from heaving, and to keep the excavation stable. This is an important consideration for excavations in cohesionless material below the groundwater table and for excavations left open greater than a day. Liquids removed as a result of dewatering operations must be handled as potentially~~

~~contaminated materials. Procedures for the collection and disposal of such materials should be discussed in the site-specific project plans.~~

~~Where possible excavations and test pits shall be opened and closed within the same working day. Where this is not possible, the following engineering controls shall be put in place to control access:~~

- ~~Trench covers/street plates~~
- ~~Fences encompassing the entire excavation intended to control access~~
- ~~Warning signs warning personnel of the hazards~~
- ~~Amber flashing lights to demarcate boundaries of the excavation at night~~

~~Excavations left open will have emergency means to exit should someone accidentally enter.~~

~~6.8.3 Sampling in Test Pits and Trenches~~

~~6.8.3.1 General~~

~~Log test pits and trenches as they are excavated in accordance with the Test Pit Log presented in Attachment C. These records include plan and profile sketches of the test pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records also include safety and sample screening information.~~

~~Entry of test pits by personnel is extremely dangerous, shall be avoided unless absolutely necessary, and can occur only after all applicable health and safety and OSHA requirements have been met as stated above. These provisions will be reiterated as appropriate in the project-specific HASP.~~

~~The final depth and type of samples obtained from each test pit will be determined at the time the test pit is excavated. Sufficient samples are usually obtained and analyzed to quantify contaminant distribution as a function of depth for each test pit. Additional samples of each waste phase and any fluids encountered in each test pit may also be collected.~~

~~In some cases, samples of soil may be extracted from the test pit for reasons other than waste sampling and chemical analysis, for instance, to obtain geotechnical information. Such information includes soil types, stratigraphy, strength, etc., and could therefore entail the collection of disturbed (grab or bulk) or relatively undisturbed (hand-carved or pushed/driven) samples that can be tested for geotechnical properties. The purposes of such explorations are very similar to those of shallow exploratory or test borings, but often test pits offer a faster, more cost-effective method of sampling than installing borings.~~

~~6.8.3.2 Sampling Equipment~~

~~The following equipment is needed for obtaining samples for chemical or geotechnical analysis from test pits and trenches:~~

- ~~Backhoe or other excavating machinery.~~
- ~~Shovels, picks, hand augers, and stainless steel trowels/disposable trowels.~~
- ~~Sample container - bucket with locking lid for large samples; appropriate bottle ware for chemical or geotechnical analysis samples.~~

- ~~Polyethylene bags for enclosing sample containers; buckets.~~

- ~~Remote sampler consisting of 10-foot sections of steel conduit (1-inch-diameter), hose clamps, and right angle adapter for conduit (see Attachment D).~~

~~6.8.3.3 Sampling Methods~~

~~The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 6.8.3.4.~~

- ~~Excavate the trench or pit in several 0.5- to 1.0-foot depth increments. Where soil types support the use of a sand bar cutting plate, use of this device is recommended to avoid potentially snagging utilities with the excavator teeth. It is recommended that soil probes or similar devices be employed where buried items or utilities may be encountered. This permits the trench floor to be probed prior to the next cut.~~

- ~~After each increment:~~

  - ~~the operator shall wait while the sampler inspects the test pit from grade level~~

  - ~~the sampler shall probe the next interval where this is considered necessary. Practical depth increments for lithological evaluations may range from 2 to 4 feet i or where lithological changes are noted.~~

- ~~The backhoe operator, who will have the best view of the test pit, shall immediately cease digging if:~~

  - ~~Any fluid phase, including groundwater seepage, is encountered in the test pit~~

  - ~~Any drums, other potential waste containers, obstructions, or utility lines are encountered~~

  - ~~Distinct changes of material being excavated are encountered~~

~~This action is necessary to permit proper sampling of the test pit and to prevent a breach of safety protocol. Depending on the conditions encountered, it may be required to excavate more slowly and carefully with the backhoe.~~

~~For obtaining test pit samples from grade level, the following procedure shall be followed:~~

- ~~Use the backhoe to remove loose material from the excavation walls and floor to the greatest extent possible.~~

- ~~Secure the walls of the pit, if necessary. (There is seldom any need to enter a pit or trench that would justify the expense of shoring the walls. All observations and samples should be taken from the ground surface.)~~

- ~~Samples of the test pit material are to be obtained either directly from the backhoe bucket or from the material after it has been deposited on the ground, as follows:~~

  a. ~~The sampler or FOL shall direct the backhoe operator to remove material from the selected depth or location within the test pit/trench.~~

  b. ~~The backhoe operator shall bring the bucket over to a designated location on the sidewall a sufficient distance from the pit (at least 5 feet) to allow the sampler to work around the bucket.~~

c. ~~After the bucket has been set on the ground, the backhoe operator shall either disengage the controls or shut the machine down.~~

d. ~~When signaled by the operator that it is safe to do, the sampler will approach the bucket.~~

e. ~~The soil shall be monitored with a photoionization or flame ionization detector (PID or FID) as directed in the project -specific planning documents.~~

f. ~~The sampler shall collect the sample from the center of the bucket or pile in accordance with surface soil sampling procedures of Section 6.3 or 6.4, as applicable. Collecting samples from the center of a pile or bucket eliminates cross-contamination from the bucket or other depth intervals.~~

- ~~If a composite sample is desired, several depths or locations within the pit/trench will be selected, and the bucket will be filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory conditions. However, if compositing in the field is required, each sample container shall be filled from materials that have been transferred into a mixing bucket and homogenized. Note that homogenization/compositing is not applicable for samples to be subjected to volatile organic analysis.~~

> ~~***CAUTION***~~
> ~~Care must be exercised when using the remote sampler described in the next step because of potential instability of trench walls. In situations where someone must move closer than 2 feet to the excavation edge, a board or platform should be used to displace the sampler's weight to minimize the chance of collapse of the excavation edge. Fall protection should also be employed when working near the edges or trenches greater than 6 feet deep. An immediate means to extract people who have fallen into the trench will be immediately available. These means may include ladders or rope anchor points.~~

- ~~Using the remote sampler shown in Attachment D, samples can be taken at the desired depth from the sidewall or bottom of the pit as follows:~~

a. ~~Scrape the face of the pit/trench using a long-handled shovel or hoe to remove the smeared zone that has contacted the backhoe bucket.~~

b. ~~Collect the sample directly into the sample jar, by scraping with the jar edge, eliminating the need for sample handling equipment and minimizing the likelihood of cross-contamination.~~

c. ~~Cap the sample jar, remove it from the remote sampler assembly, and package the sample for shipment in accordance with SOP SA-6.3.~~

- ~~Complete documentation as described in SOP SA-6.3 and Attachment C of this SOP.~~

~~6.8.3.4 In-Pit Sampling~~

~~Under rare conditions, personnel may be required to enter the test pit/trench. This is necessary only when soil conditions preclude obtaining suitable samples from the backhoe bucket (e.g., excessive mixing of soil or wastes within the test pit/trench) or when samples from relatively small discrete zones within the test pit are required. This approach may also be necessary to sample any seepage occurring at discrete levels or zones in the test pit that are not accessible with remote samplers.~~

~~In general, personnel shall sample and log pits and trenches from the ground surface, except as provided for by the following criteria:~~

- ~~There are no practical alternative means of obtaining such data.~~
- ~~The SSO and Competent Person determine that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the pit/trench after it is dug (including, at a minimum, measurements of oxygen concentration, flammable gases, and toxic compounds, in that order). Action levels will be provided in project-specific planning documents.~~
- ~~A company-designated Competent Person determines that the pit/trench is stable trough soil classification evaluation/inspections or is made stable (by cutting/grading the sidewalls or using shoring) prior to entrance of any personnel. OSHA requirements shall be strictly observed.~~

~~If these conditions are satisfied, only one person may enter the pit/trench. On potentially hazardous waste sites, this individual shall be dressed in selected PPE as required by the conditions in the pit. He/she shall be affixed to a harness and lifeline and continuously monitored while in the pit.~~

~~A second and possible third individual shall be fully dressed in protective clothing including a self-contained breathing device and on standby during all pit entry operations to support self rescue or assisted self rescue. The individual entering the pit shall remain therein for as brief a period as practical, commensurate with performance of his/her work. After removing the smeared zone, samples shall be obtained with a decontaminated trowel or spoon.~~

~~6.8.3.5 Geotechnical Sampling~~

~~In addition to the equipment described in Section 6.8.3.2, the following equipment is needed for geotechnical sampling:~~

- ~~Soil sampling equipment, similar to that used in shallow drilled boring (i.e., thin-walled tube samplers), that can be pushed or driven into the floor of the test pit.~~
- ~~Suitable driving (e,g., sledge hammer) or pushing (e.g., backhoe bucket) equipment used to advance the sampler into the soil.~~
- ~~Knives, spatulas, and other suitable devices for trimming hand-carved samples.~~
- ~~Suitable containers (bags, jars, tubes, boxes, etc.), labels, wax, etc. for holding and safely transporting collected soil samples.~~
- ~~Geotechnical equipment (pocket penetrometer, torvane, etc.) for field testing collected soil samples for classification and strength properties.~~

~~Disturbed grab or bulk geotechnical soil samples may be collected for most soil in the same manner as comparable soil samples for chemical analysis. These collected samples may be stored in jars or plastic-lined sacks (larger samples), which will preserve their moisture content. Smaller samples of this type are usually tested for their index properties to aid in soil identification and classification: larger bulk samples are usually required to perform compaction tests.~~

~~Relatively undisturbed samples are usually extracted in cohesive soil using thin-walled tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability, and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe,~~

~~rather than by a drill rig. Also, the sampler may be extracted from the test pit by excavation around the tube when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit, the requirements described in Section 6.8.3.4 shall be followed. The thin-walled tube sampler shall be pushed or driven vertically into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate because the sample will not have the correct orientation.~~

~~A sledge hammer or backhoe may be used to drive or push the tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, thus minimizing disturbance to the sample. When using a sledge hammer, it is recommended that the sampler be stabilized using a rope/strap wrench or pipe wrench to remove the person's hands holding the sampler from the strike zone. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hook the sampler to the excavator or backhoe and extract. This means an alternative head will be used as a connection point or that multiple choke hitches will be applied to extract the sampler. If this fails and the excavator can dig deeper without potentially impacting subsurface utilities, excavate the sampler. If this fails or if the excavator cannot be used due to subsurface utilities, hand-excavate to remove the soil from around the sides of the sampler. If hand-excavation requires entry into the test pit, the requirements in Section 6.8.3.4 must be followed. Prepare the sample as described in Steps 9 through 13 in Section 6.2.3, and label, pack and transport the sample in the required manner, as described in SOPs SA-6.3 and SA-6.1.~~

~~6.8.4 Backfilling of Trenches and Test Pits~~

~~All test pits and excavations must be either backfilled, covered, or otherwise protected at the end of each day. No excavations shall remain open during non-working hours unless adequately covered or otherwise protected.~~

~~Before backfilling, the onsite crew may photograph, if required by the project-specific work plan, all significant features exposed by the test pit and trench and shall include in the photograph a scale to show dimensions. Photographs of test pits shall be marked to include site number, test pit number, depth, description of feature, and date of photograph. In addition, a geologic description of each photograph shall be entered in the site logbook. All photographs shall be indexed and maintained as part of the project file for future reference.~~

~~After inspection, backfill material shall be returned to the pit under the direction of the FOL. Backfill should be returned to the trench or test pit in 6-inch to 1-foot lifts and compacted with the bucket. Remote controlled tampers or rollers may be lowered into the trench and operated from top side. This procedure will continue to the grade surface. It is recommended that the trench be tracked or rolled in. During excavation, clean soil from the top 2 feet may have been separated to be used to cover the last segments. Where these materials are not clean, it is recommended that clean fill be used for the top cover.~~

~~If a low-permeability layer is penetrated (resulting in groundwater flow from an upper contaminated flow zone into a lower uncontaminated flow zone), backfill material must represent original conditions or be impermeable. Backfill could consist of a soil-bentonite mix prepared in a proportion specified by the FOL (representing a permeability equal to or less than original conditions). Backfill can be covered by "clean" soil and graded to the original land contour. Revegetation of the disturbed area may also be required.~~

6.9 Records

The appropriate sample log sheet (see Attachment A of this SOP) must be completed by the site geologist/sampler for all samples collected. All soil sampling locations should be documented by tying in the location of two or more nearby permanent landmarks (building, telephone pole, fence, etc.) or

obtaining GPS coordinates; and shall be noted on the appropriate sample log sheet, site map, or field notebook. Surveying may also be necessary, depending on the project requirements.

~~Test pit logs (see Attachment C of this SOP) shall contain a sketch of pit conditions. If the project-specific work plan requires photographs, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Boreholes, test pits, and trenches shall be logged by the field geologist in accordance with SOP GH-1.5.~~

Other data to be recorded in the field logbook include the following:

- Name and location of job
- Date of boring and excavation
- Approximate surface elevation
- Total depth of boring and excavation
- Dimensions of pit
- Method of sample acquisition
- Type and size of samples
- Soil and rock descriptions
- Photographs if required
- Groundwater levels
- PID/FID/LEL/O_2 meter readings
- Other pertinent information, such as waste material encountered

In addition, site-specific documentation to be maintained by the SSO and/or Competent Person will be required including:

- Calibration logs
- Excavation inspection checklists
- Soil type classification

7.0 REFERENCES

American Society for Testing and Materials, 1987. ASTM Standards D1587-83 and D1586-84. ASTM Annual Book of Standards. ASTM. Philadelphia, Pennsylvania. Volume 4.08.

NUS Corporation, 1986. Hazardous Material Handling Training Manual.

NUS Corporation and CH2M Hill, August, 1987. Compendium of Field Operation Methods. Prepared for the U.S. EPA.

OSHA, Excavation, Trenching and Shoring 29 CFR 1926.650-653.

~~OSHA, Confined Space Entry 29 CFR 1910.146.~~

USEPA, November 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.

ATTACHMENT A
SOIL & SEDIMENT SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date:	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

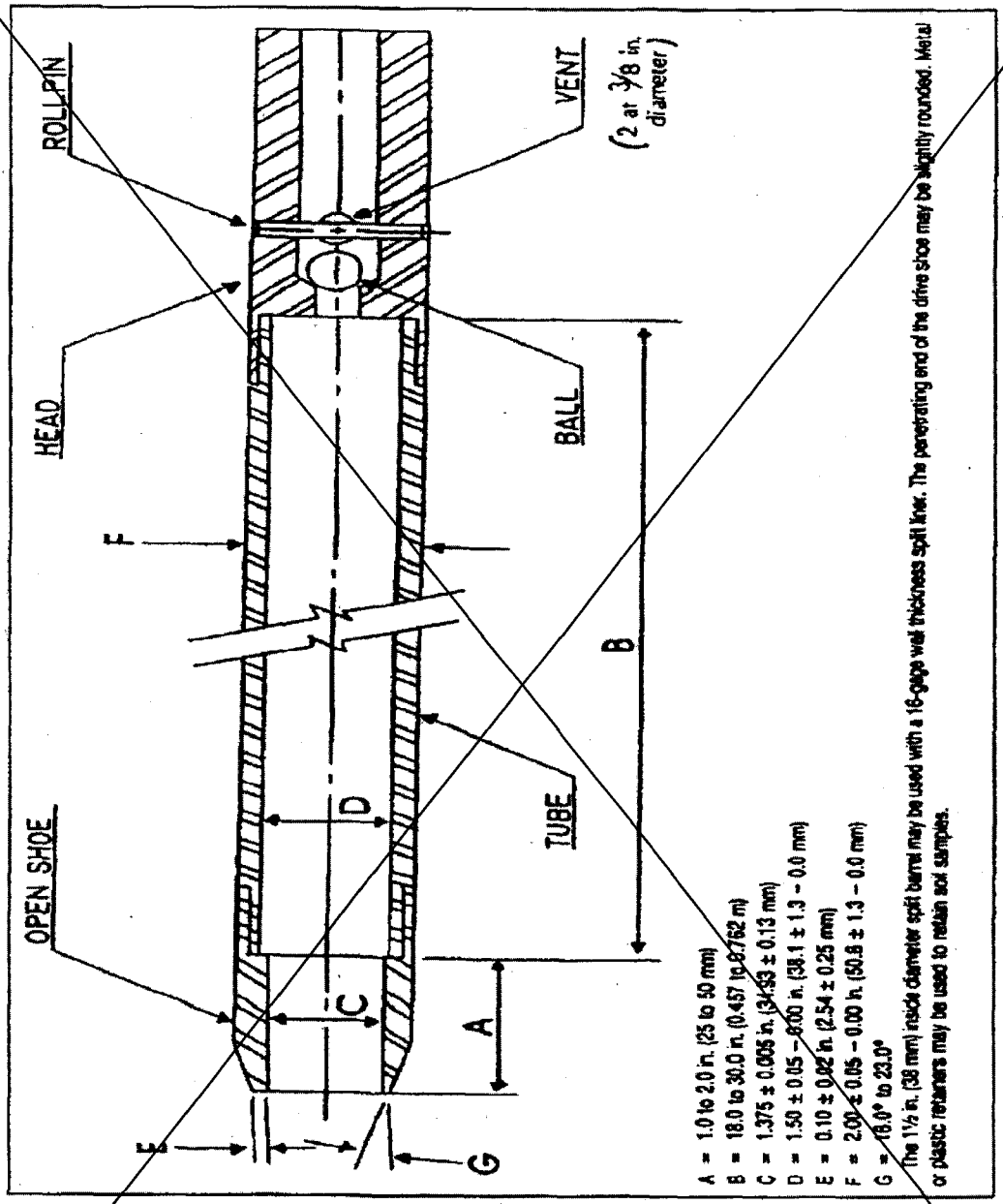
MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

~~ATTACHMENT B~~
~~SPLIT-SPOON SAMPLER~~



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 18.0° to 23.0°
The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

~~ATTACHMENT C~~
~~TEST PIT LOG~~

Tetra Tech NUS, Inc.

TEST PIT LOG

Page ___ of ___

PROJECT NAME: _____ TEST PIT No.: _____
PROJECT NUMBER: _____ DATE: _____
LOCATION: _____ GEOLOGIST: _____

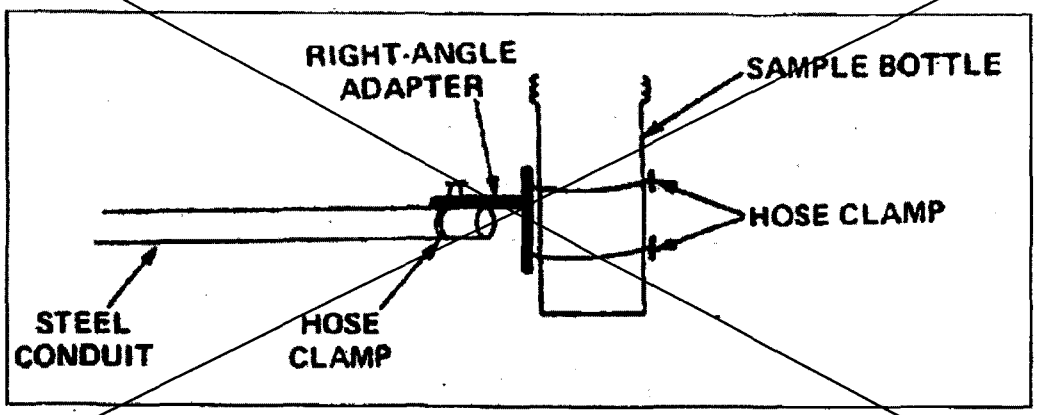
Depth (Ft.)	Lithology Change (Depth/Ft.)	MATERIAL DESCRIPTION Soil/Waste Characteristics (lithology, density, color, etc.)	USCS	Remarks	PID/FID READING Source (ppm)	BZ (ppm)

TEST PIT CROSS SECTION AND / OR PLAN VIEW

REMARKS: _____

PHOTO LOG: _____

~~ATTACHMENT D~~
~~REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING~~



TETRA TECH	STANDARD OPERATING PROCEDURES	Number SA-1.1	Page 1 of 34
		Effective Date 04/07/2008	Revision 7
		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING		Approved Tom Johnston	

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the process to be used for purging groundwater monitoring wells prior to sampling, for collecting groundwater samples, and for measuring groundwater quality parameters.

2.0 SCOPE

This document provides information on proper sampling equipment, onsite water quality testing, safety measures to ensure the safety of the field technician(s), and techniques for groundwater sampling. All personnel are encouraged to review the information contained herein to facilitate planning of the field sampling effort. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

Conductivity – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions and their total concentration, mobility, valence, and relative concentrations and on temperature. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 microSiemens per centimeter (mS/cm) at 14°C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

Groundwater Sample – A quantity of water removed from the ground, usually via a monitoring well that may or may not be lined with a well casing.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode immersed in water, as referenced against a reference electrode. A reference electrode commonly used in the field is the silver/silver chloride electrode, which has a voltage offset of about 210 mV from the standard hydrogen electrode (SHE). To convert field ORP measurements to equivalent SHE values, approximately 210 mV must be added to the ORP values obtained using the silver/silver chloride electrode. The actual offset depends on the concentration of the potassium chloride (KCl) in the field reference electrode and the temperature. Offsets typically range from 199 (saturated KCl) to 205 (3.5 Molar KCl) to 222 mV (1 Molar KCl) at 25°C and are greater at lower temperatures.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

Salinity – The measurement of dissolved salts in a given mass of solution. Note: most field meters determined salinity automatically from conductivity and temperature. The value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent). The parts per thousand symbol ($^0/_{00}$) is not the same as the percent symbol (%).

Turbidity – Turbidity in water is caused by suspended matter such as clay, silt, and fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, initial sampling locations, and field procedures used in the collection of groundwater samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager identifies sampling locations.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP). This includes but is not be limited to performing air quality monitoring during sampling, boring and excavation activities, and ensuring that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO or SSO designee may also be required to advise the FOL on other safety-related matters regarding sampling, such as mitigative measures to address potential hazards from hazardous objects or conditions.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

Project Hydrogeologist – This individual is responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), equipment to be used, and providing detailed input in this regard to the project planning documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of site sampling personnel.

Field Operations Leader (FOL) – This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is ultimately responsible for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.
General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.

- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Specific safety and health precautions are identified throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- Knee injuries from kneeling on hard surfaces
- Slips, trips, and falls
- Cuts and lacerations
- Traffic hazards associated with sampling in parking areas and roadways and along highways.

Methods of avoiding these hazards are provided below.

Knee injuries – Many monitoring wells are installed as flush mounts. Personnel are required to kneel to open these wells and to take groundwater level measurements, etc. This could result in knee injuries from kneeling on stones/foreign objects and general damage due to stress on the joints. To combat this hazard:

- Clear any foreign objects from the work area.
- Wear hard-sided knee pads.

Slips, Trips, and Falls – These hazards exist while traversing varying terrains carrying equipment to sample wells. To minimize these hazards:

- Pre-survey well locations. Eliminate, barricade, or otherwise mark physical hazards leading to the locations.
- Carry small loads that do not restrict the field of vision.
- Travel the safest and clearest route (not necessarily the shortest).

Cuts and Lacerations – To prevent cuts and lacerations associated with groundwater sampling, the following provisions are required:

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.
- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.

- Keep cutting surfaces clean and smooth.
- Secure items to be cut -- do not hold them against the opposing hand, a leg, or other body part.
- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.
- DO NOT throw broken glass or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

Vehicular and Foot Traffic Hazards – When sampling along the roadway or near traffic patterns, follow the following precautions:

- Motorists may be distracted by onsite activities – ASSUME THEY DO NOT SEE YOU OR MEMBERS OF YOUR FIELD CREW.
- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind spot.
- **Provide a required free space of travel**. Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.
- Face Traffic. Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.
- Wear high-visibility vests to increase visual recognition by motorists.
- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver. Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.
- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

6.1 General

For information derived from a groundwater sample to be useful and accurate, the sample must be representative of the particular zone being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis to keep any changes in water quality parameters to a minimum.

CAUTION

A closed well may generate and accumulate gases due to biological degradation, evolution of volatile chemicals from groundwater into the air, or other chemical actions. These gases may also be artificially generated, such as in the case of air sparging or

extraction wells, which may take several days to depressurize. See Section 6.6.2 for safety measures to be employed to protect sampling personnel.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air or nitrogen, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water sample due to external influences of the sampling technique(s). In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. Concentration gradients resulting from mixing and dispersion processes, layers of variable geologic permeability, and the presence of separate-phase product (e.g., floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase contaminant concentrations in the collected sample compared to what is representative of the integrated water column as it naturally occurs at that point, resulting in the collection of a non-representative sample. To safeguard against collecting non-representative samples, the following approach shall be followed prior to sample acquisition:

CAUTION

Mechanical agitation of well water may cause off-gas generation of volatile contaminants, creating an inhalation exposure to the sampler(s). Where avoiding an inhalation exposure is not possible and mechanical agitation is possible, pump into closed-top containers to control potential air emissions.

1. If possible, position yourself (and the sampling equipment) upwind of the well head.

2. Purge the monitoring well to be sampled prior to obtaining any samples from it. Evacuation of three to five well volumes is recommended prior to sampling, unless low-flow purging and sampling methods are utilized as described in Section 6.7 (Consult the site-specific SAP for exact purging parameters). In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical as it is in a low-yielding well or in wells containing stagnant water.

3. For wells with low yields that are purged dry during sampling, evacuate the well and allow it to recover to 75 percent of full capacity prior to sample acquisition. If the recovery rate is fairly rapid (generally 300 mL per minute or greater), attempt to continue evacuation until the number of well volumes specified in the SAP is achieved. If this cannot be accomplished, allow recovery to 75 percent of capacity and begin sampling.

CAUTION

For moderate to high-yielding monitoring wells, an evacuation rate that does not cause excessive turbulence in the well should be selected. There is no absolute safeguard against contaminating the sample with stagnant water; hence, special techniques are required for purging to minimize the potential for sample contamination (see below).

4. For moderate to high-yielding monitoring wells, use one of the following purge techniques:

- Place a submersible pump or the intake line of a surface pump or bailer just below the water surface when removing the stagnant water.

- While purging and as the water level decreases, lower the pump or intake line as the water level drops in the well. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. After this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.

- Unless otherwise directed, place the intake line of the sampling pump (or the submersible pump itself) near the center of the screened section, and pump approximately one casing volume of water from the well at a low purge rate equal to the well's recovery rate (low-flow sampling).

6.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform to the guidelines in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment – Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler materials, ice, labels, and chain-of-custody documents.

- Field tools and instrumentation

  - Multi-parameter water quality meter with an in-line sample chamber capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity, and salinity, or individual meters (as applicable)

  - pH Paper

  - Camera and film (if appropriate)

  - Appropriate keys (for locked wells)

  - Water level indicator and/or oil-water interface probe if separate-phase product is expected

- Pumps

  - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with drop lines and air-lift apparatus (compressor and tubing) where applicable.

  - ~~Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.~~

- Other sampling equipment – Bailers, graduated cylinder, stopwatch, and inert line with tripod-pulley assembly (if necessary).

- Pails – Plastic, graduated.

- Clean paper or cotton towels for cleaning equipment.

- Buckets with lids for collecting purge water.

- Decontamination solutions – Deionized water, potable water, phosphate-free laboratory-grade detergent, and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

6.3 Calculations of Well Volume

To ensure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to know the volume of standing water in the well pipe (including well screen where applicable). This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form or equivalent electronic form(s) (see SOP SA-6.3):

1. Obtain all available information on well construction (location, casing, screen, etc.).

2. Determine well or inner casing diameter.

3. Measure and record static water level (depth below ground level or top of casing reference point).

4. Determine depth of well by sounding using a clean, decontaminated, weighted tape measure or water level indicator.

5. Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

6. Calculate one static well volume in gallons $V = (0.163)(T)(r^2)$

   where: V = Static volume of well in gallons.
   T = Linear feet of water in the well.
   r = Inside radius of well casing in inches.
   0.163 = Conversion factor (compensates for conversion of casing radius from inches to feet and cubic feet to gallons and pi.

7. Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

Measuring devices may become contaminated when gathering the above information if they are submerged in contaminated water. Decontamination of the tape or water level indicator must be conducted between measurements in different wells as follows:

1. Saturate a paper towel or clean cotton towel with deionized water.

2. As the measuring device is extracted, wipe the tape, changing the cleaning surface frequently.

3. After it is extracted, rinse the probe or tape using a spray bottle of deionized water over a bucket or similar collection container.

Based on the contaminant (oily, etc), it may be necessary to use a soap and water wash and rinse to remove contaminants. Isopropanol can be used on the probe/tape. However, it is recommended that the use of solvents on the tape be minimized because they could degrade the protective covering or possibly remove the scale designations. If isopropanol (or some other solvent) is used, assure that the manufacturer/supplier Material Safety Data Sheet (MSDS) is obtained, kept on site at a readily available location with other MSDSs, and reviewed by personnel prior to the first usage of the solvent. Also, add the substance to the site-specific Hazardous Chemical Inventory list (see Section 5 of the TtNUS Health and Safety Guidance Manual [HSGM], Hazard Communication Program and OSHA Standard 29 CFR 1910.1200).

6.4 Evacuation of Static Water – Purging

6.4.1 General

The amount to be purged from each well will be determined prior to sample collection. This amount will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of the aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately, the well can be pumped until parameters such as temperature, specific conductance, pH, and turbidity (as applicable) have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook or field notebook or on standardized data sheets or an equivalent electronic form(s).

6.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. All of these techniques involve equipment that is portable and readily available.

~~Bailers~~

~~Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of tubing equipped with a base plate and ball check valve at the bottom. Bailers are comprised of stainless steel and plastic. They come in a variety of sizes, but the two most often used are 2 inches and 4 inches in diameter. An inert non-absorbent line such as polyethylene rope is used to lower and then raise the bailer to retrieve the sample. As the bailer is lowered into the water column, the ball is pushed up allowing the tube to be filled. When the bailer is pulled upward, the ball seats in the base plate preventing water from escaping.~~

~~Advantages of bailers include the following:~~

- ~~There are few limitations on size and materials used.~~
- ~~No external power source is needed.~~
- ~~Bailers are inexpensive and can be dedicated and hung in a well to reduce the chances of cross-contamination.~~
- ~~Bailers are relatively easy to decontaminate.~~

~~Limitations on the use of bailers include the following:~~

- ~~It is time consuming to remove stagnant water using a bailer.~~
- ~~Splashing the bailer into the water or transfer of sample may cause aeration.~~
- ~~The use of a bailer does not permit constant in-line monitoring of groundwater parameters.~~
- ~~Use of bailers is physically demanding, especially in warm temperatures at personal protection equipment (PPE) levels above Level D.~~

~~Safety concerns using a bailer include the following:~~

- ~~Muscle stress and strain, especially when using 4-inch bailers and when pulling from excessively deep wells.~~
- ~~Entanglement, possible hand/finger injuries, and rope burns during a sudden release of the bailer back down the well.~~
- ~~Direct contact with contaminants of concern and sample preservatives when discharging the bailer contents because there is not a high level of control during a direct pour, and splashing and indirect contact with contaminants/preservatives could occur.~~

~~Control measures for these hazards are provided in Section 6.6.2.~~

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low-volume pump that uses rollers to squeeze flexible tubing to create suction. This tubing can be dedicated to a well to prevent cross-contamination from well to well. Suction pumps are all portable, inexpensive, and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause loss of dissolved gases and volatile organics. Another limitation of these pumps is that they require a secondary energy source to drive them. Electrically driven pumps may require portable generators as energy sources. Air diaphragm pumps require air compressors and/or compressed gas cylinders to drive them. The advantage of the peristaltic pump is that it will operate from a portable battery source. Safety measures associated with these pumps are provided below.

~~Air-Lift and Gas-Lift Samplers~~

~~This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force groundwater up a sampling tube. These pumps are also relatively inexpensive. Air- or gas-lift samplers are more suitable for well development than for sampling because the samples may be aerated as a result of pump action. Aeration can cause pH changes and subsequent trace metal precipitation or loss of volatile organics.~~

~~Submersible Pumps~~

~~Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. Operation principles vary, and~~

~~displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2 inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).~~

~~Limitations of this class of pumps include the following:~~

- ~~They may have low delivery rates.~~
- ~~Many models are expensive.~~
- ~~Compressed gas or electric power is needed.~~
- ~~Sediment in water may cause clogging of the valves or eroding of the impellers with some of these pumps.~~
- ~~Decontamination of internal components can be difficult and time consuming.~~

~~Compressed Gases~~

~~Safety concerns using compressed gases as an energy source in these pumps are numerous. The nitrogen gas or compressed air is provided in a compressed gas cylinder at a pressure of approximately 2,000 psi. If damaged, these cylinders can become dangerous projectiles. Additionally, a sudden release of a cylinder's contents can involve considerable force that could cause significant damage to the eyes and/or skin. Protective measures include the following:~~

- ~~Always wear safety impact glasses when handling compressed gases.~~
- ~~Always administer compressed gases through an appropriate pressure-reducing regulator.~~
- ~~When clearing the cylinder connection port, open the cylinder valve only enough to clear foreign debris. During this process, always position the cylinder valve so that it faces away from you and others.~~
- ~~If the cylinder is designed to accept a valve protection cap, always keep that protection cap in place, except the cylinder is connected for use.~~
- ~~When using the cylinder, lay the cylinder on its side to avoid the potential of it falling and knocking the valve off (and becoming a missile).~~
- ~~DO NOT use the compressed nitrogen or air to clean clothing or to spray off the skin. Small cuts in the protective layer of the skin may permit the gas to enter into the bloodstream, presenting the potential danger of an embolism.~~

~~See the project-specific HASP for additional direction concerning cylinder safe handling procedures pertaining to the safe handling, transportation, and storage of compressed gas cylinders.~~

Electrical Shock

Even in situations where portable batteries are used, the potential for electrical shock exists. This potential risk is increased in groundwater sampling activities because of the presence of groundwater near the batteries. This potential is also increased in (prohibited) situations where jury-rigging of electrical connections is performed. Other potential hazards occur when field samplers open the hood of

a running car to access the battery as a power source. To control these hazards:

- If you are unfamiliar with electrical devices, do not experiment, get help, and get the proper equipment necessary to power your device.
- Use the proper portable power inverters for cigarette lighter connections to minimize the need to access the battery under the hood of your vehicle.
- Use of electrical generators may pose a number of hazards including noise, those associated with fueling, and indirect sample influence.

To minimize or eliminate electrical generator hazards:

- Inspect the generator before use. Ensure that the generator and any extension cords are rated for the intended operation and have a Ground Fault Circuit Interrupter (GFCI) in line to control potential electrical shock.
- Fuel the generator before purging and sampling to avoid loss of power during sampling.
- Fuel engines only when they are turned OFF and have cooled sufficiently to prevent a fire hazard.
- Place the generator and any fuel source at least 50 feet from the well to be sampled to avoid indirect influence to the sample from fuel vapors or emission gases.

Lifting Hazards

This hazard may be experienced when moving containers of purge water, equipment, cylinders, etc. To control these potential hazards:

- Do not fill purge buckets to more than 80 percent of their capacity.
- Obtain a gas cylinder of sufficient size to complete the designated task but not too large to handle. K-size cylinders weigh approximately 135 pounds and are difficult to handle. M-size cylinders weigh approximately 50 pounds and are easier to handle and move.
- When necessary, get help lifting and moving gas cylinders and other heavy objects. Minimize twisting and turning while lifting. If it is necessary to move these cylinders or generators over significant distance, use mechanical means (carts, etc.).
- Use proper lifting techniques as described in Section 4.4 of the HSGM.

6.5 Onsite Water Quality Testing

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific conductance
- Temperature
- DO
- ORP
- Turbidity

- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous waste site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, or colloidal material or other suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Because instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters used to measure field parameters require calibration on a daily basis. Refer to SOP SA-6.3 for an example equipment calibration log.

6.5.1 Measurement of pH

6.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken and recorded on the groundwater sample log sheet (Attachment B) or equivalent electronic form.

Two methods are given for pH measurement: the pH meter and pH indicator paper. Indicator paper is used when only an approximation of the pH is required or when pH meter readings need to be verified, and the pH meter is used when a more accurate measurement is needed. The response of a pH meter can be affected by high levels of colloidal or suspended solids, but the effect is generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, or colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

6.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific, or narrower range, pH range paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion activity (which is usually similar to concentration) across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

6.5.1.3 Equipment

The following equipment is to be used for obtaining pH measurements:

- A stand-alone portable pH meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Combination electrode with polymer body to fit the above meter. Alternately, a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- Buffer solutions, as specified by the manufacturer. If the buffer solutions are considered hazardous per 29 Code of Federal Regulations (CFR) 1910.1200 (Hazard Communication) or the volumes used are greater than consumer commodity levels, the SSO shall obtain MSDSs from the manufacturer for the specific buffer solutions (see Section 4 of the HSGM regarding the Hazard Communication Program)
- pH indicator paper to cover the pH range 2 through 12.
- Manufacturer's operation manual. All personnel must be familiar with the equipment operation to ensure that the integrity of samples is preserved and that the equipment is operated safely.

6.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure shall be used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

1. Inspect the instrument and batteries prior to initiation of the field effort.
2. Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.
3. If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
4. Calibrate the meter and electrode(s) on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on a water quality meter calibration log sheet (Attachment C) or equivalent electronic form.
5. Immerse the electrode(s) in the sample. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. The failure of the measurements to stabilize must be clearly noted in the logbook or equivalent electronic form.
6. Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH standard unit. Also record the sample temperature (unless otherwise specified in the SAP, record temperatures to the nearest whole degree Fahrenheit or 0.5 degree Celsius).
7. Rinse the electrode(s) with deionized water.
8. Store the electrode(s) in an accordance with manufacturer’s instructions when not in use.

Any visual observation of conditions that may interfere with pH measurement, such as oily materials or turbidity, shall be noted and avoided as much as possible.

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is determined. To measure the pH with pH paper:

1. Collect a small portion of sample into a clean container.

2. Dip the pH paper into this small portion of sample.

3. Compare the color of the paper to the color chart that is provided with the pH paper and read the corresponding pH from the chart.

4. Record the pH value from the chart on the sampling log sheet.

5. Discard the used pH paper as trash.

6. Discard the small volume of sample that was used for the pH measurement with the other investigative derived waste.

6.5.2 Measurement of Specific Conductance

6.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination. Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample because temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect specific conductance. Most conductivity meters in use today display specific conductance in units of mS/cm, which is the conductivity normalized to a temperature of 25°C. These are the required units to be recorded on the groundwater sample log field form or equivalent electronic form.

6.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, and the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases, and salts such as hydrochloric acid, sodium carbonate, and sodium chloride, respectively, are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also

be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on the ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell, which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

6.5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- Stand-alone portable conductivity meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available that may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirements of the sampling program.

6.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are as follows (calibration shall be conducted according to manufacturer's instructions):

1. Check batteries and calibrate instrument before going into the field.
2. Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used for calibration.
3. Rinse the cell with one or more portions of the sample to be tested or with deionized water and shake excess water from the cell.
4. Immerse the electrode in the sample and measure the conductivity.
5. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.
6. Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for troubleshooting assistance.

6.5.3 Measurement of Temperature

6.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in situ, or as quickly as possible in the field because collected water samples may rapidly equilibrate with the temperature of their surroundings.

6.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury-filled, dial-type thermometers or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22). In addition, various meters such as specific conductance or DO meters that have temperature measurement capabilities may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

6.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample, use the following procedure:

1. Immerse the thermometer in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples that will undergo subsequent chemical analysis.

2. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

If a temperature meter or probe is used:

1. Calibrate the instrument according to manufacturer's recommendations prior to use.

2. Immerse the meter/probe in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the meter/probe shall not be inserted into samples that will undergo subsequent chemical analysis.
3. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

6.5.4 Measurement of Dissolved Oxygen

6.5.4.1 General

DO levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. In addition, the growth of many aquatic organisms and the rate of corrosivity are dependent on DO concentrations. Thus, analysis for DO is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in situ because concentrations may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of DO meters. Chemical methods of analysis (i.e., Winkler methods) are available but require more equipment and greater sample manipulation. Furthermore, DO meters using a membrane electrode are suitable for highly polluted waters because the probe is completely submersible and is not susceptible to interference caused by color, turbidity, or colloidal material or suspended matter.

6.5.4.2 Principles of Equipment Operation

DO probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH^-) occurs at the cathode surface. An electrical

current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode. This rate is proportional to the oxygen concentration in the water being measured.

Because the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, leaving the surface of the solution undisturbed.

DO probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases such as chlorine or with gases such as hydrogen sulfide that are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field logbook and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer. This compensation can counteract some of the temperature effects but not all of them.

6.5.4.3 Equipment

The following equipment is needed to measure DO concentrations:

- A stand-alone portable DO meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

6.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

DO probes differ as to instructions for use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure DO concentrations:

1. Check the DO meter batteries before going to the field.
2. Condition the probe in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
3. Calibrate the instrument in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature.
4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.
5. Rinse the probe with deionized water.
6. Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells may be moved up and down to achieve the required mixing.

7. Record the DO content and temperature of the sample in a field logbook or on a sample log sheet or equivalent electronic form.

8. Rinse the probe with deionized water.

9. Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable because sample handling is not involved. This however may not always be practical.

Special care shall be taken during sample collection to avoid turbulence that can lead to increased oxygen solubilization and positive test interferences.

6.5.5 Measurement of Oxidation-Reduction Potential

6.5.5.1 General

ORP provides a measure of the tendency of organic or inorganic chemicals to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of reduced to oxidized species in the sample.

6.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as DO, may be correlated with ORP to provide knowledge of the quality of the solution, water, or wastewater.

6.5.5.3 Equipment

The following equipment is needed for measuring the ORP of a solution:

- A combination meter with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring ORP:

1. Check the equipment using the manufacturer's recommended reference solution and check its batteries before going to the field.

2. Thoroughly rinse the electrode with deionized water.

3. If the probe does not respond properly to the recommended reference solution, verify the sensitivity of the electrodes by noting the change in millivolts when the pH of a test solution is altered. The ORP will increase when the pH of a test solution decreases, and the ORP will decrease when the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note that the ORP drops sharply when the caustic is added (i.e., pH increases) thus indicating that the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions or the probe should be replaced.

4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.

6.5.6 Measurement of Salinity

6.5.6.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Most field meters determine salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent).

6.5.6.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (such as are found in Standard Methods for the Examination of Water and Wastewater). Depending on the meter, the results are displayed in either ppt or percent. The salinity measurements are carried out in reference to the conductivity of standard seawater (corrected to salinity = 35 ppt).

6.5.6.3 Equipment

The following equipment is needed for salinity measurements:

- A multi-parameter water quality meter capable of measuring conductivity and temperature and converting them to salinity (e.g., Horiba U-22 or YSI 600 series).

- Calibration solution as specified by the manufacturer.

- Manufacturer's operation manual.

6.5.6.4 Measurement Techniques for Salinity

The steps involved in taking salinity measurements are as follows (standardization shall be conducted according to manufacturer's instructions):

1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.

2. Check batteries and calibrate the meter before going into the field.

3. Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.

4. Rinse the cell with the sample to be tested. This is typically accomplished as the probe is placed in line during the collection of the purge water up to the time of sample acquisition.

5. Immerse the multi-probe in the sample and measure the salinity. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.

6. Rinse the probes with deionized water.

6.5.7 Measurement of Turbidity

6.5.7.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter such as clay, silt, or other finely divided organic and inorganic matter and microscopic organisms including plankton.

It is important to obtain a turbidity reading immediately after taking a sample because irreversible changes in turbidity may occur if the sample is stored too long.

6.5.7.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method, which is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, nephelometric turbidity units (NTUs) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

6.5.7.3 Equipment

The following equipment is needed for turbidity measurements:

- A turbidity meter (e.g., LaMotte 2020) that calibrates easily using test cells with standards of 0.0, 1.0, and 10 NTUs, or a combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).

- Calibration solution and sample tubes, as specified by the manufacturer.

- Manufacturer's operation manual.

6.5.7.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements utilizing an electrode (e) or light meter (l) are listed below (standardization shall be done according to manufacturer's instructions):

1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.

2. Check batteries and calibrate the instrument before going into the field.

3. Calibrate on a daily basis according to the manufacturer's instructions, and record all pertinent information on a turbidity meter calibration log sheet (Attachment C) or equivalent electronic form.

4. When using the YSI and/or Horiba U-22, rinse the electrode with one or more portions of the sample to be tested or with deionized water.

5. When using the Lamotte 2020, fill the light meter's glass test cell with approximately 5 mL of sample, screw on the cap, wipe off glass to remove all residue that could intercept the instrument's light beam, place the test cell in the light meter, and close the lid.

6. Immerse the electrode in the sample and measure the turbidity.

7. The reading must be taken immediately because suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.

8. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.

9. Rinse the electrode or test cell with deionized water.

6.6 Sampling

6.6.1 Sampling Plan

The sampling approach consisting of the following shall be developed as part of the project planning documents approved prior to beginning work in the field:

- Background and objectives of sampling.

- Brief description of area and waste characterization.

- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

- Intended number, sequence, volumes, and types of samples. If the relative degree of contamination between wells is insignificant, a sampling sequence that facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells. In situations where

the well is not well-characterized and the nature or extent of airborne contamination is unknown, it is recommended that head space analysis using a photoionization detector (PID) or flame ionization detector (FID) is performed to rate the wells, sampling from least contaminated to most contaminated. Refer to the project-specific HASP for appropriate information and direction on air monitoring requirements.

- Sample preservation requirements.

- Work schedule.

- List of team members.
- List of observers and contacts.

- Other information, such as the necessity for a warrant or permission of entry, requirements for split samples, access problems, location of keys, etc.

- The FOL shall ensure that the sampling method(s) to be employed is accurately represented in the HASP, indicating the types of sampling to be employed and the hazards. If the methods are not accurately represented, the FOL should rectify this with the HASP author.

- The FOL shall ensure that sampling teams understand the sampling approach that they are to follow. Where sampling teams are made up of personnel from multiple locations, personal sampling experiences may vary. Therefore the FOL shall review project-specific requirements, SOPs, and protocol to be followed. The FOL will conduct periodic surveys to ensure that these methods are being completed per his/her direction.

6.6.2 Sampling Methods as Related to Low-Flow Sampling

The collection of a groundwater sample consists of the following steps:

1. Ensure the safety of the sample location. Take a few minutes to evaluate the area for physical hazards (trip hazards, uneven ground, overhanging branches, etc.) and natural hazards (snakes, bees, spiders, etc.) that may exist in the area or that may have constructed nests in the well head. Snakes often like to sun themselves on concrete well pads. Follow provisions in the project-specific HASP and/or HSGM for addressing natural hazards.

2. As indicated earlier, some monitoring wells have the potential to contain pressurized headspace (e.g., through the generation of gases form contaminated groundwater, due to biological processes, degradation of contaminants, or simply based on location such as near a landfill or in areas that intersect lithological abnormalities) or through intentional artificial means such as those associated with air sparging systems. Injection or extraction wells may be artificially pressurized and may remain so for several days after the system has been turned off. This presents a hazard to people opening these wells. The Field Sampling Technician shall employ the following practices to minimize these hazards:

    - Wear safety glasses to protect the eyes. If site-specific observations and conditions indicate that the wells may be pressurized, wear a full-face shield over the safety impact eye protection.

    - DO NOT place your face or any other part of your body over the well when opening because this may place you in a strike zone.

    - Open the well cover at arms length, then step away and allow the well to off gas and stabilize.

Follow directions provided in the project-specific HASP, Work Plan and/or Sampling Plan pertaining to the use of volatile chemical detection equipment (PID or FID) within the breathing zone of the sampler during sampling to determine the need to retreat from the work area and/or for the use of respiratory protection (as specified in the HASP).

3. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet or equivalent electronic form; then calculate the fluid volume in the well pipe (as previously described in this SOP). It is imperative that downhole equipment be adequately decontaminated between wells to prevent cross-contamination. Just as sampling occurs from the least contaminated to the most contaminated, it is also recommended that groundwater level measurements be taken in this manner.

4. Calculate volume of well water to be removed as described in Section 6.3.

5. Select the appropriate purging equipment (see Attachment A to this SOP) or as designated within your Work Plan/Sampling Plan. If an electric submersible pump with packer is chosen, go to Step 10.

6. Lower the purging equipment or intake into the well to a short distance below the water level or mid-screen as indicated in project-specific documentation and begin water removal. Remember that some contaminants are "bottom dwellers," and in these cases, project-specific direction may specify placing the intake just above (1 to 2 feet) the well bottom. Secure the pump intake at the well and secure the effluent at the collection container and begin pumping. The pumping rate will be determined based on the decrease in the water level (see Section 6.7) or as directed in your project-specific documents or this SOP. Purge water is generally collected in a 5-gallon bucket or similar open- or closed-top container. To minimize the potential for spills and back injuries, do not fill 5-gallon buckets beyond approximately 80 percent of their capacity. Dispose of purge water was as indicated in the planning document(s). Where necessary, slow the pumping rate or lower the pump intake as required to maintain submergence.

7. Estimate the approximate rate of discharge frequently and record it on the Low Flow Purge Data Sheet (see Attachment D). Estimate flow rate by noting the amount of discharge in a bucket or graduated cylinder per unit time using a watch with a second hand or a stopwatch.

8. Observe the peristaltic pump tubing intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.

9. Purge a minimum of three to five casing volumes before sampling (or as directed by the site-specific SAP). In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Allow the well to recover to 75 percent of initial water level before sampling. Do not overfill purge containers because this increases the potential for spills and lifting injuries.

10. ~~If sampling using a submersible pump, lower the pump intake to mid-screen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.~~

11. ~~For pump and packer assemblies only: Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.~~

12. If the recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of

producing a sufficient volume of sample at any time, take the largest quantity available and record this occurrence in the site logbook or equivalent electronic form. When this occurs, contact the analytical laboratory to alert them that a reduced sample volume(s) will be submitted for analysis.

13. Fill sample containers and preserve and label them as described in SOP SA-6.1. Many sample bottles will contain preservative when they are shipped to the field. In those cases, do not add preservative.

14. Replace the well cap and lock it as appropriate. Make sure the well is readily identifiable as the source of the sample.

15. Process sample containers as described in SOP SA-6.1.

16. Decontaminate equipment as described in SOP SA-7.1.

6.7 Low-Flow Purging and Sampling

6.7.1 Scope and Application

Low-flow purging and sampling techniques may be required for groundwater sampling activities. The purpose of low-flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. This minimum-stress procedure emphasizes negligible water level drawdown and low pumping rates to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen length, or open interval, of 10 feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semivolatile organic compounds, pesticides, polychlorinated biphenyls [PCBs], metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This low-flow procedure is not designed for collection of non-aqueous phase liquid samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs).

This procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTUs and to achieve a water level drawdown of less than 0.3 foot during purging and sampling. If these goals cannot be achieved, sample collection can take place provided that the remaining criteria in this procedure are met.

6.7.2 Equipment

The following equipment is required (as applicable) for low-flow purging and sampling:

- Adjustable rate submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).

- Disposable clear plastic bottom-filling bailers to be used to check for and obtain samples of LNAPLs or DNAPLs.

- Tubing – Teflon, Teflon-lined polyethylene, polyethylene, polyvinyl chloride (PVC), Tygon, or stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.

- Water level measuring device with 0.01-foot accuracy (electronic devices are preferred for tracking water level drawdown during all pumping operations).

- Interface probe.
- Flow measurement supplies.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments – pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional indicators - ORP, salinity, and DO. A flow-through cell (also referred to as an in-line sample chamber) is required.
- Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s) and other forms (see Attachments B through D) or equivalent electronic form(s).
- Sample bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event (if available).
- Field Sampling Plan.
- PID or FID instrument for measuring volatile organic compounds (VOCs) per the HASP.

6.7.3 Purging and Sampling Procedure

1. Open the monitoring well as stated earlier and step away. Prepare sampling equipment while allowing 3 to 5 minutes to allow the water level to reach equilibrium. In situations where VOCs are the primary contaminants of concern, air monitoring of the samplers' breathing zone areas may be required by the HASP (typically with a PID or FID).

2 Measure the water level immediately prior to placing the pump in the well and record the water level on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well.

3. Lower the measuring device further into the well to collect the total depth measurement. Again wait 3 to 5 minutes to allow the well to equilibrate to the initial water level prior to placing the pump or pump intake in the well.

4. Record the total well depth on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well

5. Lower the pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible, keep the pump intake at least 2 feet above the bottom of the well to minimize mobilization of sediment that may be present in the bottom of the well.

Collection of turbidity-free water samples may be difficult if there is 3 feet or less of standing water in the well.

6. Start with the initial pump rate set at approximately 0.1 liter per minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust the pumping rates as necessary to prevent drawdown from exceeding 0.3 foot during purging. If no drawdown is noted, the pump rate may be increased (to a maximum of 0.4 liter per minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below the top of the well screen, purging shall cease or the well shall be pumped to dryness and then allowed to recover before purging continues. Well recovery to 75 percent is necessary prior to sampling. Slow-recovering wells should be identified and purged at the beginning of the workday to maximize field work efficiency. If possible, samples should be collected from these wells within the same workday and no later than 24 hours after the end of purging.

7. Measure the water level in the well every 5 to 10 minutes using the water level meter. Record the well water level on the Low Flow Purge Data Form (Attachment D) or equivalent electronic form.
8. Record on the Low Flow Purge Data Form every 5 to 10 minutes the water quality parameters (pH, specific conductance, temperature, turbidity, ORP, DO, and salinity or as specified by the approved site-specific planning document) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form or equivalent electronic form.

9. Estimate the flow rate by noting the amount of discharge in a graduated cylinder per unit time using a watch with a second hand. Remeasure the flow rate any time the pump rate is adjusted and periodically during purging. This will determine if a reduction in rate has occurred due to possible battery depletion.

10. During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections and tighten, repair, or replace them as necessary to achieve a tight connection.

11. Wait until stabilization is achieved, or a minimum of two saturated screen volumes have been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits, then begin sampling:

    - pH ±0.2 standard units
    - Specific conductance ±10%
    - Temperature ±10%
    - Turbidity less than 10 NTUs
    - DO ±10%

12. If the above conditions have not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data Form onto the Groundwater Sample Log Form or equivalent electronic form.

NOTE: VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

13. If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples:

    - Collect samples for non-VOC analyses first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample for VOCs, and record the new flow rate.

    - Reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel) or clamp, which should reduce the flow rate by constricting the end of the tubing. Proceed with sample collection.

    - Insert a narrow-diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, then collect the sample from the narrow diameter tubing.

    - Prepare samples for shipping as per SOP SA-6.1.

7.0 REFERENCES

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ATTACHMENT A

PURGING EQUIPMENT SELECTION

Diameter Casing		~~Bailer~~	Peristaltic Pump	~~Vacuum Pump~~	~~Air lift~~	~~Diaphragm "Trash" Pump~~	~~Submersible Diaphragm Pump~~	~~Submersible Electric Pump~~	~~Submersible Electric Pump w/Packer~~
~~1.25 Inch~~	~~Water level <25 feet~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			
	~~Water Level >25 feet~~	~~X~~			~~X~~				
2-Inch	Water level <25 feet	~~X~~	X	~~X~~	~~X~~	~~X~~	~~X~~		
	~~Water Level >25 feet~~	~~X~~			~~X~~		~~X~~		
~~4 Inch~~	~~Water level <25 feet~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~
	~~Water Level >25 feet~~	~~X~~			~~X~~		~~X~~	~~X~~	~~X~~
~~6 Inch~~	~~Water level <25 feet~~				~~X~~	~~X~~		~~X~~	~~X~~
	~~Water Level >25 feet~~				~~X~~			~~X~~	~~X~~
~~8 Inch~~	~~Water level <25 feet~~				~~X~~	~~X~~		~~X~~	~~X~~
	~~Water Level >25 feet~~				~~X~~			~~X~~	~~X~~

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 2

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	$300-400	Requires compressed gas; piezometric level indicator; other materials available.

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 3

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl chloride
SS	Stainless steel
PC	Polycarbonate
EPDM	Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

NA	Not applicable
AC	Alternating current
DC	Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

ATTACHMENT B
GROUNDWATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[ ] Domestic Well Data
[x] Monitoring Well Data
[ ] Other Well Type: _____
[ ] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____
Type of Sample:
[X] Low Concentration
[ ] High Concentration

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	ORP	Other
Time:	Visual	Standard	mS/cm	Degrees C	NTU	mg/l	mV	NA
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	ORP	Other
Method:								
Monitor Reading (ppm):			SEE LOW FLOW PURGE DATA SHEET					
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle if Applicable:		Signature(s):
MS/MSD	Duplicate ID No.:	

ATTACHMENT C
EQUIPMENT CALIBRATION LOG

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

ATTACHMENT D
LOW FLOW PURGE DATA SHEET

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: _____ WELL ID.: _____
PROJECT NUMBER: _____ DATE: _____

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments

SIGNATURE(S): _____ PAGE___OF___

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information on Direct Push Technology (DPT). DPT is designed to collect soil, groundwater, and soil gas samples without using conventional drilling techniques. The advantage of using DPT over conventional drilling includes the generation of little or no drill cuttings, sampling in locations with difficult accessibility, reduced overhead clearance requirements, no fluid introduction during probing, and typical lower costs per sample than with conventional techniques. Disadvantages include a maximum penetration depth of approximately 15 to 40 feet in dense soils (although it may be as much as 60 to 80 feet in certain types of geological environments), reduced capability of obtaining accurate water-level measurements, and the inability to install permanent groundwater monitoring wells. The methods and equipment described herein are for collection of surface and subsurface soil samples and groundwater samples. Soil gas sampling is discussed in SOP SA-2.4.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for DPT. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

Direct Push Technology (DPT) - DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. A primary advantage of DPT over conventional drilling techniques is that DPT results in the generation of little or no investigation derived waste.

Geoprobe® - Geoprobe® is a manufacturer of a hydraulically-powered, percussion/probing machines utilizing DPT to collect subsurface environmental samples. Geoprobe® relies on a relatively small amount of static weight (vehicle) combined with percussion as the energy for advancement of a tool string. The Geoprobe® equipment can be mounted in a multitude of vehicles for access to all types of environmental sites.

HydroPunch™ - HydroPunch™ is a manufacturer of stainless steel and Teflon® sampling tools that are capable of collecting representative groundwater and/or soil samples without requiring the installation of a groundwater monitoring well or conventional soil boring. HydroPunch™ is an example of DPT sampling equipment.

Flame Ionization Detector (FID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing a flame as the energizing source.

Photo Ionization Detector (PID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing ultraviolet radiation as the energizing source.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for selecting and/or reviewing the appropriate DPT drilling procedure required to support the project objectives.

Field Operations Leader (FOL)- The FOL is primarily responsible for performing the DPT in accordance with the project-specific plan.

5.0 SOIL SAMPLING PROCEDURES

5.1 General

The common methodology for the investigation of the vadose zone is soil boring drilling and soil sampling. However, drilling soil borings can be very expensive. Generally the advantage of DPT for subsurface soil sampling is the reduced cost of disposal of drilling cuttings and shorter sampling times.

5.2 Sampling Equipment

Equipment needed for conducting DPT drilling for subsurface soil sampling includes, but is not limited to, the following:

- Geoprobe® Sampling Kit
- Cut-resistant gloves
- 4-foot x 1.5-inch diameter macrocore sampler
- Probe sampling adapters
- Roto-hammer with 1.5-inch bit
- Disposable acetate liners for soil macrocore sampler
- Cast aluminum or steel drive points
- Geoprobe® AT-660 Series Large Bore Soil Sampler, or equivalent
- Standard decontamination equipment and solutions

For health and safety equipment and procedures, follow the direction provided in the Safe Work Permit in Attachment 1, or the more detailed directions provided in the project's Health and Safety Plan.

5.3 DPT Sampling Methodology

There are several methods for the collection of soil samples using DPT drilling. The most common method is discussed in the following section. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project-specific plan.

- Macrocore samplers fitted with detachable aluminum or steel drive points are driven into the ground using hydraulic pressure. If there is concrete or pavement over a sampling location, a Roto-hammer is used to drill a minimum 1.5-inch diameter hole through the surface material. A Roto-hammer may also be used if very dense soils are encountered.

- The sampler is advanced continuously in 4-foot intervals or less if desired. No soil cuttings are generated because the soil which is not collected in the sampler is displaced within the formation.

- The sampler is retracted from the hole, and the 4-foot continuous sample is removed from the outer coring tube. The sample is contained within an inner acetate liner.

- Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tail gate of a vehicle. If a vehicle with a tail gate is not available, secure the trough on another suitable surface.

- Place the acetate liner containing the soils in the trough.

- While wearing cut-resistant gloves (constructed of leather or other suitable material), cut the acetate liner through its entire length using the double-bladed knife that accompanies the Geoprobe® Sampling Kit. Then remove the strip of acetate from the trough to gain access to the collected soils. Do not attempt to cut the acetate liner while holding it in your hand.

- Field screen the sample with an FID or PID, and observe/examine the sample (according to SOP GH-1.3). If appropriate, transfer the sample to sample bottles for laboratory analysis. If additional volume is required, push an additional boring adjacent to the first and composite/mix the same interval. Field compositing is usually not acceptable for sample requiring volatile organics analysis.

- Once sampling has been completed, the hole is backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch is used to cap holes through paved or concrete areas. All holes should be finished smooth to existing grade.

- In the event the direct push van/truck cannot be driven to a remote location or a sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric operated equipment (e.g., jack hammer).

- Sampling equipment is decontaminated prior to collecting the next sample.

~~6.0 GROUNDWATER SAMPLING PROCEDURES~~

~~6.1 General~~

~~The most common methodology for the investigation of groundwater is the installation and sampling of permanent monitoring wells. If only groundwater screening is required, the installation and sampling of temporary well points may be performed. The advantage of temporary well point installation using DPT is reduced cost due to no or minimal disposal of drilling cuttings and well construction materials, and shorter installation/times sampling.~~

~~Two disadvantages of DPT drilling for well point installation are:~~

- ~~In aquifers with low yields, well points may have to be sampled without purging or development.~~
- ~~If volume requirements are high, this method can be time consuming for low yield aquifers.~~

~~6.2 Sampling Equipment~~

~~Equipment needed for temporary well installation and sampling using DPT includes, but is not limited, to the following:~~

- ~~2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point~~
- ~~Connecting rods~~
- ~~Roto-hammer with 1.5-inch bit~~
- ~~Mechanical jack~~
- ~~1/4-inch OD polyethylene tubing~~
- ~~3/8-inch OD polyethylene tubing~~
- ~~Peristaltic pump~~
- ~~Standard decontamination equipment and solutions~~

~~6.3 DPT Temporary Well Point Installation and Sampling Methodology~~

~~There are several methods for the installation and sampling of temporary well points using DPT. The most common methodology is discussed below. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project specific plan.~~

- ~~A 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point attached to connecting rods is driven into the ground to the desired depth using a rotary electric hammer or other direct push drill rig. If there is concrete or pavement over a sampling location, a Roto-hammer or electric coring machine is used to drill a hole through the surface material.~~

- ~~The well point will be allowed to equilibrate for at least 15 minutes, after which a measurement of the static water level will be taken. The initial measurement of the water level will be used to assess the amount of water which is present in the well point and to determine the amount of silt and sand infiltration that may have occurred.~~

- ~~The well point will be developed using a peristaltic pump and polyethylene tubing to remove silt and sand which may have entered the well point. The well point is developed by inserting polyethylene tubing to the bottom of the well point and lifting and lowering the tubing slightly while the pump is operating. The pump will be operated at a maximum rate of approximately 2 liters per minute. After removal of sediment from the bottom of the well point, the well point will be vigorously pumped at maximum capacity until discharge water is visibly clear and no further sediments are being generated. Measurements of pH, specific conductance, temperature, and turbidity shall be recorded every 5 to 10 minutes during the purging process. After two consistent readings of pH, specific conductance, temperature and turbidity (±10 percent), the well may be sampled.~~

- ~~A sample will be collected using the peristaltic pump set at the same or reduced speed as during well development. Samples (with the exception of the samples to be analyzed for volatile organic compounds, VOCs) will be collected directly from the pump discharge. Sample containers for VOCs will be filled by (first shutting off the pump) crimping the discharge end of the sample tubing when filled, removing the inlet end of the sample tubing from the well, suspending the inlet tubing above the vial, and allowing water to fill each vial by gravity flow.~~

- ~~Once the groundwater sample has been collected, the connecting rods and well point will be removed from the hole with the direct push rig hydraulics. The hole will be backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch will be used to cap holes through paved or concrete areas. All holes will be finished smooth to existing grade.~~

- ~~In the event the direct push van/truck cannot be driven to a remote location or sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric operated equipment (e.g., jack hammer).~~

- ~~Decontaminate the equipment before moving to the next location.~~

7.0 RECORDS

A record of all field procedures, tests, and observations must be recorded in the field logbook, boring logs, and sample log sheets, as needed. Entries should include all pertinent data regarding the investigation. The use of sketches and field landmarks will help to supplement the investigation and evaluation.

ATTACHMENT 1
SAFE WORK PERMIT FOR DPT OPERATIONS

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): **Monitoring well drilling and installation through direct push technology**

II. Required Monitoring Instruments: _____

III. Field Crew: _____

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____ _____
TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

V. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐
Detailed on Reverse

Respiratory equipment required
Full face APR ☐ Escape Pack ☐
Half face APR ☐ SCBA ☐
SKA-PAC SAR ☐ Bottle Trailer ☐
Skid Rig ☐ None ☒

Level D Minimum Requirements: Sleeved shirt and long pants, safety footwear, and work gloves. Safety glasses, hard hats, and hearing protection will be worn when working near or sampling in the vicinity of the DPT rig.

Modifications/Exceptions.

VI. Chemicals of Concern _____ Action Level(s) _____ Response Measures _____

VII. Additional Safety Equipment/Procedures

Hard-hat	☒ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☒ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio	☐ Yes	☒ No
Splash Shield	☐ Yes	☒ No	Barricades	☒ Yes	☐ No
Splash suits/coveralls	☐ Yes	☐ No	Gloves (Type - _____)	☐ Yes	☐ No
Steel toe Work shoes or boots	☒ Yes	☐ No	Work/warming regimen	☐ Yes	☐ No

Modifications/Exceptions: Reflective vests for high traffic areas.

VIII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☐	☒	Emergency alarms	☐	☐
Daily tail gate meetings	☒	☐	Evacuation routes	☐	☐
Contractor tools/equipment/PPE inspected	☐	☐	Assembly points	☐	☐

IX. Site Preparation

Utility Clearances obtained for areas of subsurface investigation	☐ Yes	☐ No
Physical hazards removed or blockaded	☐ Yes	☐ No
Site control boundaries demarcated/signage	☐ Yes	☐ No

X. Equipment Preparation

	Yes	NA
Equipment drained/depressurized	☐	☒
Equipment purged/cleaned	☐	☒
Isolation checklist completed	☐	☒
Electrical lockout required/field switch tested	☐	☒
Blinds/misalignments/blocks & bleeds in place	☐	☒
Hazardous materials on walls/behind liners considered	☐	☒

XI. Additional Permits required (Hot work, confined space entry). ☐ Yes ☐ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

XII. Special instructions, precautions:
_____
_____

Permit Issued by: _____ Permit Accepted by: _____

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information on sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in SOP SA-6.3. Sample identification is addressed in SOP CT-04.

2.0 SCOPE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped off site for chemical analysis.

3.0 GLOSSARY

Hazardous Material - A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. Under 49 CFR, the term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials, as well as materials designated as hazardous under the provisions of §172.101 and §172.102 and materials that meet the defining criteria for hazard classes and divisions in Part 173. With slight modifications, IATA has adopted DOT "hazardous materials" as IATA "Dangerous Goods."

Hazardous Waste - Any substance listed in 40 CFR, Subpart D (y261.30 et seq.), or otherwise characterized as ignitable, corrosive, reactive, or toxic (as defined by Toxicity Characteristic Leaching Procedure, TCLP, analysis) as specified under 40 CFR, Subpart C (y261.20 et seq.), that would be subject to manifest requirements specified in 40 CFR 262. Such substances are defined and regulated by EPA.

Marking - A descriptive name, identification number, instructions, cautions, weight, specification or UN marks, or combination thereof required on outer packaging of hazardous materials.

n.o.i - Not otherwise indicated (may be used interchangeably with n.o.s.).

n.o.s. - Not otherwise specified.

Packaging - A receptacle and any other components or materials necessary for compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank-car tanks to perform a containment function in conformance with the minimum packaging requirements of 49 CFR 173.24(a) & (b).

Placard - Color-coded, pictorial sign which depicts the hazard class symbol and name and which is placed on the side of a vehicle transporting certain hazardous materials.

Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - H_2SO_4
- Nitric Acid - HNO_3
- Sodium Hydroxide - NaOH

Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - $Na_2S_2O_3$

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing 1 gram-atom of replaceable hydrogen or its equivalent.

Reportable Quantity (RQ) - For the purposes of this SOP, means the quantity specified in column 3 of the Appendix to DOT 49 CFR §172.101 for any material identified in column 1 of the appendix. A spill greater than the amount specified must be reported to the National Response Center.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the location and time of collection.

4.0 RESPONSIBILITIES

Field Operations Leader - Directly responsible for the bottling, preservation, labeling, packaging, shipping, and custody of samples up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record (per SOP SA-6.3), implementing the packaging and shipping requirements, and maintaining custody of samples until they are relinquished to another custodian or to the shipper.

5.0 PROCEDURES

Sample identification, labeling, documentation, and chain-of-custody are addressed by SOP SA-6.3.

5.1 Sample Containers

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, whereas many organic chemicals may dissolve various types of plastic containers. Attachments A and B show proper containers (as well as other information) per 40 CFR 136. In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds, head space shall be omitted. The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. Shelby tubes or other sample containers are generally provided by the driller for samples requiring geotechnical analysis. Sufficient lead time shall be allowed for a delivery of sample container orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

5.2 Sample Preservation

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological

changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/ freezing (certain biological samples only).

5.2.1 Overview

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or be added in the field (in a clean environment). Only high purity reagents shall be used for preservation. In general, aqueous samples of low-concentration organics (or soil samples of low- or medium-concentration organics) are cooled to 4°C. Medium-concentration aqueous samples, high-hazard organic samples, and some gas samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO_3, whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to 4°C, whereas high-hazard samples are not cooled.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

The FOL is responsible for ensuring that an accurate Chemical Inventory is created and maintained for all hazardous chemicals brought to the work site (see Section 5 of the TtNUS Health and Safety Guidance Manual). Furthermore, the FOL must ensure that a corresponding Material Safety Data Sheet (MSDS) is collected for every substance entered on the site Chemical Inventory, and that all persons using/handling/ disposing of these substances review the appropriate MSDS for substances they will work with. The Chemical Inventory and the MSDSs must be maintained at each work site in a location and manner where they are readily-accessible to all personnel.

5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

Acid/Base	Dilution	Concentration	Estimated Amount Required for Preservation
Hydrochloric Acid (HCl)	1 part concentrated HCl: 1 part double-distilled, deionized water	6N	5-10 mL
Sulfuric Acid (H_2SO_4)	1 part concentrated H_2SO_4: 1 part double-distilled, deionized water	18N	2 - 5 mL
Nitric Acid (HNO_3)	Undiluted concentrated HNO_3	16N	2 - 5 mL
Sodium Hydroxide (NaOH)	400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution	10N	2 mL

The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample. This assumes that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions vary, more preservative may be required. Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

- Pour off 5-10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.

- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).

- Cap sample bottle and seal securely.

Additional considerations are discussed below:

- To test if ascorbic acid must be used to remove oxidizing agents present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

  If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

  Continue with proper base preservation of the sample as described above.

- Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 ml of sample.

  The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

  The sample pH is then raised to 9 using the NaOH preservative.

- Sodium thiosulfate must be added to remove residual chlorine from a sample. To test the sample for residual chlorine use a field test kit specially made for this purpose.

  If residual chlorine is present, add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.

  Continue with proper acidification of the sample as described above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory before sampling begins.

5.3 Field Filtration

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed prior to the preservation of samples as described above. General procedures for field filtration are described below:

- The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after collection. The filtration system shall consist of dedicated filter canister, dedicated tubing, and a peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).

- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 ml of sample through the filter and discard prior to sample collection.

- Continue by preserving the filtrate (contained in the filter canister), as applicable and generally described above.

5.4 Sample Packaging and Shipping

Only employees who have successfully completed the TtNUS "Shipping Hazardous Materials" training course are authorized to package and ship hazardous substances. These trained individuals are responsible for performing shipping duties in accordance with this training.

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly.)

- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental samples are outlined in the remainder of this section.

5.4.1 Environmental Samples

Environmental samples are packaged as follows:

- Place properly identified sample container, with lid securely fastened, in a plastic bag (e.g. Ziploc baggie), and seal the bag.

- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic bag (e.g. "garbage" bag). Drain plugs on coolers must be taped shut.

- Pack with enough cushioning materials such as bubble wrap (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking.

- If cooling is required (see Attachments A and B), place ice around sample container shoulders, and on top of packing material (minimum of 8 pounds of ice for a medium-size cooler).

- Seal (i.e., tape or tie top in knot) large liner bag.

- The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing the vials for VOC analysis. The COC form should then state how many coolers are included with that shipment.

- Close and seal outside of cooler as described in SOP SA-6.3. Signed custody seals must be used.

Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. APHA, Washington, D.C.

International Air Transport Association (latest issue). Dangerous Goods Regulations, Montreal, Quebec, Canada.

U.S. Department of Transportation (latest issue). Hazardous Materials Regulations, 49 CFR 171-177.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, U.S. EPA-EMSL, Cincinnati, Ohio.

ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration		Container[1]	Sample Size	Preservation[2]	Holding Time[2]
WATER					
Organics (GC&GC/MS)	VOC Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days[9]
	Extractables (Low SVOCs and pesticide/PCBs)	Amber glass	2x2 L or 4x1 L	Cool to 4°C	7 days to extraction; 40 days after extraction
	Extractables (Medium SVOCs and pesticide/PCBs)	Amber glass	2x2 L or 4x1 L	None	7 days to extraction; 40 days after extraction
Inorganics	Metals Low	High-density polyethylene	1 L	HNO_3 to pH ≤2	6 months (Hg-28 days)
	Medium	Wide-mouth glass	16 oz.	None	6 months
	Cyanide Low	High-density polyethylene	1 L	NaOH to pH>12	14 days
	Cyanide Medium	Wide-mouth glass	16 oz.	None	14 days
Organic/ Inorganic	High Hazard	Wide-mouth glass	8 oz.	None	14 days
SOIL					
Organics (GC&GC/MS)	VOC	EnCore Sampler	(3) 5 g Samplers	Cool to 4°C	48 hours to lab preservation
	Extractables (Low SVOCs and pesticides/PCBs)	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
	Extractables (Medium SVOCs and pesticides/PCBs)	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
Inorganics	Low/Medium	Wide-mouth glass	8 oz.	Cool to 4°C	6 months (Hg - 28 days) Cyanide (14 days)
Organic/Inorganic	High Hazard	Wide-mouth glass	8 oz.	None	NA
Dioxin/Furan	All	Wide-mouth glass	4 oz.	None	35 days until extraction; 40 days after extraction
TCLP	All	Wide-mouth glass	8 oz.	None	7 days until preparation; analysis as per fraction
AIR					
Volatile Organics	Low/Medium	Charcoal tube -- 7 cm long, 6 mm OD, 4 mm ID	100 L air	Cool to 4°C	5 days recommended

1 All glass containers should have Teflon cap liners or septa.
2 See Attachment E. Preservation and maximum holding time allowances per 40 CFR 136.

ATTACHMENT B

ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS:			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia - Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Biochemical Oxygen Demand (BOD)	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical Oxygen Demand (COD)	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Chloride	P, G	None required	28 days
Chlorine, Total Residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P, G	Cool, 4°C; NaOH to pH 12; 0.6 g ascorbic acid[5]	14 days[6]
Fluoride	P	None required	28 days
Hardness	P, G	HNO_3 to pH 2; H_2SO_4 to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C; HCl or H_2SO_4 to pH 2	28 days
Orthophosphate	P, G	Filter immediately; Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle & top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle & top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Residue, Total	P, G	Cool, 4°C	7 days
Residue, Filterable (TDS)	P, G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, Settleable	P, G	Cool, 4°C	48 hours
Residue, Volatile (Ash Content)	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE TWO

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS (Cont'd):			
Sulfide	P, G	Cool, 4°C; add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4°C	48 hours
METALS:[7]			
Chromium VI (Hexachrome)	P, G	Cool, 4°C	24 hours
Mercury (Hg)	P, G	HNO_3 to pH 2	28 days
Metals, except Chromium VI and Mercury	P, G	HNO_3 to pH 2	6 months
ORGANIC TESTS:[8]			
Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5] HCl to pH 2[9]	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5] adjust pH to 4-5.[10]	14 days
Phenols[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Benzidines[11],[12]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction[13]
Phthalate esters[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitrosamines[11],[14]	G, Teflon-lined cap	Cool, 4°C; store in dark; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
PCBs[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitroaromatics & Isophorone[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]; store in dark	7 days until extraction; 40 days after extraction
Polynuclear Aromatic Hydrocarbons (PAHs)[11],[14]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]; store in dark	7 days until extraction; 40 days after extraction
Haloethers[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Dioxin/Furan (TCDD/TCDF)[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE THREE

(1) Polyethylene (P): generally 500 ml or Glass (G): generally 1L.
(2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.
(3) When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).
(4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer periods, and has received a variance from the Regional Administrator.
(5) Should only be used in the presence of residual chlorine.
(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments are made to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.
(7) Samples should be filtered immediately on site before adding preservative for dissolved metals.
(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.
(9) Sample receiving no pH adjustment must be analyzed within 7 days of sampling.
(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.
(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).
(12) If 1,2-diphenylthydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.
(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
(14) For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.
(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

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6.0 LISTING OF TETRA TECH NUS FIELD FORMS FOUND ON THE TTNUS INTRANET SITE. HTTP://INTRANET.TTNUS.COM CLICK ON FIELD LOG SHEETS **7**

ATTACHMENTS

A TYPICAL SITE LOGBOOK ENTRY **9**
B SAMPLE LABEL **10**
C CHAIN-OF-CUSTODY RECORD FORM **11**
D CHAIN-OF-CUSTODY SEAL **12**

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs and reports generally initiated and maintained for documenting Tetra Tech NUS field activities.

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Tetra Tech NUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

Project Manager (PM) - The Project Manager is responsible for obtaining hardbound, controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The Field Operations Leader is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports illustrated in this guideline (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time-frame.

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded or referenced (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Time and date of H&S training
- Arrival/departure of equipment
- Time and date of equipment calibration
- Start and/or completion of borehole, trench, monitoring well installation, etc.
- Daily onsite activities performed each day
- Sample pickup information
- Health and Safety issues (level of protection observed, etc.)
- Weather conditions

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day

that onsite activities take place which involve Tetra Tech NUS or subcontractor personnel. Upon completion of the fieldwork, the site logbook must become part of the project's central file.

The following information must be recorded on the cover of each site logbook:

- Project name
- Tetra Tech NUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2), but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the field notebook in which the measurements are recorded (see Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated. The site logbook must also be signed by the Field Operations Leader at the end of each day.

5.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be *numbered sequentially to correspond to logbook/notebook entries. The name of the photographer*, date, time, site location, site description, and weather conditions must be entered in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided, since they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend upon the subject matter, type of camera (digital or film), and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Once processed, the slides of photographic prints shall be consecutively numbered and labeled according to the logbook/notebook descriptions. The site photographs and associated negatives and/or digitally saved images to compact disks must be docketed into the project's central file.

5.2 Field Notebooks

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

5.3 Field Forms

All Tetra Tech NUS field forms (see list in Section 6.0 of this SOP) can be found on the company's intranet site (http://intranet.ttnus.com) under Field Log Sheets. Forms may be altered or revised for project-specific needs contingent upon client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. A log sheet must be completed for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Adhesive labels must be completed and applied to every sample container. Sample labels can usually be obtained from the appropriate Program source electronically generated in-house, or are supplied from the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One carbonless copy of the completed COC form is retained by the field crew, one copy is sent to the Project Manager (or designee), while the original is sent to the laboratory. The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing vials for VOC analysis or the cooler with the air bill attached. The air bill should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment C. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Tetra Tech NUS Project Manager). The COC form is signed and copied. The laboratory will retain the copy while the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The Custody seal is an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. The COC seals are signed and dated by the sampler(s) and affixed across the lid and body of each cooler (front and back) containing environmental samples (see SOP SA-6.1). COC seals may be available from the laboratory; these seals may also be purchased from a supplier.

5.3.1.5 Geochemical Parameters Log Sheets

Field Analytical Log Sheets are used to record geochemical and/or natural attenuation field test results.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

A Groundwater Level Measurement Sheet must be filled out for each round of water level measurements made at a site.

~~5.3.2.2 Data Sheet for Pumping Test~~

~~During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The Pumping Test Data Sheet facilitates this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be laid out in advance.~~

~~5.3.2.3 Packer Test Report Form~~

~~A Packer Test Report Form must be completed for each well upon which a packer test is conducted.~~

5.3.2.4 Boring Log

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring, or Boring Log is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a PID or FID), these readings must be entered on the boring log at the appropriate depth. The "Remarks" column can be used to subsequently enter the laboratory sample number, the concentration of key analytical results, or other pertinent information. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

~~5.3.2.6 Test Pit Log~~

~~When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.~~

5.3.2.7 Miscellaneous Monitoring Well Forms

Monitoring Well Materials Certificate of Conformance should be used as the project directs to document all materials utilized during each monitoring well installation.

The Monitoring Well Development Record should be used as the project directs to document all well development activities.

5.3.2.8 Miscellaneous Field Forms - QA and Checklists

Container Sample and Inspection Sheet should be used as the project directs each time a container (drum, tank, etc.) is sampled and/or inspected.

QA Sample Log Sheet should be used at the project directs each time a QA sample is colleted, such as Rinsate Blank, Source Blank, etc.

Field Task Modification Request (FTMR) will be prepared for all deviations from the project planning documents. The FOL is responsible for initiating the FTMRs. Copies of all FTMRs will be maintained with the onsite planning documents and originals will be placed in the final evidence file.

The Field Project Daily Activities Check List and Field Project Pre-Mobilization Checklist should be used during both the planning and field effort to assure that all necessary tasks are planned for and completed. These two forms are not a requirement but a useful tool for most field work.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used or in accordance with the manufacturer's recommendations.

5.4 Field Reports

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by project management.

5.4.1 Daily Activities Report

To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

5.4.1.1 Description

The Daily Activities Report (DAR) documents the activities and progress for each day's field work. This report must be filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the TtNUS intranet site.

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

It should be noted that in addition to summaries described herein, other summary reports may also be contractually required.

All Tetra Tech NUS field forms can be found on the company's intranet site at http://intranet.ttnus.com under Field Log Sheets.

6.0 LISTING OF TETRA TECH NUS FIELD FORMS FOUND ON THE TTNUS INTRANET SITE. HTTP://INTRANET.TTNUS.COM CLICK ON FIELD LOG SHEETS

Groundwater Sample Log Sheet
Surface Water Sample Log Sheet
Soil/Sediment Sample Log Sheet
Container Sample and Inspection Sheet
Geochemical Parameters (Natural Attenuation)
Groundwater Level Measurement Sheet
~~Pumping Test Data Sheet~~
~~Packer Test Report Form~~
Boring Log
~~Monitoring Well Construction Bedrock Flush Mount~~
~~Monitoring Well Construction Bedrock Open Hole~~
~~Monitoring Well Construction Bedrock Stick Up~~
Monitoring Well Construction Confining Layer
Monitoring Well Construction Overburden Flush Mount
Monitoring Well Construction Overburden Stick Up
~~Test Pit Log~~
Monitoring Well Materials Certificate of Conformance
Monitoring Well Development Record

Daily Activities Record
Field Task Modification Request
Hydraulic Conductivity Test Data Sheet
Low Flow Purge Data Sheet
QA Sample Log Sheet
Equipment Calibration Log
Field Project Daily Activities Checklist
Field Project Pre-Mobilization Checklist

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____

PERSONNEL:

TtNUS	DRILLER	SITE VISITORS
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.
2. Drilling activities at well ____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well _____.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.
4. Well _____ drilled. Rig geologist was _____. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.
8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ___ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

_____

Field Operations Leader

ATTACHMENT B

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	**Project:** **Site:** **Location:**	
Sample No:		**Matrix:**
Date:	**Time:**	**Preserve:**
Analysis:		
Sampled by:	**Laboratory:**	

ATTACHMENT C

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER 3413 | PAGE ___ OF ___

PROJECT NO:	FACILITY:	PROJECT MANAGER	PHONE NUMBER	LABORATORY NAME AND CONTACT:
SAMPLERS (SIGNATURE)		FIELD OPERATIONS LEADER	PHONE NUMBER	ADDRESS
		CARRIER/WAYBILL NUMBER		CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G)
PRESERVATIVE USED

DATE YEAR	TIME	SAMPLE ID	LOCATION ID	TOP DEPTH (FT)	BOTTOM DEPTH (FT)	MATRIX (GW, SO, SW, SD, QC, ETC.)	COLLECTION METHOD GRAP (G) COMP (C)	No. OF CONTAINERS	TYPE OF ANALYSIS								COMMENTS

1. RELINQUISHED BY	DATE	TIME	1. RECEIVED BY	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3. RECEIVED BY	DATE	TIME
COMMENTS					

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

4/02R
FORM NO. TtNUS-001

ATTACHMENT D

CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL	**CUSTODY SEAL**
Date	**Date**
Signature	**Signature**

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ATTACHMENTS

A INVESTIGATION-DERIVED WASTE LABEL 15

1.0 PURPOSE

Decontamination is the process of removing and/or neutralizing site contaminants that have contacted and/or accumulated on equipment. The purpose of this Standard Operating Procedure (SOP) is to protect site personnel, the general public, and the environment while preserving or maintaining sample integrity. It is further intended through this procedure to describe the steps necessary for proper decontamination of drilling equipment, earth-moving equipment , chemical sampling equipment and field operation and analytical equipment.

2.0 SCOPE AND APPLICABILITY

This procedure applies to all equipment used to provide access to/acquire environmental samples that may have become contaminated through direct contact with contaminated media including air, water, and soil. This equipment includes drilling and heavy equipment and chemical sampling and field analytical equipment. Where technologically and economically feasible, single-use sealed disposable equipment will be employed to minimize the potential for cross-contamination. This SOP also provides general reference information on the control of contaminated materials.

Decontamination methods and equipment requirements may differ from one project to another. General equipment items are specified in Section 6.0, but project-specific equipment must be obtained to address the project-specific decontamination procedures presented in Section 7.0 and applicable subsections.

3.0 GLOSSARY

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Decontamination Solution - A solution selected/identified in the Health and Safety Plan or Project-Specific Quality Assurance Plan. The solution is selected and employed as directed by the project chemist/health and safety professional.

Deionized Water (DI) - Tap water that has been treated by passing through a standard deionizing resin column. This water may also pass through additional filtering media to attain various levels of analyte-free status. The DI water should meet College of American Pathologists (CAP) and National Committee for Clinical Laboratory Standards (NCCLS) specifications for reagent-grade Type I water.

Potable Water - Tap water from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Pressure Washing - Process employing a high-pressure pump and nozzle configuration to create a high-pressure spray of potable water. High-pressure spray is employed to remove solids from equipment.

Solvent – A liquid in which solid chemicals or other liquids are dissolved. The solvent of choice is pesticide-grade isopropanol. Use of other solvents (methanol, acetone, or hexane) may be required for particular projects or for a particular purpose (e.g., removal of concentrated waste) and must be justified in the project planning documents. For example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

Steam Pressure Washing - A cleaning method employing a high-pressure spray of heated potable water to remove various organic/inorganic chemicals from equipment.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Decontamination Personnel - Individuals assigned the task of decontamination. It is the responsibility of these individuals to understand the use and application of the decontamination process and solutions as well as the monitoring of that process to ensure that it is working properly. This is accomplished through visual evaluation, monitoring instrument scanning of decontaminated items, and/or through the collection of rinsate blanks to verify contaminant removal.

Field Operations Leader (FOL) - Responsible for the implementation of project-specific planning documents. This includes on-site verification that all field activities are performed in compliance with approved SOPs or as otherwise dictated by the approved project plan(s). The FOL is also responsible for the completion and accuracy of all field documentation.

Site Safety Officer (SSO) - Exercises shared responsibility with the FOL concerning decontamination effectiveness. All equipment arriving on site (as part of the equipment inspection), leaving the site, and moving between locations is required to go through a decontamination evaluation. This is accomplished through visual examination and/or instrument screening to determine the effectiveness of the decontamination process. Improper or incomplete decontamination is sufficient to restrict equipment from entering the site, exiting the site, or moving to a new location on the site until the objectives are successfully completed.

General personnel qualifications for decontamination activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate decontamination procedures.

5.0 HEALTH AND SAFETY

In addition to the health and safety issues and reminders specified in subsections of this SOP, the following considerations and requirements must be observed as SOPs for field equipment decontamination activities:

- If any solvents or hazardous chemicals (e.g., isopropyl alcohol) are to be used in equipment decontamination activities, the FOL must first obtain the manufacturer's/supplier's Material Safety Data Sheet (MSDS) and assure that it is reviewed by all users (prior to its use), added to the site Hazardous Chemical Inventory, and maintained on site as part of the project Hazard Communication Program.
- Review and observe specific health and safety requirements (e.g., personal protective equipment [PPE]) specified in the project-specific health and safety plan for this activity.

6.0 EQUIPMENT LIST

- Wood for decontamination pad construction, when applicable (see Section 7.1).
- Tools for constructing decontamination pad frame, when applicable (see Section 7.1).

- Visqueen sheeting or comparable material to cover decontamination pad frame, when applicable (see Section 7.1).
- Wash/drying racks for auger flights and drill/drive rods, when applicable (see Section 7.2).
- PPE as specified in the project health and safety plan.
- Soap and water for washing and rinsing.
- Deionized water for final rinsing.
- Solvents (e.g., pesticide-grade isopropanol) for rinsing (see applicable portions of Section 7.2).
- Tubs, buckets, etc. for containerizing rinse water (see applicable portions of Section 7.2).
- ~~Sample bottles for collecting rinsate blanks (see Section 7.2).~~
- Calibrated photoionization detector (PID) or flame ionization detector (FID) to monitor decontaminated equipment for organic vapors generated through the existence of residual contamination or the presence of decontamination solvent remaining after the piece was rinsed.
- Aluminum foil or clear clean plastic bag for covering cleaned equipment (see applicable portions of Section 7.2).
- Paper towels or cloths for wiping.
- Brushes, scrapers, or other hand tools useful for removing solid materials from equipment.
- Clear plastic wrap for covering or wrapping large decontaminated equipment items (see Section 7.2.2).
- Drum-moving equipment for moving filled waste drums (optional) (see Section 7.3).
- Drum labels for waste drums (see Attachment A).

7.0 PROCEDURES

The process of decontamination is accomplished through the removal of contaminants, neutralization of contaminants, or isolation of contaminants. To accomplish this activity, preparation is required including site preparation, equipment selection, and evaluation of the decontamination requirements and processes. Site contaminant types, concentrations, and media types are primary drivers in the selection of the types of decontamination and where it will be conducted. For purposes of this SOP, discussion is limited to decontamination procedures for general environmental investigations.

Decontamination processes will be performed at the location(s) specified in project-specific planning documents. Typical decontamination locations include the following:

- Temporary decontamination pads/facilities
- Sample locations
- Centralized decontamination pad/facilities
- Combination of some or all of the above

The following discussion includes general considerations for the decontamination process. Specific construction and implementation procedures will be as specified in the project-specific planning documents and/or may be as dictated by site-specific conditions as long as the intent of the requirements in the planning documents is met. This intent is to contain any residual fluids and solids generated through the decontamination process.

7.1 Decontamination Pad Design/Construction Considerations

7.1.1 Temporary Decontamination Pads

Temporary decontamination pads may be constructed at satellite locations within the site area in support of temporary work areas. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth-moving equipment but can be employed for smaller articles.

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soil generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations:

- Site location – The decontamination site selected should be far enough from the work site to maximize decontamination effectiveness while minimizing travel distance. The location of the decontamination site shall be selected to provide, in the judgment of the FOL or FOL designee, compliance with as many of the following characteristics as practicable:

  - Well removed from pedestrian/vehicle thoroughfares.

  - Avoidance of areas where control/custody cannot be maintained.

  - Avoidance of areas where potential releases of contaminated media or decontamination fluids may be compounded through access to storm water transport systems, streams, or other potentially sensitive areas.

  - Avoidance of potentially contaminated areas.

  - Avoidance of areas too close to the ongoing operation, where cross-contamination may occur.

  The selected decontamination site should include the following, where possible:

  - Areas where potable water and electricity are provided.

> ***Safety Reminder***
>
> When utilizing electrical power sources, either hard-wired or portable-generated sources, ensure that:
>
> - All power is routed through a Ground Fault Circuit Interrupter (GFCI).
>
> - All power cords are in good condition (no physical damage), rated for the intended energy load, and designated for outdoor use.
>
> In situations where accomplishing these elements is not possible, it will be necessary to implement a site electrical grounding program.

- Areas where support activities such as removing decontamination waters soil and sediment are possible without entering an active exclusion zone.

- Areas that offer sufficient size to carry out the specific decontamination sequence.

- Decontamination pad (decon pad) – The decon pad shall be constructed to meet the following characteristics:

  - Size – The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination. The size should permit these movements utilizing pressure/steam washer wands and hoses and minimizing splash due to work in close quarters.

  - Slope – An adequate slope will be constructed to permit the collection of water and potentially contaminated soil within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks. Because the pad will be sloped, place a light coating of sand over the plastic to minimize potential slips and falls. See the text about liners below.

  - Sidewalls – The sidewalls shall be at least 6 inches in height (or as high as possible if 6 inches is not achievable) to provide adequate containment for wash waters and soil. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls may be constructed of wood, inflatables, sand bags, etc. to permit containment. Splash guards are typically wood frames with Visqueen coverings to control overspray.

  - Liner – Depending on the types of equipment and decontamination method to be used, the liner should be of sufficient thickness to provide a puncture-resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp articles (sticks, stones, debris) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of 10 mil to 30 mil. The desired thickness may be achieved through layering materials of lighter construction. It should be noted that various materials (rubber, polyethylene sheeting) become slippery when wet. To minimize this potential hazard associated with a sloped liner, a light coating of sand shall be applied to provide traction as necessary.

  - Wash/drying racks – Auger flights, drill/drive rods, and similar equipment require racks positioned off of the ground to permit these articles to be washed, drained, and dried while secured from falling during this process.

For decontamination of direct-push technology (DPT) equipment, the pad may be as simple as a mortar tub containing buckets of soapy water for washing and an empty bucket to capture rinse waters. Decontamination may be conducted at the rear of the rig to permit rapid tool exchange.

- Maintenance – Maintain the decontamination area by:

  - Periodically clearing the work area of standing water, soil, and debris, and coiling hoses to aid in eliminating slip, trip, and fall hazards. In addition, these articles will reduce potential backsplash and cross-contamination.

  - Regularly changing the decontamination fluids to ensure proper cleaning and prevent cross-contamination.

- PPE – Periodically evaluate the condition of, and maintain the decontamination equipment, including regular cleaning of face shields and safety glasses. This is critical to ensuring the safety of decontamination personnel and the integrity of the decontamination process, and it will ensure that equipment is functioning properly.

7.1.2 Decontamination Activities at Drill Rigs/DPT Units

During subsurface sampling activities including drilling and DPT activities, decontamination of drive rods, Macro Core Samplers, split spoons, etc. is typically conducted at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes. This area requires sufficient preparation to accomplish the decontamination objectives.

Buckets shall be placed within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected environmental media. Drying racks shall be employed as directed for temporary pads to permit parts to dry and be evaluated prior to use/reuse. Methodology regarding this activity is provided in Section 7.2.

~~7.1.3 Decontamination Activities at Remote Sample Locations~~

~~When sampling at remote locations, sampling equipment such as trowels and pumps/tubing should be evacuated of potentially contaminated media to the extent possible. This equipment should be wrapped in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition. Flushing and cleaning of single-use equipment such as disposable trowels, tubing, and surgeon's gloves may allow disposal of this equipment after visible soil and water remnants have been removed.~~

7.2 Equipment Decontamination Procedures

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

7.2.1 Monitoring Well Sampling Equipment

7.2.1.1 Groundwater sampling equipment – This includes pumps inserted into monitoring wells such as bladder pumps, Whale pumps, and Redi-Flo pumps and reusable bailers, etc.

1. Evacuate to the extent possible, any purge water within the pump/bailer.
2. Scrub using soap and water and/or steam clean the outside of the pump/bailer and, if applicable, the pump tubing.
3. Insert the pump and tubing/bailer into a clean container of soapy water. Pump/run a sufficient amount of soapy water through the pump/bailer to flush out any residual well water. After the pump is flushed, circulate soapy water through the pump to ensure that the internal components are thoroughly flushed.
4. Remove the pump and tubing/bailer from the container
5. Rinse external pump components using tap water.
6. Insert the pump and tubing/bailer into a clean container of tap water. Pump/run a sufficient amount of tap water through the pump/bailer to evacuate all of the soapy water (until clear).

CAUTION

Do not rinse PE, PVC, and associated tubing with solvents – Use the procedures defined in the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 7 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

7. If groundwater contains or is suspected to contain oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment to be cleaned with pesticide-grade isopropanol.

8. Pass deionized water through the hose to flush out the tap water and solvent residue as applicable.

9. Drain residual deionized water to the extent possible.

10. Allow components of the equipment to air dry.

~~11. For bladder pumps, disassemble the pump and wash the internal components with soap and water, then rinse with tap water, isopropanol, and deionized water and allow to dry. After the parts are dry, conduct a visual inspection and a monitoring instrument scan to ensure that potential contaminants and all decontamination solvent have been removed. Collect a rinsate blank in accordance with the project-specific planning documents to ensure that the decontamination process is functioning as intended. The typical frequency of collection for rinsate blanks is 1 per 20 field samples. In addition, wipe samples or field tests such as UV light may be used.~~

12. Wrap pump/bailer in aluminum foil or a clear clean plastic bag for storage.

SAFETY REMINDER

Remember when handling powered equipment to disconnect the power source and render the equipment to a zero energy state (both potential and kinetic) before opening valves, disconnecting lines, etc.

7.2.1.2 Electronic Water Level Indicators/Sounders/Tapes

During water level measurements, rinsing the extracted tape and probe with deionized water and wiping the surface of the extracted tape between locations is acceptable. However, periodic full decontamination should be conducted as follows:

1. Wash with soap and water
2. Rinse with tap water
3. Rinse with deionized water

NOTE

In situations where oil, grease, free product, other hard to remove materials are encountered, probes and exposed tapes should be washed in hot soapy water. If probes or tapes cannot be satisfactorily decontaminated (they are still stained, discolored, etc.), they should be removed from service.

7.2.1.3 Miscellaneous Equipment

Miscellaneous equipment including analytical equipment (water quality testing equipment) shall be cleaned per manufacturers' instructions. This generally includes wiping the sensor housing and rinsing with tap and deionized water.

Coolers/shipping containers employed to ship samples are received from the laboratory in a variety of conditions including marginal to extremely poor. Coolers shall be evaluated prior to use for the following:

- Structural integrity – Coolers missing handles or having breaks in the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples in the cooler(s) provided is too great and request a replacement unit.

- Cleanliness – As per protocol, only volatile organic samples are accompanied by a trip blank. If a cooler's cleanliness is in question (visibly dirty/stained) or if there are noticeable odors, the cooler should be decontaminated prior to use as follows:

  1. Wash with soap and water
  2. Rinse with tap water
  3. Dry

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and ask the cooler provider (e.g., the analytical laboratory) to provide a replacement unit.

7.2.2 Downhole Drilling Equipment

This includes any portion of the drill rig that is over the borehole, including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. The following procedure is to be employed prior to initiating the drilling/sampling activity, then between locations:

> ***CAUTION***
> Exercise care when using scrapers to remove soil and debris from downhole drilling equipment. Inadvertent slips of scrapers have resulted in cuts, scrapes, and injured knuckles, so use scrapers carefully when removing soil from these items.

1. Remove loose soil using shovels, scrapers, etc.

2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment being decontaminated.

> ***CAUTION***
> In Step 3, do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

3. Rinse the equipment with tap water, where applicable (steam cleaning and pressure washing incorporate rinsing as part of the process).

4. If the equipment has directly or indirectly contacted contaminated sample media and is known or suspected of being contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse equipment with pesticide-grade isopropanol

5. To the extent possible, allow components to air dry.

6. If the decontaminated equipment is to be used immediately after decontamination, screen it with a calibrated photoionization detector (PID)/flame ionization detector (FID) to ensure that all contaminants and possible decontamination solvents (if they were used) have been adequately removed.

7. Wrap or cover equipment in clear plastic until it is time to be used.

SAFETY REMINDER

Even when equipment is disconnected from power sources, dangers such as the following may persist:

Falls - An auger flight standing on its end may fall and injure someone. Secure all loose articles to prevent heavy articles from falling onto people or equipment.

Burns - Steam cleaner water is heated to more than 212 °F and exhibits thermal energy that can cause burns. Prevent contact of skin with hot water or surfaces.

High water pressure - Pressure washer discharge can have 2,000 to 4,000 psi of water pressure. Water under this amount of pressure can rupture skin and other human tissues. Water at 4,000 psi exiting a 0° tip can be dangerous because of its relatively high cutting power. The exit velocity and cutting power of the water are reduced when exiting a 40° fan tip, but damage to soft tissues is still possible.

In general, follow the rules below to avoid injury, equipment damage, or incomplete decontamination:

1. Read the operating manual and follow the manufacturers' recommended safety practices before operating pressure washers and steam cleaners.

2. Never point the pressure washer or steam cleaner at another person or use to clean your boots or other parts of your body. Water lacerations and burns may appear to be minor at first but can be life threatening. Do not attempt to hold small parts in your hand while washing them with high-temperature or high-pressure water.

3. Always wear PPE as specified in the HASP such as:

   - Hard hat, safety glasses, splash shield, impermeable apron or splash suit, and hearing protection. Remember that excessive noise is a hazard when operating gas-powered engines and electrically driven pressure washers. PPE will be identified in your project specific planning documents.

4. Inspect each device before use. An inspection checklist will be provided in the project-specific planning documents. If it is a rented device, safety measures are typically provided by the vendor. In all cases, if you are not familiar with the operation of a pressure washer/steam cleaner, do not operate it until you obtain and thoroughly review operating instructions and recommended safety practices.

5. Do not modify equipment unless the manufacturer has approved the modifications.

7.2.3 Soil/Sediment Sampling Equipment

This section applies to soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, Macro Core samplers, etc.

1. Remove all loose soil from the equipment through manual means.
2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment.
3. Rinse the equipment with tap water.

> ***CAUTION***
> Do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

4. If the equipment is contaminated or suspected to be contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment with pesticide-grade isopropanol.
5. Rinse the equipment with deionized water.
6. To the extent possible, allow components to air dry.
7. If the equipment is to be used immediately after decontamination, screen it with a calibrated PID/FID to ensure that all solvents (if they were used) and trace contaminants have been adequately removed.
8. After the equipment has dried, wrap it in aluminum foil for storage until use.

Dredges employed in sediment sampling are typically decontaminated as follows:

- Remove the sediment sample from the sampling device
- If sufficient associated surface water is available at the sampling site, place the dredge in the water and flush to remove visible sediment.
- Extract the dredge and wash it in soap and water per the project-specific planning documents.

> ***CAUTION***
> When handling dredges, the primary safety concern is trapping fingers or extremities in the larger dredge samplers within the jaws or pinch points of the mechanical jaws. Keep hands, fingers, and extremities away from these pinch and compression points. Either handle the device by the rope or preferably lock the jaws in place to control the potential for closing during maintenance and/or cleaning.

7.3 Contact Waste/Materials

During the course of field investigations, disposable/single-use equipment becomes contaminated. These items include tubing, trowels, PPE (gloves, overboots, splash suits, etc.), and broken sample containers.

With the exception of the broken glass, single-use articles should be cleaned (washed and rinsed) of visible materials and disposed as normal refuse. The exception to this rule is that extremely soiled materials that cannot be cleaned shall be containerized for disposal in accordance with applicable federal, state, and local regulations.

7.3.1 Investigation-Derived Wastes - Decontamination Wash Waters and Sediments

> ***NOTE***
> Requirements for waste storage may differ from one facility to the next. Facility-specific directions for waste storage areas will be provided in project-specific documents, or separate direction will be provided by the Project Manager.

1. Assume that all investigation-derived waste (IDW) generated from decontamination activities contains the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. Waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.

2. Where possible, use filtering systems to extend the use of water within a closed system wash unit to recycle water and to reduce possible waste amounts.

> ***NOTE***
> Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility.

3. Label waste storage containers appropriately labeled (see Attachment A).

4. Ensure that the IDW storage area is configured to meet the following specifications to permit access to the containers and to conduct spill/leak monitoring, sampling, and extraction when the disposal route is determined:

   - Enclose areas accessible by the general public using construction fencing and signs.
   - Stored materials in 55-gallon drums on pallets with four (or fewer) drums per pallet.
   - Maintain the retaining bolt and label on the outside of storage containers where readily visible.
   - Provide at least 4 feet of room between each row of pallets to allow access to containers for sampling, drum removal, and spill response.
   - As directed in project-specific planning documents, maintain an IDW Inventory List and provide the list to the site Point of Contact at the termination of each shift.
   - Maintain spill response equipment at the IDW storage area in case it is required for immediate access.
   - Where possible, use equipment for moving containers. Where not possible, obtain help to manipulate containers.

CAUTION

Each container of water can weigh up to 490 pounds. Each 55-gallon drum of wet soil can weigh more than 750 pounds. Fill drums and temporary containers to 80 percent capacity to minimize spill and handling difficulties. Use drum carts to move filled drums.

See safe lifting techniques provided in Section 4.4 of the Tetra Tech NUS, Inc. Health and Safety Guidance Manual.

When placing drums, keep your fingers out of pinch and smash points such as between the drums. In some cases such as well development and/or purge water, you can place the drums to be filled on the pallet and transport materials in smaller easier to handle containers.

7.4 Decontamination Evaluation

Upon decontamination of equipment, determine the effectiveness of the decontamination process in the following manner:

- Visual evaluation – A visual evaluation will be conducted to ensure the removal of particulate matter. This shall be done to ensure that the washing/rinsing process is working as intended.

- Instrument Screening – A properly calibrated PID/FID should be used to evaluate the presence of site contaminants and solvents used in the cleaning process. The air intake of the instrument shall be passed over the article to be evaluated. Avoid placing the instrument probe into residual waters. A PID/FID reading greater than the daily established background level requires a repeat of the decontamination process, followed by rescreening with the PID/FID. This sequence must be repeated until no instrument readings greater than the daily established background level are observed. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instrument's capabilities.

NOTE

When required by project-specific planning documents, collection of rinsate blanks (see next step) shall be completed without exception unless approval to not collect these samples is obtained from the Project Manager.

- ~~Collection of Rinsate Blanks – It is recommended that rinsate samples be collected to:~~

  - ~~Evaluate the decontamination procedure representing different equipment applications (pumps versus drilling equipment) and different decontamination applications.~~

  - ~~Single-use disposable equipment – The number of samples should represent different types of equipment as well as different lot numbers of single-use articles.~~

  - ~~The collection and the frequency of collection of rinsate samples are as follows unless specified differently in the project-specific planning documents:~~

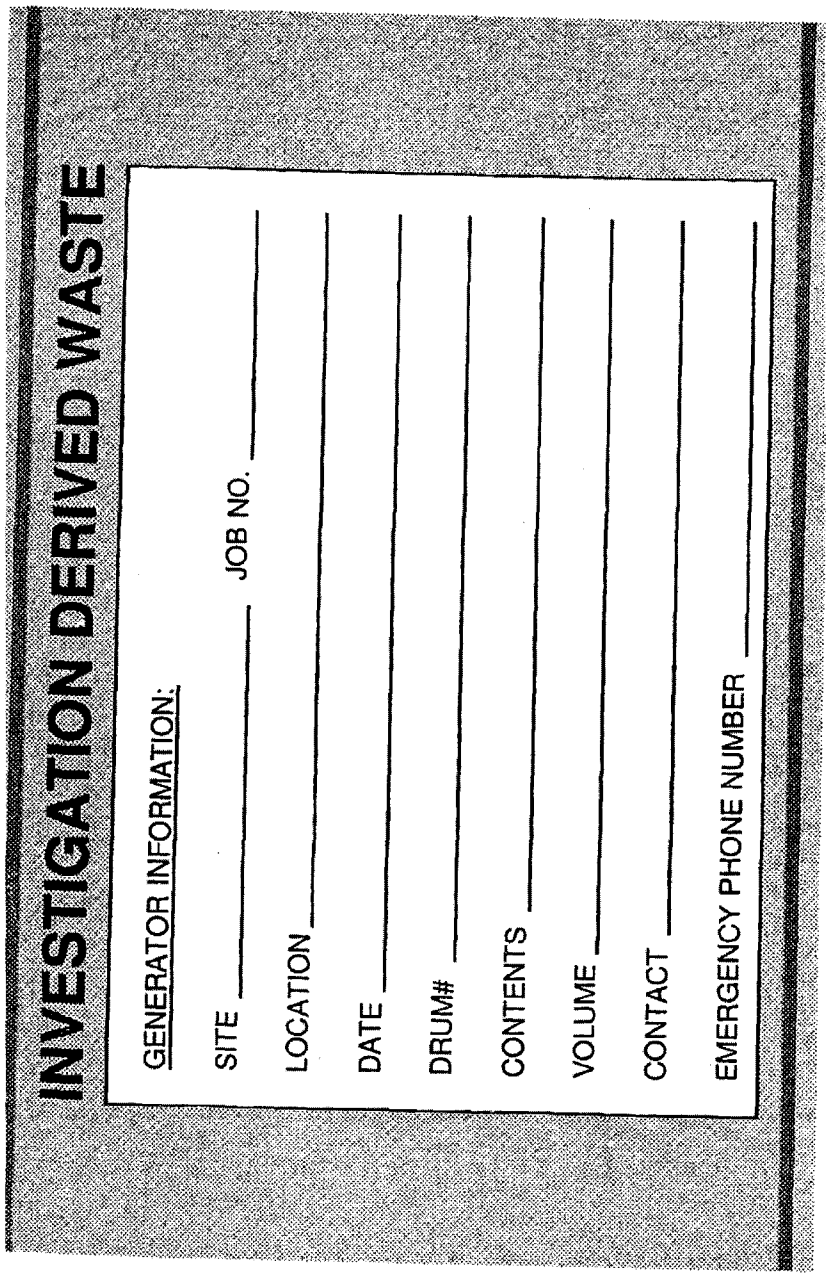
    - ~~Per decontamination method~~
    - ~~Per disposable article/batch number of disposable articles~~

~~NOTE~~

~~It is recommended that an initial rinsate sample be collected early in the project to ensure that the decontamination process is functioning properly and to avoid using a contaminated batch of single-use articles. It is recommended that a follow-up sample be collected later during the execution of the project to ensure that those conditions do not change.~~

~~Rinsate samples collection may be driven by types of and/or levels of contaminant. Difficult to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional rinsates due to the obvious challenges to the decontamination process. This is a field consideration to be determined by the FOL.~~

Attachment A
DW Label



APPENDIX F

PROJECT ACTION LIMIT REFERENCE TABLES

TABLE F-1A
REFERENCE DATA FOR PROJECT ACTION LIMITS -
ILLINOIS TACO VALUES
SITE 12
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CORRECTED PARAMETER	CORRECTED CAS	TACO Residential Inhalation (1)		NON-TACO Residential Ingestion (3)		TACO Residential Ingestion (1)		NON-TACO Residential Ingestion (3)		TACO Industrial Inhalation (2)		NON-TACO Industrial Inhalation (4)		TACO Industrial Ingestion (2)		NON-TACO Industrial Ingestion(4)		TACO - Construction Worker Soil Inhalation(2)		NON-TACO - Construction Worker Soil Inhalation(4)		TACO - Construction Worker Soil Ingestion(2)		NON-TACO - Construction Worker Soil Ingestion(4)		TACO - SO to GW Class I (1)		NON-TACO - SO to GW Class I (3)		TACO pH Specific Criteria		Minimum IL Criteria		MINIMUM IL BASIS
SEMIVOLATILES																																		
BIS(2-CHLOROETHYL)ETHER	111-44-4	200	UG/KG	NC		600	UG/KG	NC		470	UG/KG	NC		5000	UG/KG	NC		660	UG/KG	NC		75000	UG/KG	NC		0.4	UG/KG	NC		NC		0.4	UG/KG	TACO - SO to GW Class I
2-CHLOROPHENOL	95-57-8	53000000	UG/KG	NC		390000	UG/KG	NC		53000000	UG/KG	NC		10000000	UG/KG	NC		53000000	UG/KG	NC		10000000	UG/KG	NC		4000	UG/KG	NC		3600	UG/KG	3600	UG/KG	TACO pH Specific Criteria
PHENOL	108-95-2	NC		NC		23000000	UG/KG	NC		NC		NC		610000000	UG/KG	NC		NC		NC		61000000	UG/KG	NC		100000	UG/KG	NC		NC		100000	UG/KG	TACO - SO to GW Class I
HEXACHLOROETHANE	67-72-1	NC		NC		78000	UG/KG	NC		NC		NC		2000000	UG/KG	NC		NC		NC		2000000	UG/KG	NC		500	UG/KG	NC		NC		500	UG/KG	TACO - SO to GW Class I
N-NITROSO-DI-N-PROPYLAMINE	621-64-7	NC		NC		90	UG/KG	NC		NC		NC		800	UG/KG	NC		NC		NC		18000	UG/KG	NC		0.05	UG/KG	NC		NC		0.05	UG/KG	TACO - SO to GW Class I
NITROBENZENE	98-95-3	92000	UG/KG	NC		39000	UG/KG	NC		140000	UG/KG	NC		1000000	UG/KG	NC		9400	UG/KG	NC		1000000	UG/KG	NC		100	UG/KG	NC		NC		100	UG/KG	TACO - SO to GW Class I
2-METHYLPHENOL	95-48-7	NC		NC		3900000	UG/KG	NC		NC		NC		100000000	UG/KG	NC		NC		NC		100000000	UG/KG	NC		15000	UG/KG	NC		NC		15000	UG/KG	TACO - SO to GW Class I
ISOPHORONE	78-59-1	4600000	UG/KG	NC		15600000	UG/KG	NC		4600000	UG/KG	NC		410000000	UG/KG	NC		4600000	UG/KG	NC		410000000	UG/KG	NC		8000	UG/KG	NC		NC		8000	UG/KG	TACO - SO to GW Class I
4-METHYLPHENOL	106-44-5	NC		NC		NC		390000	UG/KG	NC		NC		NC		10000000	UG/KG	NC		NC		NC		NC		NC		200	UG/KG	NC		200	UG/KG	NON-TACO - SO to GW Class I
1,1-BIPHENYL	92-52-4	NC		NC		NC		3900000	UG/KG	NC		NC		NC		100000000	UG/KG	NC		NC		NC		10000000	UG/KG	NC		150000	UG/KG	NC		150000	UG/KG	NON-TACO - SO to GW Class I
2,2'-OXYBIS(1-CHLOROPROPANE)	108-60-1	NC		1300000	UG/KG	NC		3100000	UG/KG	NC		1300000	UG/KG	NC		82000000	UG/KG	NC		NC		NC		NC		NC		2400	UG/KG	NC		2400	UG/KG	NON-TACO - SO to GW Class I
2,4,5-TRICHLOROPHENOL	95-95-4	NC		NC		7800000	UG/KG	NC		NC		NC		200000000	UG/KG	NC		NC		NC		200000000	UG/KG	NC		270000	UG/KG	NC		130000	UG/KG	130000	UG/KG	TACO pH Specific Criteria
2,4,6-TRICHLOROPHENOL	88-06-2	200000	UG/KG	NC		58000	UG/KG	NC		390000	UG/KG	NC		520000	UG/KG	NC		540000	UG/KG	NC		11000000	UG/KG	NC		200	UG/KG	NC		90	UG/KG	90	UG/KG	TACO pH Specific Criteria
2,4-DICHLOROPHENOL	120-83-2	NC		NC		230000	UG/KG	NC		NC		NC		6100000	UG/KG	NC		NC		NC		610000	UG/KG	NC		1000	UG/KG	NC		860	UG/KG	860	UG/KG	TACO pH Specific Criteria
2,4-DIMETHYLPHENOL	105-67-9	NC		NC		1600000	UG/KG	NC		NC		NC		41000000	UG/KG	NC		NC		NC		41000000	UG/KG	NC		9000	UG/KG	NC		NC		9000	UG/KG	TACO - SO to GW Class I
2,4-DINITROPHENOL	51-28-5	NC		NC		160000	UG/KG	NC		NC		NC		4100000	UG/KG	NC		NC		NC		410000	UG/KG	NC		200	UG/KG	NC		NC		200	UG/KG	TACO - SO to GW Class I
2,4-DINITROTOLUENE	121-14-2	NC		NC		900	UG/KG	NC		NC		NC		8400	UG/KG	NC		NC		NC		180000	UG/KG	NC		0.8	UG/KG	NC		NC		0.8	UG/KG	TACO - SO to GW Class I
2,6-DINITROTOLUENE	606-20-2	NC		NC		900	UG/KG	NC		NC		NC		8400	UG/KG	NC		NC		NC		NC		NC		0.7	UG/KG	NC		NC		0.7	UG/KG	TACO - SO to GW Class I
2-CHLORONAPHTHALENE	91-58-7	NC		NC		NC		6300000	UG/KG	NC		NC		NC		160000000	UG/KG	NC		NC		NC		410000	UG/KG	NC		49000	UG/KG	NC		49000	UG/KG	NON-TACO - SO to GW Class I
2-NITROANILINE	88-74-4	NC		35000	UG/KG	NC		230000	UG/KG	NC		56000	UG/KG	NC		6100000	UG/KG	NC		3600	UG/KG	NC		610000	UG/KG	NC		140	UG/KG	NC		140	UG/KG	NON-TACO - SO to GW Class I
2-NITROPHENOL	88-75-5	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
3,3'-DICHLOROBENZIDINE	91-94-1	NC		NC		1000	UG/KG	NC		NC		NC		13000	UG/KG	NC		NC		NC		280000	UG/KG	NC		7	UG/KG	NC		NC		7	UG/KG	TACO - SO to GW Class I
3-NITROANILINE	99-09-2	NC		250000	UG/KG	NC		23000	UG/KG	NC		400000	UG/KG	NC		610000	UG/KG	NC		26000	UG/KG	NC		61000	UG/KG	NC		10	UG/KG	NC		10	UG/KG	NON-TACO - SO to GW Class I
4,6-DINITRO-2-METHYLPHENOL	534-52-1	NC		NC		NC		7800	UG/KG	NC		NC		NC		200000	UG/KG	NC		NC		NC		NC		NC		3.1	UG/KG	NC		3.1	UG/KG	NON-TACO SO to GW Class I pH Spec
4-BROMOPHENYL PHENYL ETHER	101-55-3	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
4-CHLORO-3-METHYLPHENOL	59-50-7	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
4-CHLOROANILINE	106-47-8	NC		NC		310000	UG/KG	NC		NC		NC		8200000	UG/KG	NC		NC		NC		NC		NC		700	UG/KG	NC		NC		700	UG/KG	TACO - SO to GW Class I
4-CHLOROPHENYL PHENYL ETHER	7005-72-3	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
4-NITROANILINE	100-01-6	NC		1000000	UG/KG	NC		230000	UG/KG	NC		1600000	UG/KG	NC		6100000	UG/KG	NC		110000	UG/KG	NC		610000	UG/KG	NC		100	UG/KG	NC		100	UG/KG	NON-TACO - SO to GW Class I
4-NITROPHENOL	100-02-7	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
ACETOPHENONE	98-86-2	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		820000	UG/KG	NC		NC		NC		NC		NC
ATRAZINE	1912-24-9	NC		NC		2700000	UG/KG	NC		NC		NC		72000000	UG/KG	NC		NC		NC		7100000	UG/KG	NC		66	UG/KG	NC		NC		66	UG/KG	TACO - SO to GW Class I
BENZALDEHYDE	100-52-7	NC		620000	UG/KG	NC		7800000	UG/KG	NC		620000	UG/KG	NC		200000000	UG/KG	NC		620000	UG/KG	NC		200000000	UG/KG	NC		3300	UG/KG	NC		3300	UG/KG	NON-TACO - SO to GW Class I
BIS(2-CHLOROETHOXY)METHANE	111-91-1	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
BIS(2-ETHYLHEXYL)PHTHALATE	117-81-7	31000000	UG/KG	NC		46000	UG/KG	NC		31000000	UG/KG	NC		410000	UG/KG	NC		NC		1300000	UG/KG	NC		8200000	UG/KG	3600000	UG/KG	NC		NC		46000	UG/KG	TACO Residential Ingestion
BUTYL BENZYL PHTHALATE	85-68-7	930000	UG/KG	NC		16000000	UG/KG	NC		930000	UG/KG	NC		410000000	UG/KG	NC		930000	UG/KG	NC		4100000000	UG/KG	NC		930000	UG/KG	NC		NC		930000	UG/KG	TACO Residential Ingestion
CAPROLACTAM	105-60-2	NC		NC		NC		39000000	UG/KG	NC		NC		NC		1000000000	UG/KG	NC		NC		NC		100000000	UG/KG	NC		14000	UG/KG	NC		14000	UG/KG	NON-TACO - SO to GW Class I
CARBAZOLE	86-74-8	NC		NC		32000	UG/KG	NC		NC		NC		290000	UG/KG	NC		NC		NC		6200000	UG/KG	NC		600	UG/KG	NC		NC		600	UG/KG	TACO - SO to GW Class I
DIBENZOFURAN	132-64-9	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		820000	UG/KG	NC		NC		NC		820000	UG/KG	NON-TACO Const Worker
DIETHYL PHTHALATE	84-66-2	2000000	UG/KG	NC		63000000	UG/KG	NC		2000000	UG/KG	NC		1000000000	UG/KG	NC		2000000	UG/KG	NC		1000000000	UG/KG	NC		470000	UG/KG	NC		NC		470000	UG/KG	TACO - SO to GW Class I
DIMETHYL PHTHALATE	131-11-3	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
DI-N-BUTYL PHTHALATE	84-74-2	2300000	UG/KG	NC		7800000	UG/KG	NC		2300000	UG/KG	NC		200000000	UG/KG	NC		2300000	UG/KG	NC		2000000000	UG/KG	NC		2300000	UG/KG	NC		NC		2300000	UG/KG	TACO Residential Ingestion
DI-N-OCTYL PHTHALATE	117-84-0	10000000	UG/KG	NC		1600000	UG/KG	NC		10000000	UG/KG	NC		41000000	UG/KG	NC		10000000	UG/KG	NC		4100000	UG/KG	NC		10000000	UG/KG	NC		NC		1600000	UG/KG	TACO Residential Ingestion
HEXACHLOROBENZENE	118-74-1	1000	UG/KG	NC		400	UG/KG	NC		1800	UG/KG	NC		4000	UG/KG	NC		2600	UG/KG	NC		78000	UG/KG	NC		2000	UG/KG	NC		NC		400	UG/KG	TACO Residential Ingestion
HEXACHLOROBUTADIENE	87-68-3	NC		150000	UG/KG	NC		78000	UG/KG	NC		150000	UG/KG	NC		2000000	UG/KG	NC		72000	UG/KG	NC		200000	UG/KG	NC		2200	UG/KG	NC		2200	UG/KG	NON-TACO - SO to GW Class I
HEXACHLOROCYCLOPENTADIENE	77-47-4	10000	UG/KG	NC		550000	UG/KG	NC		16000	UG/KG	NC		14000000	UG/KG	NC		1100	UG/KG	NC		1400000	UG/KG	NC		400000	UG/KG	NC		NC		10000	UG/KG	TACO Residential Ingestion
N-NITROSODIPHENYLAMINE	86-30-6	NC		NC		130000	UG/KG	NC		NC		NC		1200000	UG/KG	NC		NC		NC		25000000	UG/KG	NC		1000	UG/KG	NC		NC		1000	UG/KG	TACO - SO to GW Class I
PENTACHLOROPHENOL	87-86-5	NC		NC		3000	UG/KG	NC		NC		NC		24000	UG/KG	NC		NC		NC		520000	UG/KG	NC		30	UG/KG	NC		20	UG/KG	20	UG/KG	TACO pH Specific Criteria
POLYNUCLEAR AROMATIC HYDROCARBONS																																		
ACENAPHTHENE	83-32-9	NC		NC		4700000	UG/KG	NC		NC		NC		120000000	UG/KG	NC		NC		NC		120000000	UG/KG	NC		570000	UG/KG	NC		NC		570000	UG/KG	TACO - SO to GW Class I
ACENAPHTHYLENE	208-96-8	NC		NC		NC		2300000	UG/KG	NC		NC		NC		61000000	UG/KG	NC		NC		NC		61000000	UG/KG	NC		85000	UG/KG	NC		85000	UG/KG	NON-TACO - SO to GW Class I
ANTHRACENE	120-12-7	NC		NC		23000000	UG/KG	NC		NC		NC		610000000	UG/KG	NC		NC		NC		610000000	UG/KG	NC		12000000	UG/KG	NC		NC		12000000	UG/KG	TACO - SO to GW Class I
BENZO(A)ANTHRACENE	56-55-3	NC		NC		900	UG/KG	NC		NC		NC		8000	UG/KG	NC		NC		NC		170000	UG/KG	NC		2000	UG/KG	NC		NC		900	UG/KG	TACO Residential Ingestion
BENZO(A)PYRENE	50-32-8	NC		NC		90	UG/KG	NC		NC		NC		800	UG/KG	NC		NC		NC		17000	UG/KG	NC		8000	UG/KG	NC		NC		90	UG/KG	TACO Residential Ingestion
BENZO(B)FLUORANTHENE	205-99-2	NC		NC		900	UG/KG	NC		NC		NC		8000	UG/KG	NC		NC		NC		170000	UG/KG	NC		5000	UG/KG	NC		NC		900	UG/KG	TACO Residential Ingestion
BENZO(G,H,I)PERYLENE	191-24-2	NC		NC		NC		2300000	UG/KG	NC		NC		NC		61000000	UG/KG	NC		NC		NC		61000000	UG/KG	NC		27000000	UG/KG	NC		2300000	UG/KG	NON-TACO Residential Ingestion
BENZO(K)FLUORANTHENE	207-08-9	NC		NC		9000	UG/KG	NC		NC		NC		78000	UG/KG	NC		NC		NC		1700000	UG/KG	NC		49000	UG/KG	NC		NC		9000	UG/KG	TACO Residential Ingestion
CHRYSENE	218-01-9	NC		NC		88000	UG/KG	NC		NC		NC		780000	UG/KG	NC		NC		NC		17000000	UG/KG	NC		160000	UG/KG	NC		NC		88000	UG/KG	TACO Residential Ingestion
DIBENZO(A,H)ANTHRACENE	53-70-3	NC		NC		90	UG/KG	NC		NC		NC		800	UG/KG	NC		NC		NC		17000	UG/KG	NC		2000	UG/KG	NC		NC		90	UG/KG	TACO Residential Ingestion
FLUORANTHENE	206-44-0	NC		NC		3100000	UG/KG	NC		NC		NC		82000000	UG/KG	NC		NC		NC		82000000	UG/KG	NC		4300000	UG/KG	NC		NC		3100000	UG/KG	TACO Residential Ingestion
FLUORENE	86-73-7	NC		NC		3100000	UG/KG	NC		NC		NC		82000000	UG/KG	NC		NC		NC		82000000	UG/KG	NC		560000	UG/KG	NC		NC		560000	UG/KG	TACO - SO to GW Class I
2-METHYLNAPHTHALENE	91-57-6	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
INDENO(1,2,3-CD)PYRENE	193-39-5	NC		NC		900	UG/KG	NC		NC		NC		8000	UG/KG	NC		NC		NC		170000	UG/KG	NC		14000	UG/KG	NC		NC		900	UG/KG	TACO Residential Ingestion
NAPHTHALENE	91-20-3	170000	UG/KG	NC		1600000	UG/KG	NC		270000	UG/KG	NC		41000000	UG/KG	NC		1800	UG/KG	NC		4100000	UG/KG	NC		12000	UG/KG	NC		NC		12000	UG/KG	TACO - SO to GW Class I
PHENANTHRENE	85-01-8	NC		NC		NC		2300000	UG/KG	NC		NC		NC		61000000	UG/KG	NC		NC		NC		61000000	UG/KG	NC		200000	UG/KG	NC		200000	UG/KG	NON-TACO - SO to GW Class I
PYRENE	129-00-0	NC		NC		2300000	UG/KG	NC		NC		NC		61000000	UG/KG	NC		NC		NC		61000000	UG/KG	NC		4200000	UG/KG	NC		NC		2300000	UG/KG	TACO Residential Ingestion
PCBs																																		
AROCLOR-1016	12674-11-2	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
AROCLOR-1221	11104-28-2	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
AROCLOR-1232	11141-16-5	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
AROCLOR-1242	53469-21-9	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
AROCLOR-1248	12672-29-6	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
AROCLOR-1254	11097-69-1	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
AROCLOR-1260	11096-82-5	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
TOTAL AROCLOR	1336-36-3	NC		NC		1000	UG/KG	NC		NC		NC		1000	UG/KG	NC		NC		NC		1000		NC		NC		NC		NC		1000	UG/KG	TACO Residential Ingestion
INORGANICS																																		
ALUMINUM	7429-90-5	NC		1000000	MG/KG	NC		78000	MG/KG	NC		1000000	MG/KG	NC		1000000	MG/KG	NC		870000	MG/KG	NC		410000	MG/KG	NC		NC		NC		78000	MG/KG	NON-TACO Residential Ingestion
ANTIMONY	7440-36-0	NC		NC		31	MG/KG	NC		NC		NC		820	MG/KG	NC		NC		NC		82	MG/KG	NC		NC		NC		5	MG/KG	5	MG/KG	TACO pH Specific Criteria
ARSENIC	7440-38-2	750	MG/KG	NC		NC		NC		1200	MG/KG	NC		NC		NC		25000	MG/KG	NC		61	MG/KG	NC		NC		NC		30	MG/KG	30	MG/KG	TACO pH Specific Criteria
BARIUM	7440-39-3	690000	MG/KG	NC		5500	MG/KG	NC		910000	MG/KG	NC		140000	MG/KG	NC		870000	MG/KG	NC		14000	MG/KG	NC		NC		NC		1800	MG/KG	1800	MG/KG	TACO pH Specific Criteria
BERYLLIUM	7440-41-7	1300	MG/KG	NC		160	MG/KG	NC		2100	MG/KG	NC		4100	MG/KG	NC		44000	MG/KG	NC		410	MG/KG	NC		NC		NC		1000	MG/KG	160	MG/KG	TACO Residential Ingestion
CADMIUM	7440-43-9	1800	MG/KG	NC		78	MG/KG	NC		2800	MG/KG	NC		2000	MG/KG	NC		59000	MG/KG	NC		200	MG/KG	NC		NC		NC		59	MG/KG	59	MG/KG	TACO pH Specific Criteria
CALCIUM	7440-70-2	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
CHROMIUM	7440-47-3	270	MG/KG	NC		230	MG/KG	NC		420	MG/KG	NC		6100	MG/KG	NC		690	MG/KG	NC		4100	MG/KG	NC		NC		NC		NC		230	MG/KG	TACO Residential Ingestion
COBALT	7440-48-4	NC		NC		4700	MG/KG	NC		NC		NC		120000	MG/KG	NC		NC		NC		12000	MG/KG	NC		NC		NC		NC		4700	MG/KG	TACO Residential Ingestion
COPPER	7440-50-8	NC		NC		2900	MG/KG	NC		NC		NC		82000	MG/KG	NC		NC		NC		8200	MG/KG	NC		NC		NC		330000	MG/KG	2900	MG/KG	TACO Residential Ingestion
IRON	7439-89-6	NC		NC		NC		55000	MG/KG	NC		NC		NC		1000000	MG/KG	NC		NC		NC		140000	MG/KG	NC		NC		NC		55000	MG/KG	NON-TACO Residential Ingestion
LEAD	7439-92-1	NC		NC		400	MG/KG	NC		NC		NC		800	MG/KG	NC		NC		NC		700	MG/KG	NC		NC		NC		107	MG/KG	107	MG/KG	TACO pH Specific Criteria
MAGNESIUM	7439-95-4	NC		NC		325000	MG/KG	NC		NC		NC		NC		NC		NC		NC		730000	MG/KG	NC		NC		NC		NC		325000	MG/KG	TACO Residential Ingestion
MANGANESE	7439-96-5	69000	MG/KG	NC		1600	MG/KG	NC		91000	MG/KG	NC		41000	MG/KG	NC		8700	MG/KG	NC		4100	MG/KG	NC		NC		NC		NC		1600	MG/KG	TACO Residential Ingestion

TABLE F-1A
REFERENCE DATA FOR PROJECT ACTION LIMITS -
ILLINOIS TACO VALUES
SITE 12
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CORRECTED PARAMETER	CORRECTED CAS	TACO Residential Inhalation (1)		NON-TACO Residential Ingestion (3)		TACO Residential Ingestion (1)		NON-TACO Residential Ingestion (3)		TACO Industrial Inhalation (2)		NON-TACO Industrial Inhalation (4)		TACO Industrial Ingestion (2)		NON-TACO Industrial Ingestion(4)		TACO - Construction Worker Soil Inhalation(2)		NON-TACO - Construction Worker Soil Inhalation(4)		TACO - Construction Worker Soil Ingestion(2)		NON-TACO - Construction Worker Soil Ingestion(4)		TACO - SO to GW Class I (1)		NON-TACO - SO to GW Class I (3)		TACO pH Specific Criteria		Minimum IL Criteria		MINIMUM IL BASIS
MERCURY	7439-97-6	10	MG/KG	NC		23	MG/KG	NC		16	MG/KG	NC		610	MG/KG	NC		0.1	MG/KG	NC		61	MG/KG	NC		NC		NC		6.4	MG/KG	6.4	MG/KG	TACO pH Specific Criteria
NICKEL	7440-02-0	13000	MG/KG	NC		1600	MG/KG	NC		21000	MG/KG	NC		41000	MG/KG	NC		440000	MG/KG	NC		4100	MG/KG	NC		NC		NC		700	MG/KG	700	MG/KG	TACO pH Specific Criteria
POTASSIUM	7440-09-7	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
SELENIUM	7782-49-2	NC		NC		390	MG/KG	NC		NC		NC		10000	MG/KG	NC		NC		NC		1000	MG/KG	NC		NC		NC		3.3	MG/KG	3.3	MG/KG	TACO pH Specific Criteria
SILVER	7440-22-4	NC		NC		390	MG/KG	NC		NC		NC		10000	MG/KG	NC		NC		NC		1000	MG/KG	NC		NC		NC		39	MG/KG	39	MG/KG	TACO pH Specific Criteria
SODIUM	7440-23-5	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
THALLIUM	7440-28-0	NC		NC		6.3	MG/KG	NC		NC		NC		160	MG/KG	NC		NC		NC		160	MG/KG	NC		NC		NC		3.4	MG/KG	3.4	MG/KG	TACO pH Specific Criteria
VANADIUM	7440-62-2	NC		NC		550	MG/KG	NC		NC		NC		14000	MG/KG	NC		NC		NC		1400	MG/KG	NC		NC		NC		980	MG/KG	550	MG/KG	TACO Residential Ingestion
ZINC	7440-66-6	NC		NC		23000	MG/KG	NC		NC		NC		610000	MG/KG	NC		NC		NC		61000	MG/KG	NC		NC		NC		16000	MG/KG	16000	MG/KG	TACO pH Specific Criteria
TCLP-INORGANICS																																		
ALUMINUM	7429-90-5	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		3.5	MG/L	NC		3.5	MG/L	NON-TACO - SO to GW Class I
ANTIMONY	7440-36-0	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		0.006	MG/L	NC		NC		0.006	MG/L	TACO - SO to GW Class I
ARSENIC	7440-38-2	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		0.05	MG/L	NC		NC		0.05	MG/L	TACO - SO to GW Class I
BARIUM	7440-39-3	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		2	MG/L	NC		NC		2	MG/L	TACO - SO to GW Class I
BERYLLIUM	7440-41-7	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		0.004	MG/L	NC		NC		0.004	MG/L	TACO - SO to GW Class I
CADMIUM	7440-43-9	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		0.005	MG/L	NC		NC		0.005	MG/L	TACO - SO to GW Class I
CALCIUM	7440-70-2	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
CHROMIUM	7440-47-3	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		0.1	MG/L	NC		NC		0.1	MG/L	TACO - SO to GW Class I
COBALT	7440-48-4	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		1	MG/L	NC		NC		1	MG/L	TACO - SO to GW Class I
COPPER	7440-50-8	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		0.65	MG/L	NC		NC		0.65	MG/L	TACO - SO to GW Class I
IRON	7439-89-6	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		5	MG/L	5	MG/L	NC		5	MG/L	TACO - SO to GW Class I
LEAD	7439-92-1	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		0.0075	MG/L	NC		NC		0.0075	MG/L	TACO - SO to GW Class I
MAGNESIUM	7439-95-4	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
MANGANESE	7439-96-5	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		0.15	MG/L	NC		NC		0.15	MG/L	TACO - SO to GW Class I
MERCURY	7439-97-6	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		0.002	MG/L	NC		NC		0.002	MG/L	TACO - SO to GW Class I
NICKEL	7440-02-0	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		0.1	MG/L	NC		NC		0.1	MG/L	TACO - SO to GW Class I
POTASSIUM	7440-09-7	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
SELENIUM	7782-49-2	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		0.05	MG/L	NC		NC		0.05	MG/L	TACO - SO to GW Class I
SILVER	7440-22-4	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		0.05	MG/L	NC		NC		0.05	MG/L	TACO - SO to GW Class I
SODIUM	7440-23-5	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
THALLIUM	7440-28-0	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		0.002	MG/L	NC		NC		0.002	MG/L	TACO - SO to GW Class I
VANADIUM	7440-62-2	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		0.049	MG/L	NC		NC		0.049	MG/L	TACO - SO to GW Class I
ZINC	7440-66-6	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		5	MG/L	NC		NC		5	MG/L	TACO - SO to GW Class I
VOLATILE ORGANICS																																		
1,1,1-TRICHLOROETHANE	71-55-6	1200000	UG/KG	NC		NC		NC		1200000	UG/KG	NC		NC		NC		1200000	UG/KG	NC		NC		NC		2000	UG/KG	NC		NC		2000	UG/KG	TACO - SO to GW Class I
1,1,2,2-TETRACHLOROETHANE	79-34-5	NC		2000000	UG/KG	NC		310000	UG/KG	NC		2000000	UG/KG	NC		8200000	UG/KG	NC		2100000	UG/KG	NC		NC		NC		220	UG/KG	NC		220	UG/KG	NON-TACO - SO to GW Class I
1,1,2-TRICHLOROETHANE	79-00-5	1800000	UG/KG	NC		310000	UG/KG	NC		1800000	UG/KG	NC		8200000	UG/KG	NC		NC		2000000	UG/KG	NC		NC		20	UG/KG	NC		NC		20	UG/KG	TACO - SO to GW Class I
1,1-DICHLOROETHANE	75-34-3	1300000	UG/KG	NC		7800000	UG/KG	NC		1700000	UG/KG	NC		200000000	UG/KG	NC		130000	UG/KG	NC		200000000	UG/KG	NC		23000	UG/KG	NC		NC		23000	UG/KG	TACO - SO to GW Class I
1,1-DICHLOROETHENE	75-35-4	290000	UG/KG	NC		3900000	UG/KG	NC		470000	UG/KG	NC		100000000	UG/KG	NC		3000	UG/KG	NC		10000000	UG/KG	NC		60	UG/KG	NC		NC		60	UG/KG	TACO - SO to GW Class I
1,2,4-TRICHLOROBENZENE	120-82-1	3200000	UG/KG	NC		780000	UG/KG	NC		3200000	UG/KG	NC		20000000	UG/KG	NC		920000	UG/KG	NC		2000000	UG/KG	NC		5000	UG/KG	NC		NC		5000	UG/KG	TACO - SO to GW Class I
1,2-DIBROMOETHANE	106-93-4	60	UG/KG	NC		320	UG/KG	NC		120	UG/KG	NC		2900	UG/KG	NC		160	UG/KG	NC		62000	UG/KG	NC		0.4	UG/KG	NC		NC		0.4	UG/KG	TACO - SO to GW Class I
1,2-DICHLOROBENZENE	95-50-1	560000	UG/KG	NC		7000000	UG/KG	NC		560000	UG/KG	NC		180000000	UG/KG	NC		310000	UG/KG	NC		18000000	UG/KG	NC		17000	UG/KG	NC		NC		17000	UG/KG	TACO - SO to GW Class I
1,2-DICHLOROETHANE	107-06-2	400	UG/KG	NC		7000	UG/KG	NC		700	UG/KG	NC		63000	UG/KG	NC		990	UG/KG	NC		1400000	UG/KG	NC		20	UG/KG	NC		NC		20	UG/KG	TACO - SO to GW Class I
1,2-DICHLOROPROPANE	78-87-5	15000	UG/KG	NC		9000	UG/KG	NC		23000	UG/KG	NC		84000	UG/KG	NC		500	UG/KG	NC		1800000	UG/KG	NC		30	UG/KG	NC		NC		30	UG/KG	TACO - SO to GW Class I
1,3-DICHLOROBENZENE	541-73-1	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
1,4-DICHLOROBENZENE	106-46-7	11000000	UG/KG	NC		NC		NC		17000000	UG/KG	NC		NC		NC		340000	UG/KG	NC		NC		NC		2000	UG/KG	NC		NC		2000	UG/KG	TACO - SO to GW Class I
2-BUTANONE	78-93-3	NC		NC		NC		NC		NC		NC		NC		NC		NC		710000	UG/KG	NC		120000000	UG/KG	NC		NC		NC		NC		NC
2-HEXANONE	591-78-6	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
4-METHYL-2-PENTANONE	108-10-1	NC		3100000	UG/KG	NC		NC		NC		3100000	UG/KG	NC		NC		NC		340000	UG/KG	NC		NC		NC		NC		NC		340000	UG/KG	NON-TACO Const Worker
ACETONE	67-64-1	100000000	UG/KG	NC		70000000	UG/KG	NC		100000000	UG/KG	NC		NC		NC		100000000	UG/KG	NC		NC		NC		25000	UG/KG	NC		NC		25000	UG/KG	TACO - SO to GW Class I
BENZENE	71-43-2	800	UG/KG	NC		12000	UG/KG	NC		1600	UG/KG	NC		100000	UG/KG	NC		2200	UG/KG	NC		2300000	UG/KG	NC		30	UG/KG	NC		NC		30	UG/KG	TACO - SO to GW Class I
BROMODICHLOROMETHANE	75-27-4	3000000	UG/KG	NC		10000	UG/KG	NC		3000000	UG/KG	NC		92000	UG/KG	NC		3000000	UG/KG	NC		2000000	UG/KG	NC		600	UG/KG	NC		NC		600	UG/KG	TACO - SO to GW Class I
BROMOFORM	75-25-2	53000	UG/KG	NC		81000	UG/KG	NC		100000	UG/KG	NC		720000	UG/KG	NC		140000	UG/KG	NC		16000000	UG/KG	NC		800	UG/KG	NC		NC		800	UG/KG	TACO - SO to GW Class I
BROMOMETHANE	74-83-9	10000	UG/KG	NC		110000	UG/KG	NC		15000	UG/KG	NC		2900000	UG/KG	NC		3900	UG/KG	NC		1000000	UG/KG	NC		200	UG/KG	NC		NC		200	UG/KG	TACO - SO to GW Class I
CARBON DISULFIDE	75-15-0	720000	UG/KG	NC		7800000	UG/KG	NC		720000	UG/KG	NC		200000000	UG/KG	NC		9000	UG/KG	NC		20000000	UG/KG	NC		32000	UG/KG	NC		NC		9000	UG/KG	TACO Const Worker
CARBON TETRACHLORIDE	56-23-5	300	UG/KG	NC		5000	UG/KG	NC		640	UG/KG	NC		44000	UG/KG	NC		900	UG/KG	NC		410000	UG/KG	NC		70	UG/KG	NC		NC		70	UG/KG	TACO - SO to GW Class I
CHLOROBENZENE	108-90-7	130000	UG/KG	NC		1600000	UG/KG	NC		210000	UG/KG	NC		41000000	UG/KG	NC		1300	UG/KG	NC		4100000	UG/KG	NC		1000	UG/KG	NC		NC		1000	UG/KG	TACO - SO to GW Class I
CHLOROETHANE	75-00-3	NC		1500000	UG/KG	NC		NC		NC		1500000	UG/KG	NC		NC		NC		97000	UG/KG	NC		NC		NC		NC		NC		97000	UG/KG	NON-TACO Const Worker
CHLOROFORM	67-66-3	300	UG/KG	NC		100000	UG/KG	NC		540	UG/KG	NC		940000	UG/KG	NC		760	UG/KG	NC		2000000	UG/KG	NC		600	UG/KG	NC		NC		300	UG/KG	TACO Residential Ingestion
CHLOROMETHANE	74-87-3	NC		110000	UG/KG	NC		NC		NC		180000	UG/KG	NC		NC		NC		11000	UG/KG	NC		NC		NC		NC		NC		11000	UG/KG	NON-TACO Const Worker
1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	11000	UG/KG	NC		460	UG/KG	NC		17000	UG/KG	NC		4000	UG/KG	NC		110		NC		89000	UG/KG	NC		2	UG/KG	NC		NC		2	UG/KG	TACO - SO to GW Class I
CIS-1,2-DICHLOROETHENE	156-59-2	1200000	UG/KG	NC		780000	UG/KG	NC		1200000	UG/KG	NC		20000000	UG/KG	NC		1200000	UG/KG	NC		20000000	UG/KG	NC		400	UG/KG	NC		NC		400	UG/KG	TACO - SO to GW Class I
CIS-1,3-DICHLOROPROPENE	10061-01-5	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
CYCLOHEXANE	110-82-7	NC		280000	UG/KG	NC		NC		NC		280000	UG/KG	NC		NC		NC		110000	UG/KG	NC		NC		NC		NC		NC		110000	UG/KG	NON-TACO Const Worker
CHLORODIBROMOMETHANE	124-48-1	1300000	UG/KG	NC		1600000	UG/KG	NC		1300000	UG/KG	NC		41000000	UG/KG	NC		1300000	UG/KG	NC		41000000	UG/KG	NC		400	UG/KG	NC		NC		400	UG/KG	TACO - SO to GW Class I
DICHLORODIFLUOROMETHANE	75-71-8	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
ETHYLBENZENE	100-41-4	400000	UG/KG	NC		7800000	UG/KG	NC		400000	UG/KG	NC		200000000	UG/KG	NC		58000	UG/KG	NC		20000000	UG/KG	NC		13000	UG/KG	NC		NC		13000	UG/KG	TACO - SO to GW Class I
ISOPROPYLBENZENE	98-82-8	NC		NC		NC		NC		NC		NC		NC		NC		NC		51000	UG/KG	NC		NC		NC		NC		NC		51000	UG/KG	NON-TACO Const Worker
METHYL ACETATE	79-20-9	NC		27000000	UG/KG	NC		78000000	UG/KG	NC		27000000	UG/KG	NC		1000000000	UG/KG	NC		27000000	UG/KG	NC		1000000000	UG/KG	NC		29000	UG/KG	NC		29000	UG/KG	NON-TACO - SO to GW Class I
METHYL CYCLOHEXANE	108-87-2	NC		120000	UG/KG	NC		NC		NC		120000	UG/KG	NC		NC		NC		46000	UG/KG	NC		NC		NC		NC		NC		46000	UG/KG	NON-TACO Const Worker
METHYLENE CHLORIDE	75-09-2	13000	UG/KG	NC		85000	UG/KG	NC		24000	UG/KG	NC		760000	UG/KG	NC		34000	UG/KG	NC		12000000	UG/KG	NC		20	UG/KG	NC		NC		20	UG/KG	TACO - SO to GW Class I
METHYL TERT-BUTYL ETHER	1634-04-4	8800000	UG/KG	NC		780000	UG/KG	NC		8800000	UG/KG	NC		20000000	UG/KG	NC		140000	UG/KG	NC		2000000	UG/KG	NC		320	UG/KG	NC		NC		320	UG/KG	TACO - SO to GW Class I
STYRENE	100-42-5	1500000	UG/KG	NC		16000000	UG/KG	NC		1500000	UG/KG	NC		410000000	UG/KG	NC		430000	UG/KG	NC		41000000	UG/KG	NC		4000	UG/KG	NC		NC		4000	UG/KG	TACO - SO to GW Class I
TETRACHLOROETHENE	127-18-4	11000	UG/KG	NC		12000	UG/KG	NC		20000	UG/KG	NC		110000	UG/KG	NC		28000	UG/KG	NC		2400000	UG/KG	NC		60	UG/KG	NC		NC		60	UG/KG	TACO - SO to GW Class I
TOLUENE	108-88-3	650000	UG/KG	NC		16000000	UG/KG	NC		650000	UG/KG	NC		410000000	UG/KG	NC		42000	UG/KG	NC		410000000	UG/KG	NC		12000	UG/KG	NC		NC		12000	UG/KG	TACO - SO to GW Class I
TRANS-1,2-DICHLOROETHENE	156-60-5	3100000	UG/KG	NC		1600000	UG/KG	NC		3100000	UG/KG	NC		41000000	UG/KG	NC		3100000	UG/KG	NC		41000000	UG/KG	NC		700	UG/KG	NC		NC		700	UG/KG	TACO - SO to GW Class I
TRANS-1,3-DICHLOROPROPENE	10061-02-6	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
TRICHLOROETHENE	79-01-6	5000	UG/KG	NC		58000	UG/KG	NC		8900	UG/KG	NC		520000	UG/KG	NC		12000	UG/KG	NC		1200000	UG/KG	NC		60	UG/KG	NC		NC		60	UG/KG	TACO - SO to GW Class I
TRICHLOROFLUOROMETHANE	75-69-4	NC		NC		NC		NC		NC		NC		NC		NC		NC		88000	UG/KG	NC		140000000	UG/KG	NC		NC		NC		NC		NC
1,1,2-TRICHLOROTRIFLUOROETHANE	76-13-1	NC		1000000	UG/KG	NC		1000000000	UG/KG	NC		1000000	UG/KG	NC		1000000000	UG/KG									NC		11000000	UG/KG	NC		1000000	UG/KG	NON-TACO Residential Ingestion
VINYL CHLORIDE	75-01-4	280	UG/KG	NC		460	UG/KG	NC		1100	UG/KG	NC		7900	UG/KG	NC		1100	UG/KG	NC		170000	UG/KG	NC		10	UG/KG	NC		NC		10	UG/KG	TACO - SO to GW Class I
TOTAL XYLENES	1330-20-7	320000	UG/KG	NC		16000000	UG/KG	NC		320000	UG/KG	NC		410000000	UG/KG	NC		5600		NC		41000000	UG/KG	NC		150000	UG/KG	NC		NC		5600	UG/KG	TACO Const Worker
PESTICIDES (SW-846 METHODS 3510C/3520C/3550B/8081A)																																		
4,4'-DDD	72-54-8	NC		NC		3000	UG/KG	NC		NC		NC		24000	UG/KG	NC		NC		NC		520000	UG/KG	NC		16000	UG/KG	NC		NC		3000	UG/KG	TACO Residential Ingestion
4,4'-DDE	72-55-9	NC		NC		2000	UG/KG	NC		NC		NC		17000	UG/KG	NC		NC		NC		370000	UG/KG	NC		54000	UG/KG	NC		NC		2000	UG/KG	TACO Residential Ingestion
4,4'-DDT	50-29-3	NC		NC		2000	UG/KG	NC		1500000	UG/KG	NC		17000	UG/KG	NC		2100000	UG/KG	NC		100000	UG/KG	NC		32000	UG/KG	NC		NC		2000	UG/KG	TACO Residential Ingestion
Aldrin	309-00-2	3000	UG/KG	NC		40	UG/KG	NC		6600	UG/KG	NC		300	UG/KG	NC		9300	UG/KG	NC		6100	UG/KG	NC		500	UG/KG	NC		NC		40	UG/KG	TACO Residential Ingestion
alpha-BHC (alpha-HCH)	319-84-6	800	UG/KG	NC		100	UG/KG	NC		1500	UG/KG	NC		900	UG/KG	NC		2100	UG/KG	NC		20000	UG/KG	NC		0.5	UG/KG	NC		NC		0.5	UG/KG	TACO - SO to GW Class I
alpha-Chlordane	5103-71-9	E CHLORDANE		NC		USE CHLORDANE		NC		USE CHLORDANE		NC		USE CHLORDANE		NC		USE CHLORDANE		NC		USE CHLORDANE		NC		USE CHLORDANE		NC		NC		NC		NC
beta-BHC	319-85-7	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC
delta-BHC	319-86-8	NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC		NC

TABLE F-1A
REFERENCE DATA FOR PROJECT ACTION LIMITS -
ILLINOIS TACO VALUES
SITE 12
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CORRECTED PARAMETER	CORRECTED CAS	TACO Residential Inhalation (1)		NON-TACO Residential Ingestion (3)		TACO Residential Ingestion (1)		NON-TACO Residential Ingestion (3)		TACO Industrial Inhalation (2)		NON-TACO Industrial Inhalation (4)		TACO Industrial Ingestion (2)		NON-TACO Industrial Ingestion(4)		TACO - Construction Worker Soil Inhalation(2)		NON-TACO - Construction Worker Soil Inhalation(4)		TACO - Construction Worker Soil Ingestion(2)		NON-TACO - Construction Worker Soil Ingestion(4)		TACO - SO to GW Class I (1)		NON-TACO - SO to GW Class I (3)		TACO pH Specific Criteria		Minimum IL Criteria		MINIMUM IL BASIS
Dieldrin	60-57-1	1000	UG/KG	NC		40	UG/KG	NC		2200	UG/KG	NC		400	UG/KG	NC		3100	UG/KG	NC		7800	UG/KG	NC		4	UG/KG	NC		NC		4	UG/KG	TACO - SO to GW Class I
Endosulfan	115-29-7	NC		NC		470000	UG/KG	NC		NC		NC		12000000	UG/KG	NC		NC		NC		1200000	UG/KG	NC		18000	UG/KG	NC		NC		18000	UG/KG	TACO - SO to GW Class I
Endosulfan I	959-98-8	E ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		NC		NC		NC
Endosulfan II	33213-65-9	E ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		NC		NC		NC
Endosulfan sulfate	1031-07-8	E ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		USE ENDOSULFAN		NC		NC		NC		NC
Endrin	72-20-8	NC		NC		23000	UG/KG	NC		NC		NC		610000	UG/KG	NC		NC		NC		61000	UG/KG	NC		1000	UG/KG	NC		NC		1000	UG/KG	TACO - SO to GW Class I
Endrin aldehyde	7421-93-4	JSE ENDRIN		NC		USE ENDRIN		NC		USE ENDRIN		NC		USE ENDRIN		NC		USE ENDRIN		NC		USE ENDRIN		NC		USE ENDRIN		NC		NC		NC		NC
Endrin ketone	53494-70-5	JSE ENDRIN		NC		USE ENDRIN		NC		USE ENDRIN		NC		USE ENDRIN		NC		USE ENDRIN		NC		USE ENDRIN		NC		USE ENDRIN		NC		NC		NC		NC
gamma-BHC (Lindane)	58-89-9	NC		NC		500	UG/KG	NC		NC		NC		4000	UG/KG	NC		NC		NC		96000	UG/KG	NC		9	UG/KG	NC		NC		9	UG/KG	TACO - SO to GW Class I
gamma-Chlordane	5103-74-2	E CHLORDANE		NC		USE CHLORDANE		NC		USE CHLORDANE		NC		USE CHLORDANE		NC		USE CHLORDANE		NC		USE CHLORDANE		NC		USE CHLORDANE		NC		NC		NC		NC
Heptachlor	76-44-8	100	UG/KG	NC		100	UG/KG	NC		11000	UG/KG	NC		1000	UG/KG	NC		16000	UG/KG	NC		28000	UG/KG	NC		23000	UG/KG	NC		NC		100	UG/KG	TACO Residential Ingestion
Heptachlor epoxide	1024-57-3	5000	UG/KG	NC		70	UG/KG	NC		3200	UG/KG	NC		600	UG/KG	NC		13000	UG/KG	NC		2700	UG/KG	NC		700	UG/KG	NC		NC		70	UG/KG	TACO Residential Ingestion
Methoxychlor	72-43-5	NC		NC		390000	UG/KG	NC		NC		NC		10000000	UG/KG	NC		NC		NC		1000000	UG/KG	NC		160000	UG/KG	NC		NC		160000	UG/KG	NC
Toxaphene	8001-35-2	89000	UG/KG	NC		600	UG/KG	NC		170000	UG/KG	NC		5200	UG/KG	NC		240000	UG/KG	NC		110000	UG/KG	NC		31000	UG/KG	NC		NC		600	UG/KG	TACO Residential Ingestion

NA = not available; no criteria is available for that parameter for that chemical
1 - Section 742 Table A, Tier 1 Soil Remediation Objectives for Residential Properties (Ingestion, Inhalation, or Soil Component of Groundwater Ingestion Route)(Online July, 2008).
2 - Section 742 Table B, Tier 1 Soil Remediation Objectives for Industrial/Commercial Properties (Ingestion or Inhalation) (Online July, 2008).
3 - Soil Remediation Objectives for Residential Properties, Non-TACO Chemicals (May 1, 2007)
4 - Soil Remediation Objectives for Indusrial/Commercial Properties, Non-TACO Chemicals (May 1, 2007)
5 - Oak Ridge National Laboratory Regional Screening Level (ORNL, September 12, 2008)

Definitions:
C - Carcinogen
s - Concentration may exceeed soil saturation concentration.
DAF - Dilution Attneuation Factor
TACO - Tiered Approach to Corrective Action Objectives
N - Noncarcinogen
NC - Not Criteria: no criteria is available for that parameter for that chemical
sat - Soil Saturation Concentration
GW - Groundwater
SO - Soil
IL - Illinois
SSL - Soil Screening Limits

TABLE F-1B
REFERENCE DATA FOR PROJECT ACTION LIMITS -
USEPA and OVERALL BASIS VALUES
SITE 12
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CORRECTED PARAMETER	CORRECTED CAS	USEPA ORNL Residential Soil (5)		USEPA ORNL Risk Based SSLs (5)		USEPA ORNL SSLs for Residential Inhalation (5)		Minimum Federal Criteria		MIN FEDERAL BASIS	OVERALL MINIMUM		OVERALL BASIS
SEMIVOLATILES													
BIS(2-CHLOROETHYL)ETHER	111-44-4	210	UG/KG	0.031	UG/KG	240	UG/KG	0.031	UG/KG	USEPA Risk Based SSLs	0.031	UG/KG	USEPA Risk Based SSLs
2-CHLOROPHENOL	95-57-8	390000	UG/KG	150	UG/KG	NC		150	UG/KG	USEPA Risk Based SSLs	150	UG/KG	USEPA Risk Based SSLs
PHENOL	108-95-2	18000000	UG/KG	6300	UG/KG	NC		6300	UG/KG	USEPA Risk Based SSLs	6300	UG/KG	USEPA Risk Based SSLs
HEXACHLOROETHANE	67-72-1	35000	UG/KG	2.9	UG/KG	54000	UG/KG	2.9	UG/KG	USEPA Risk Based SSLs	2.9	UG/KG	USEPA Risk Based SSLs
N-NITROSO-DI-N-PROPYLAMINE	621-64-7	69	UG/KG	0.0072	UG/KG	NC		0.0072	UG/KG	USEPA Risk Based SSLs	0.0072	UG/KG	USEPA Risk Based SSLs
NITROBENZENE	98-95-3	4800	UG/KG	0.079	UG/KG	90000	UG/KG	0.079	UG/KG	USEPA Risk Based SSLs	0.079	UG/KG	USEPA Risk Based SSLs
2-METHYLPHENOL	95-48-7	3100000	UG/KG	1500	UG/KG	NC		1500	UG/KG	USEPA Risk Based SSLs	1500	UG/KG	USEPA Risk Based SSLs
ISOPHORONE	78-59-1	510000	UG/KG	23	UG/KG	NC		23	UG/KG	USEPA Risk Based SSLs	23	UG/KG	USEPA Risk Based SSLs
4-METHYLPHENOL	106-44-5	310000	UG/KG	150	UG/KG	NC		150	UG/KG	USEPA Risk Based SSLs	150	UG/KG	USEPA Risk Based SSLs
1,1-BIPHENYL	92-52-4	3900000	UG/KG	19000	UG/KG	NC		19000	UG/KG	USEPA Risk Based SSLs	19000	UG/KG	USEPA Risk Based SSLs
2,2'-OXYBIS(1-CHLOROPROPANE)	108-60-1	4600	UG/KG	0.12	UG/KG	6900	UG/KG	0.12	UG/KG	USEPA Risk Based SSLs	0.12	UG/KG	USEPA Risk Based SSLs
2,4,5-TRICHLOROPHENOL	95-95-4	6100000	UG/KG	14000	UG/KG	NC		14000	UG/KG	USEPA Risk Based SSLs	14000	UG/KG	USEPA Risk Based SSLs
2,4,6-TRICHLOROPHENOL	88-06-2	44000	UG/KG	23	UG/KG	200000	UG/KG	23	UG/KG	USEPA Risk Based SSLs	23	UG/KG	USEPA Risk Based SSLs
2,4-DICHLOROPHENOL	120-83-2	180000	UG/KG	130	UG/KG	NC		130	UG/KG	USEPA Risk Based SSLs	130	UG/KG	USEPA Risk Based SSLs
2,4-DIMETHYLPHENOL	105-67-9	1200000	UG/KG	860	UG/KG	NC		860	UG/KG	USEPA Risk Based SSLs	860	UG/KG	USEPA Risk Based SSLs
2,4-DINITROPHENOL	51-28-5	120000	UG/KG	82	UG/KG	NC		82	UG/KG	USEPA Risk Based SSLs	82	UG/KG	USEPA Risk Based SSLs
2,4-DINITROTOLUENE	121-14-2	1600	UG/KG	0.29	UG/KG	NC		0.29	UG/KG	USEPA Risk Based SSLs	0.29	UG/KG	USEPA Risk Based SSLs
2,6-DINITROTOLUENE	606-20-2	61000	UG/KG	50	UG/KG	NC		50	UG/KG	USEPA Risk Based SSLs	0.7	UG/KG	TACO - SO to GW Class I
2-CHLORONAPHTHALENE	91-58-7	6300000	UG/KG	15000	UG/KG	NC		15000	UG/KG	USEPA Risk Based SSLs	15000	UG/KG	USEPA Risk Based SSLs
2-NITROANILINE	88-74-4	610000	UG/KG	150	UG/KG	1200	UG/KG	150	UG/KG	USEPA Risk Based SSLs	140	UG/KG	NON-TACO - SO to GW Class I
2-NITROPHENOL	88-75-5	NC		NC		NC		NC		NC	NC		NC
3,3'-DICHLOROBENZIDINE	91-94-1	1100	UG/KG	0.98	UG/KG	NC		0.98	UG/KG	USEPA Risk Based SSLs	0.98	UG/KG	USEPA Risk Based SSLs
3-NITROANILINE	99-09-2	NC		NC		1.42E+09	UG/KG	1.42E+09	UG/KG	USEPA SSLs for Residential Inhalation	10	UG/KG	NON-TACO - SO to GW Class I
4,6-DINITRO-2-METHYLPHENOL	534-52-1	6100	UG/KG	6.2	UG/KG	NC		6.2	UG/KG	USEPA Risk Based SSLs	3.1	UG/KG	NON-TACO SO to GW Class I pH Spec
4-BROMOPHENYL PHENYL ETHER	101-55-3	NC		NC		NC		NC		NC	NC		NC
4-CHLORO-3-METHYLPHENOL	59-50-7	6100000	UG/KG	4300	UG/KG	NC		4300	UG/KG	USEPA Risk Based SSLs	4300	UG/KG	USEPA Risk Based SSLs
4-CHLOROANILINE	106-47-8	2400	UG/KG	0.14	UG/KG	NC		0.14	UG/KG	USEPA Risk Based SSLs	0.14	UG/KG	USEPA Risk Based SSLs
4-CHLOROPHENYL PHENYL ETHER	7005-72-3	NC		NC		NC		NC		NC	NC		NC
4-NITROANILINE	100-01-6	24000	UG/KG	1.4	UG/KG	5.67E+09	UG/KG	1.4	UG/KG	USEPA Risk Based SSLs	1.4	UG/KG	USEPA Risk Based SSLs
4-NITROPHENOL	100-02-7	NC		NC		NC		NC		NC	NC		NC
ACETOPHENONE	98-86-2	7800000	UG/KG	1100	UG/KG	NC		1100	UG/KG	USEPA Risk Based SSLs	1100	UG/KG	USEPA Risk Based SSLs
ATRAZINE	1912-24-9	2100	UG/KG	0.19	UG/KG	NC		0.19	UG/KG	USEPA Risk Based SSLs	0.19	UG/KG	USEPA Risk Based SSLs
BENZALDEHYDE	100-52-7	7800000	UG/KG	810	UG/KG	NC		810	UG/KG	USEPA Risk Based SSLs	810	UG/KG	USEPA Risk Based SSLs
BIS(2-CHLOROETHOXY)METHANE	111-91-1	180000	UG/KG	25	UG/KG	NC		25	UG/KG	USEPA Risk Based SSLs	25	UG/KG	USEPA Risk Based SSLs
BIS(2-ETHYLHEXYL)PHTHALATE	117-81-7	35000	UG/KG	1100	UG/KG	NC		1100	UG/KG	USEPA Risk Based SSLs	1100	UG/KG	USEPA Risk Based SSLs
BUTYL BENZYL PHTHALATE	85-68-7	260000	UG/KG	510	UG/KG	NC		510	UG/KG	USEPA Risk Based SSLs	510	UG/KG	USEPA Risk Based SSLs
CAPROLACTAM	105-60-2	31000000	UG/KG	4500	UG/KG	NC		4500	UG/KG	USEPA Risk Based SSLs	4500	UG/KG	USEPA Risk Based SSLs
CARBAZOLE	86-74-8	NC		NC		NC		NC		NC	600	UG/KG	TACO - SO to GW Class I
DIBENZOFURAN	132-64-9	NC		NC		NC		NC			82000	UG/KG	NON-TACO Const Worker
DIETHYL PHTHALATE	84-66-2	49000000	UG/KG	12000	UG/KG	NC		12000	UG/KG	USEPA Risk Based SSLs	12000	UG/KG	USEPA Risk Based SSLs
DIMETHYL PHTHALATE	131-11-3	NC		NC		NC		NC		NC	NC		NC
DI-N-BUTYL PHTHALATE	84-74-2	6100000	UG/KG	9200	UG/KG	NC		9200	UG/KG	USEPA Risk Based SSLs	9200	UG/KG	USEPA Risk Based SSLs
DI-N-OCTYL PHTHALATE	117-84-0	NC		NC		NC		NC		NC	1600000	UG/KG	TACO Residential Ingestion
HEXACHLOROBENZENE	118-74-1	300	UG/KG	0.53	UG/KG	950	UG/KG	0.53	UG/KG	USEPA Risk Based SSLs	0.53	UG/KG	USEPA Risk Based SSLs
HEXACHLOROBUTADIENE	87-68-3	6200	UG/KG	1.7	UG/KG	7800	UG/KG	1.7	UG/KG	USEPA Risk Based SSLs	1.7	UG/KG	USEPA Risk Based SSLs
HEXACHLOROCYCLOPENTADIENE	77-47-4	370000	UG/KG	160	UG/KG	29000	UG/KG	160	UG/KG	USEPA MCL Based SSLs	160	UG/KG	USEPA MCL Based SSLs
N-NITROSODIPHENYLAMINE	86-30-6	99000	UG/KG	75	UG/KG	NC		75	UG/KG	USEPA Risk Based SSLs	75	UG/KG	USEPA Risk Based SSLs
PENTACHLOROPHENOL	87-86-5	3000	UG/KG	5.7	UG/KG	NC		5.7	UG/KG	USEPA Risk Based SSLs	5.7	UG/KG	USEPA Risk Based SSLs
POLYNUCLEAR AROMATIC HYDROCARBONS													
ACENAPHTHENE	83-32-9	3400000	UG/KG	22000	UG/KG	NC		22000	UG/KG	USEPA Risk Based SSLs	22000	UG/KG	USEPA Risk Based SSLs
ACENAPHTHYLENE	208-96-8	NC		NC		NC		NC			85000	UG/KG	NON-TACO - SO to GW Class I
ANTHRACENE	120-12-7	17000000	UG/KG	360000	UG/KG	NC		360000	UG/KG	USEPA Risk Based SSLs	360000	UG/KG	USEPA Risk Based SSLs
BENZO(A)ANTHRACENE	56-55-3	150	UG/KG	10	UG/KG	NC		10	UG/KG	USEPA Risk Based SSLs	10	UG/KG	USEPA Risk Based SSLs
BENZO(A)PYRENE	50-32-8	15	UG/KG	3.5	UG/KG	NC		3.5	UG/KG	USEPA Risk Based SSLs	3.5	UG/KG	USEPA Risk Based SSLs
BENZO(B)FLUORANTHENE	205-99-2	150	UG/KG	35	UG/KG	NC		35	UG/KG	USEPA Risk Based SSLs	35	UG/KG	USEPA Risk Based SSLs
BENZO(G,H,I)PERYLENE	191-24-2	NC		NC	UG/KG	NC		NC			2300000	UG/KG	NON-TACO Residential Ingestion
BENZO(K)FLUORANTHENE	207-08-9	1500	UG/KG	350	UG/KG	NC		350	UG/KG	USEPA Risk Based SSLs	350	UG/KG	USEPA Risk Based SSLs
CHRYSENE	218-01-9	15000	UG/KG	1100	UG/KG	NC		1100	UG/KG	USEPA Risk Based SSLs	1100	UG/KG	USEPA Risk Based SSLs
DIBENZO(A,H)ANTHRACENE	53-70-3	15	UG/KG	11	UG/KG	NC		11	UG/KG	USEPA Risk Based SSLs	11	UG/KG	USEPA Risk Based SSLs
FLUORANTHENE	206-44-0	2300000	UG/KG	160000	UG/KG	NC		160000	UG/KG	USEPA Risk Based SSLs	160000	UG/KG	USEPA Risk Based SSLs
FLUORENE	86-73-7	2300000	UG/KG	27000	UG/KG	NC		27000	UG/KG	USEPA Risk Based SSLs	27000	UG/KG	USEPA Risk Based SSLs
2-METHYLNAPHTHALENE	91-57-6	310000	UG/KG	750	UG/KG	NC		750	UG/KG	USEPA Risk Based SSLs	750	UG/KG	USEPA Risk Based SSLs
INDENO(1,2,3-CD)PYRENE	193-39-5	150	UG/KG	120	UG/KG	NC		120	UG/KG	USEPA Risk Based SSLs	120	UG/KG	USEPA Risk Based SSLs
NAPHTHALENE	91-20-3	3600	UG/KG	0.47	UG/KG	170000	UG/KG	0.47	UG/KG	USEPA Risk Based SSLs	0.47	UG/KG	USEPA Risk Based SSLs
PHENANTHRENE	85-01-8	NC		NC		NC		NC			200000	UG/KG	NON-TACO - SO to GW Class I
PYRENE	129-00-0	1700000	UG/KG	120000	UG/KG	NC		120000	UG/KG	USEPA Risk Based SSLs	120000	UG/KG	USEPA Risk Based SSLs
PCBs													
AROCLOR-1016	12674-11-2	3900	UG/KG	92	UG/KG	NC		92	UG/KG	USEPA Risk Based SSLs	92	UG/KG	USEPA Risk Based SSLs
AROCLOR-1221	11104-28-2	140	UG/KG	0.12	UG/KG	NC		0.12	UG/KG	USEPA Risk Based SSLs	0.12	UG/KG	USEPA Risk Based SSLs
AROCLOR-1232	11141-16-5	140	UG/KG	0.12	UG/KG	NC		0.12	UG/KG	USEPA Risk Based SSLs	0.12	UG/KG	USEPA Risk Based SSLs
AROCLOR-1242	53469-21-9	220	UG/KG	5.3	UG/KG	NC		5.3	UG/KG	USEPA Risk Based SSLs	5.3	UG/KG	USEPA Risk Based SSLs
AROCLOR-1248	12672-29-6	220	UG/KG	5.2	UG/KG	NC		5.2	UG/KG	USEPA Risk Based SSLs	5.2	UG/KG	USEPA Risk Based SSLs
AROCLOR-1254	11097-69-1	220	UG/KG	8.8	UG/KG	NC		8.8	UG/KG	USEPA Risk Based SSLs	8.8	UG/KG	USEPA Risk Based SSLs
AROCLOR-1260	11096-82-5	220	UG/KG	24	UG/KG	NC		24	UG/KG	USEPA Risk Based SSLs	24	UG/KG	USEPA Risk Based SSLs
TOTAL AROCLOR	1336-36-3	220	UG/KG	NC		NC		220	UG/KG	USEPA Residential Soil	220	UG/KG	USEPA Residential Soil
INORGANICS													
ALUMINUM	7429-90-5	77000	MG/KG	55000	MG/KG	7090000	MG/KG	55000	MG/KG	USEPA Risk Based SSLs	55000	MG/KG	USEPA Risk Based SSLs
ANTIMONY	7440-36-0	31	MG/KG	0.66	MG/KG	NC		0.66	MG/KG	USEPA Risk Based SSLs	0.66	MG/KG	USEPA Risk Based SSLs
ARSENIC	7440-38-2	0.39	MG/KG	0.0013	MG/KG	769	MG/KG	0.0013	MG/KG	USEPA Risk Based SSLs	0.0013	MG/KG	USEPA Risk Based SSLs
BARIUM	7440-39-3	15000	MG/KG	300	MG/KG	709000	MG/KG	300	MG/KG	USEPA Risk Based SSLs	300	MG/KG	USEPA Risk Based SSLs
BERYLLIUM	7440-41-7	160	MG/KG	58	MG/KG	1380	MG/KG	58	MG/KG	USEPA Risk Based SSLs	58	MG/KG	USEPA Risk Based SSLs
CADMIUM	7440-43-9	70	MG/KG	1.4	MG/KG	1840	MG/KG	1.4	MG/KG	USEPA Risk Based SSLs	1.4	MG/KG	USEPA Risk Based SSLs
CALCIUM	7440-70-2	NC		NC		NC		0	MG/KG	NC	0	MG/KG	NC
CHROMIUM	7440-47-3	NC		NC		276	MG/KG	276	MG/KG	USEPA SSLs for Residential Inhalation	230	MG/KG	TACO Residential Ingestion
COBALT	7440-48-4	23	MG/KG	0.49	MG/KG	1180	MG/KG	0.49	MG/KG	USEPA Risk Based SSLs	0.49	MG/KG	USEPA Risk Based SSLs
COPPER	7440-50-8	3100	MG/KG	51	MG/KG	NC		51	MG/KG	USEPA Risk Based SSLs	51	MG/KG	USEPA Risk Based SSLs
IRON	7439-89-6	55000	MG/KG	640	MG/KG	NC		640	MG/KG	USEPA Risk Based SSLs	640	MG/KG	USEPA Risk Based SSLs
LEAD	7439-92-1	400	MG/KG	NC		NC		400	MG/KG	USEPA Residential Soil	107	MG/KG	TACO pH Specific Criteria
MAGNESIUM	7439-95-4	NC		NC		NC		0	MG/KG	NC	0	MG/KG	NC
MANGANESE	7439-96-5	1800	MG/KG	57	MG/KG	70900	MG/KG	57	MG/KG	USEPA Risk Based SSLs	57	MG/KG	USEPA Risk Based SSLs

TABLE F-1B
REFERENCE DATA FOR PROJECT ACTION LIMITS -
USEPA and OVERALL BASIS VALUES
SITE 12
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CORRECTED PARAMETER	CORRECTED CAS	USEPA ORNL Residential Soil (5)		USEPA ORNL Risk Based SSLs (5)		USEPA ORNL SSLs for Residential Inhalation (5)		Minimum Federal Criteria		MIN FEDERAL BASIS	OVERALL MINIMUM		OVERALL BASIS
MERCURY	7439-97-6	5.6	MG/KG	0.03	MG/KG	2.9	MG/KG	0.03	MG/KG	USEPA Risk Based SSLs	0.03	MG/KG	USEPA Risk Based SSLs
NICKEL	7440-02-0	1500	MG/KG	48	MG/KG	NC		48	MG/KG	USEPA Risk Based SSLs	48	MG/KG	USEPA Risk Based SSLs
POTASSIUM	7440-09-7	NC		NC		NC		0	MG/KG	NC	0	MG/KG	NC
SELENIUM	7782-49-2	390	MG/KG	0.95	MG/KG	NC		0.95	MG/KG	USEPA Risk Based SSLs	0.95	MG/KG	USEPA Risk Based SSLs
SILVER	7440-22-4	390	MG/KG	1.6	MG/KG	NC		1.6	MG/KG	USEPA Risk Based SSLs	1.6	MG/KG	USEPA Risk Based SSLs
SODIUM	7440-23-5	NC		NC		NC		0	MG/KG	NC	0	MG/KG	NC
THALLIUM	7440-28-0	NC		NC		NC		0	MG/KG	NC	0	MG/KG	NC
VANADIUM	7440-62-2	390	MG/KG	180	MG/KG	NC		180	MG/KG	USEPA Risk Based SSLs	180	MG/KG	USEPA Risk Based SSLs
ZINC	7440-66-6	23000	MG/KG	680	MG/KG	NC		680	MG/KG	USEPA Risk Based SSLs	680	MG/KG	USEPA Risk Based SSLs
TCLP-INORGANICS													
ALUMINUM	7429-90-5	NC		NC		NC		NC		NC	3.5	MG/L	NON-TACO - SO to GW Class I
ANTIMONY	7440-36-0	NC		NC		NC		NC		NC	0.006	MG/L	TACO - SO to GW Class I
ARSENIC	7440-38-2	NC		NC		NC		NC		NC	0.05	MG/L	TACO - SO to GW Class I
BARIUM	7440-39-3	NC		NC		NC		NC		NC	2	MG/L	TACO - SO to GW Class I
BERYLLIUM	7440-41-7	NC		NC		NC		NC		NC	0.004	MG/L	TACO - SO to GW Class I
CADMIUM	7440-43-9	NC		NC		NC		NC		NC	0.005	MG/L	TACO - SO to GW Class I
CALCIUM	7440-70-2	NC		NC		NC		NC		NC	NC		NC
CHROMIUM	7440-47-3	NC		NC		NC		NC		NC	0.1	MG/L	TACO - SO to GW Class I
COBALT	7440-48-4	NC		NC		NC		NC		NC	1	MG/L	TACO - SO to GW Class I
COPPER	7440-50-8	NC		NC		NC		NC		NC	0.65	MG/L	TACO - SO to GW Class I
IRON	7439-89-6	NC		NC		NC		NC		NC	5	MG/L	TACO - SO to GW Class I
LEAD	7439-92-1	NC		NC		NC		NC		NC	0.0075	MG/L	TACO - SO to GW Class I
MAGNESIUM	7439-95-4	NC		NC		NC		NC		NC	NC		NC
MANGANESE	7439-96-5	NC		NC		NC		NC		NC	0.15	MG/L	TACO - SO to GW Class I
MERCURY	7439-97-6	NC		NC		NC		NC		NC	0.002	MG/L	TACO - SO to GW Class I
NICKEL	7440-02-0	NC		NC		NC		NC		NC	0.1	MG/L	TACO - SO to GW Class I
POTASSIUM	7440-09-7	NC		NC		NC		NC		NC	NC		NC
SELENIUM	7782-49-2	NC		NC		NC		NC		NC	0.05	MG/L	TACO - SO to GW Class I
SILVER	7440-22-4	NC		NC		NC		NC		NC	0.05	MG/L	TACO - SO to GW Class I
SODIUM	7440-23-5	NC		NC		NC		NC		NC	NC		NC
THALLIUM	7440-28-0	NC		NC		NC		NC		NC	0.002	MG/L	TACO - SO to GW Class I
VANADIUM	7440-62-2	NC		NC		NC		NC		NC	0.049	MG/L	TACO - SO to GW Class I
ZINC	7440-66-6	NC		NC		NC		NC		NC	5	MG/L	TACO - SO to GW Class I
VOLATILE ORGANICS													
1,1,1-TRICHLOROETHANE	71-55-6	8700000	UG/KG	3200	UG/KG	1200000	UG/KG	3200	UG/KG	USEPA Risk Based SSLs	2000	UG/KG	TACO - SO to GW Class I
1,1,2,2-TETRACHLOROETHANE	79-34-5	560	UG/KG	0.026	UG/KG	580	UG/KG	0.026	UG/KG	USEPA Risk Based SSLs	0.026	UG/KG	USEPA Risk Based SSLs
1,1,2-TRICHLOROETHANE	79-00-5	1100	UG/KG	0.078	UG/KG	970	UG/KG	0.078	UG/KG	USEPA Risk Based SSLs	0.078	UG/KG	USEPA Risk Based SSLs
1,1-DICHLOROETHANE	75-34-3	3300	UG/KG	0.69	UG/KG	1200000	UG/KG	0.69	UG/KG	USEPA Risk Based SSLs	0.69	UG/KG	USEPA Risk Based SSLs
1,1-DICHLOROETHENE	75-35-4	240000	UG/KG	120	UG/KG	290000	UG/KG	120	UG/KG	USEPA Risk Based SSLs	60	UG/KG	TACO - SO to GW Class I
1,2,4-TRICHLOROBENZENE	120-82-1	22000	UG/KG	6.8	UG/KG	180000	UG/KG	6.8	UG/KG	USEPA Risk Based SSLs	6.8	UG/KG	USEPA Risk Based SSLs
1,2-DIBROMOETHANE	106-93-4	34	UG/KG	0.0018	UG/KG	0.1	UG/KG	0.0018	UG/KG	USEPA Risk Based SSLs	0.0018	UG/KG	USEPA Risk Based SSLs
1,2-DICHLOROBENZENE	95-50-1	1900000	UG/KG	360	UG/KG	600000	UG/KG	360	UG/KG	USEPA Risk Based SSLs	360	UG/KG	USEPA Risk Based SSLs
1,2-DICHLOROETHANE	107-06-2	430	UG/KG	0.042	UG/KG	360	UG/KG	0.042	UG/KG	USEPA Risk Based SSLs	0.042	UG/KG	USEPA Risk Based SSLs
1,2-DICHLOROPROPANE	78-87-5	890	UG/KG	0.13	UG/KG	15000	UG/KG	0.13	UG/KG	USEPA Risk Based SSLs	0.13	UG/KG	USEPA Risk Based SSLs
1,3-DICHLOROBENZENE	541-73-1	NC		NC		NC		NC		NC	NC		NC
1,4-DICHLOROBENZENE	106-46-7	2400	UG/KG	0.41	UG/KG	11000000	UG/KG	0.41	UG/KG	USEPA Risk Based SSLs	0.41	UG/KG	USEPA Risk Based SSLs
2-BUTANONE	78-93-3	28000000	UG/KG	1500	UG/KG	24000000	UG/KG	1500	UG/KG	USEPA Risk Based SSLs	1500	UG/KG	USEPA Risk Based SSLs
2-HEXANONE	591-78-6	210000	UG/KG	11	UG/KG	NC		11	UG/KG	USEPA Risk Based SSLs	11	UG/KG	USEPA Risk Based SSLs
4-METHYL-2-PENTANONE	108-10-1	5300000	UG/KG	450	UG/KG	2700000	UG/KG	450	UG/KG	USEPA Risk Based SSLs	450	UG/KG	USEPA Risk Based SSLs
ACETONE	67-64-1	61000000	UG/KG	4500	UG/KG	NC		4500	UG/KG	USEPA Risk Based SSLs	4500	UG/KG	USEPA Risk Based SSLs
BENZENE	71-43-2	1100	UG/KG	0.21	UG/KG	830	UG/KG	0.21	UG/KG	USEPA Risk Based SSLs	0.21	UG/KG	USEPA Risk Based SSLs
BROMODICHLOROMETHANE	75-27-4	270	UG/KG	0.032	UG/KG	NC		0.032	UG/KG	USEPA Risk Based SSLs	0.032	UG/KG	USEPA Risk Based SSLs
BROMOFORM	75-25-2	61000	UG/KG	2.3	UG/KG	52000	UG/KG	2.3	UG/KG	USEPA Risk Based SSLs	2.3	UG/KG	USEPA Risk Based SSLs
BROMOMETHANE	74-83-9	7300	UG/KG	2.2	UG/KG	9400	UG/KG	2.2	UG/KG	USEPA Risk Based SSLs	2.2	UG/KG	USEPA Risk Based SSLs
CARBON DISULFIDE	75-15-0	820000	UG/KG	310	UG/KG	720000	UG/KG	310	UG/KG	USEPA Risk Based SSLs	310	UG/KG	USEPA Risk Based SSLs
CARBON TETRACHLORIDE	56-23-5	250	UG/KG	0.077	UG/KG	330	UG/KG	0.077	UG/KG	USEPA Risk Based SSLs	0.077	UG/KG	USEPA Risk Based SSLs
CHLOROBENZENE	108-90-7	290000	UG/KG	62	UG/KG	130000	UG/KG	62	UG/KG	USEPA Risk Based SSLs	62	UG/KG	USEPA Risk Based SSLs
CHLOROETHANE	75-00-3	15000000	UG/KG	5900	UG/KG	1200000	UG/KG	5900	UG/KG	USEPA Risk Based SSLs	5900	UG/KG	USEPA Risk Based SSLs
CHLOROFORM	67-66-3	290	UG/KG	0.053	UG/KG	280	UG/KG	0.053	UG/KG	USEPA Risk Based SSLs	0.053	UG/KG	USEPA Risk Based SSLs
CHLOROMETHANE	74-87-3	120000	UG/KG	49	UG/KG	2100	UG/KG	49	UG/KG	USEPA Risk Based SSLs	49	UG/KG	USEPA Risk Based SSLs
1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	5.4	UG/KG	0.00014	UG/KG	23000	UG/KG	0.00014	UG/KG	USEPA Risk Based SSLs	0.00014	UG/KG	USEPA Risk Based SSLs
CIS-1,2-DICHLOROETHENE	156-59-2	780000	UG/KG	110	UG/KG	NC		110	UG/KG	USEPA Risk Based SSLs	110	UG/KG	USEPA Risk Based SSLs
CIS-1,3-DICHLOROPROPENE	10061-01-5	1700	UG/KG	0.15	UG/KG	1100	UG/KG	0.15	UG/KG	USEPA Risk Based SSLs	0.15	UG/KG	USEPA Risk Based SSLs
CYCLOHEXANE	110-82-7	7000000	UG/KG	13000	UG/KG	8.51E+12	UG/KG	13000	UG/KG	USEPA Risk Based SSLs	13000	UG/KG	USEPA Risk Based SSLs
CHLORODIBROMOMETHANE	124-48-1	680	UG/KG	0.039	UG/KG	NC		0.039	UG/KG	USEPA Risk Based SSLs	0.039	UG/KG	USEPA Risk Based SSLs
DICHLORODIFLUOROMETHANE	75-71-8	180000	UG/KG	610	UG/KG	250000	UG/KG	610	UG/KG	USEPA Risk Based SSLs	610	UG/KG	USEPA Risk Based SSLs
ETHYLBENZENE	100-41-4	5400	UG/KG	1.7	UG/KG	400000	UG/KG	1.7	UG/KG	USEPA Risk Based SSLs	1.7	UG/KG	USEPA Risk Based SSLs
ISOPROPYLBENZENE	98-82-8	2100000	UG/KG	1100	UG/KG	850000	UG/KG	1100	UG/KG	USEPA Risk Based SSLs	1100	UG/KG	USEPA Risk Based SSLs
METHYL ACETATE	79-20-9	78000000	UG/KG	7500	UG/KG	NC		7500	UG/KG	USEPA Risk Based SSLs	7500	UG/KG	USEPA Risk Based SSLs
METHYL CYCLOHEXANE	108-87-2	NC		NC		490000	UG/KG	490000	UG/KG	USEPA SSLs for Residential Inhalation	46000	UG/KG	NON-TACO Const Worker
METHYLENE CHLORIDE	75-09-2	11000	UG/KG	1.2	UG/KG	13000	UG/KG	1.2	UG/KG	USEPA Risk Based SSLs	1.2	UG/KG	USEPA Risk Based SSLs
METHYL TERT-BUTYL ETHER	1634-04-4	43000	UG/KG	2.8	UG/KG	8700000	UG/KG	2.8	UG/KG	USEPA Risk Based SSLs	2.8	UG/KG	USEPA Risk Based SSLs
STYRENE	100-42-5	6300000	UG/KG	1800	UG/KG	1500000	UG/KG	1800	UG/KG	USEPA Risk Based SSLs	1800	UG/KG	USEPA Risk Based SSLs
TETRACHLOROETHENE	127-18-4	550	UG/KG	0.049	UG/KG	10000	UG/KG	0.049	UG/KG	USEPA Risk Based SSLs	0.049	UG/KG	USEPA Risk Based SSLs
TOLUENE	108-88-3	5000000	UG/KG	1600	UG/KG	650000	UG/KG	1600	UG/KG	USEPA Risk Based SSLs	1600	UG/KG	USEPA Risk Based SSLs
TRANS-1,2-DICHLOROETHENE	156-60-5	150000	UG/KG	31	UG/KG	NC		31	UG/KG	USEPA Risk Based SSLs	31	UG/KG	USEPA Risk Based SSLs
TRANS-1,3-DICHLOROPROPENE	10061-02-6	1700	UG/KG	NC		1100	UG/KG	1100	UG/KG	USEPA SSLs for Residential Inhalation	1100	UG/KG	USEPA SSLs for Residential Inhalation
TRICHLOROETHENE	79-01-6	2800	UG/KG	0.72	UG/KG	71	UG/KG	0.72	UG/KG	USEPA Risk Based SSLs	0.72	UG/KG	USEPA Risk Based SSLs
TRICHLOROFLUOROMETHANE	75-69-4	790000	UG/KG	830	UG/KG	1100000	UG/KG	830	UG/KG	USEPA Risk Based SSLs	830	UG/KG	USEPA Risk Based SSLs
1,1,2-TRICHLOROTRIFLUOROETHANE	76-13-1	43000000	UG/KG	150000	UG/KG	930000	UG/KG	150000	UG/KG	USEPA Risk Based SSLs	150000	UG/KG	USEPA Risk Based SSLs
VINYL CHLORIDE	75-01-4	60	UG/KG	0.0056	UG/KG	280	UG/KG	0.0056	UG/KG	USEPA Risk Based SSLs	0.0056	UG/KG	USEPA Risk Based SSLs
TOTAL XYLENES	1330-20-7	630000	UG/KG	200	UG/KG	700000	UG/KG	200	UG/KG	USEPA Risk Based SSLs	200	UG/KG	USEPA Risk Based SSLs
PESTICIDES (SW-846 METHODS 3510C/3520C/3550B/8081A)													
4,4'-DDD	72-54-8	2000	UG/KG	86	UG/KG	NC		86	UG/KG	USEPA Risk Based SSLs	86	UG/KG	USEPA Risk Based SSLs
4,4'-DDE	72-55-9	1400	UG/KG	60	UG/KG	NC		60	UG/KG	USEPA Risk Based SSLs	60	UG/KG	USEPA Risk Based SSLs
4,4'-DDT	50-29-3	1700	UG/KG	87	UG/KG	NC		87	UG/KG	USEPA Risk Based SSLs	87	UG/KG	USEPA Risk Based SSLs
Aldrin	309-00-2	29	UG/KG	0.84	UG/KG	NC		0.84	UG/KG	USEPA Risk Based SSLs	0.84	UG/KG	USEPA Risk Based SSLs
alpha-BHC (alpha-HCH)	319-84-6	77	UG/KG	0.074	UG/KG	NC		0.074	UG/KG	USEPA Risk Based SSLs	0.074	UG/KG	USEPA Risk Based SSLs
alpha-Chlordane	5103-71-9	NC		NC		NC		NC		NC	NC		NC
beta-BHC	319-85-7	270	UG/KG	0.26	UG/KG	NC		0.26	UG/KG	USEPA Risk Based SSLs	0.26	UG/KG	USEPA Risk Based SSLs
delta-BHC	319-86-8	NC		NC		NC		NC		NC	NC		NC

TABLE F-1B
REFERENCE DATA FOR PROJECT ACTION LIMITS -
USEPA and OVERALL BASIS VALUES
SITE 12
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CORRECTED PARAMETER	CORRECTED CAS	USEPA ORNL Residential Soil (5)		USEPA ORNL Risk Based SSLs (5)		USEPA ORNL SSLs for Residential Inhalation (5)		Minimum Federal Criteria		MIN FEDERAL BASIS	OVERALL MINIMUM		OVERALL BASIS
Dieldrin	60-57-1	30	UG/KG	0.09	UG/KG	NC		0.09	UG/KG	USEPA Risk Based SSLs	0.09	UG/KG	USEPA Risk Based SSLs
Endosulfan	115-29-7	370000	UG/KG	9700	UG/KG	NC		9700	UG/KG	USEPA Risk Based SSLs	9700	UG/KG	USEPA Risk Based SSLs
Endosulfan I	959-98-8	NC		NC		NC		NC		NC	NC		NC
Endosulfan II	33213-65-9	NC		NC		NC		NC		NC	NC		NC
Endosulfan sulfate	1031-07-8	NC		NC		NC		NC		NC	NC		NC
Endrin	72-20-8	18000	UG/KG	230	UG/KG	NC		230	UG/KG	USEPA Risk Based SSLs	230	UG/KG	USEPA Risk Based SSLs
Endrin aldehyde	7421-93-4	NC		NC		NC		NC		NC	NC		NC
Endrin ketone	53494-70-5	NC		NC		NC		NC		NC	NC		NC
gamma-BHC (Lindane)	58-89-9	520	UG/KG	0.43	UG/KG	NC		0.43	UG/KG	USEPA Risk Based SSLs	0.43	UG/KG	USEPA Risk Based SSLs
gamma-Chlordane	5103-74-2	NC		NC		NC		NC		NC	NC		NC
Heptachlor	76-44-8	110	UG/KG	1.6	UG/KG	NC		1.6	UG/KG	USEPA Risk Based SSLs	1.6	UG/KG	USEPA Risk Based SSLs
Heptachlor epoxide	1024-57-3	53	UG/KG	0.079	UG/KG	NC		0.079	UG/KG	USEPA Risk Based SSLs	0.079	UG/KG	USEPA Risk Based SSLs
Methoxychlor	72-43-5	310000	UG/KG	3400	UG/KG	NC		3400	UG/KG	USEPA Risk Based SSLs	3400	UG/KG	USEPA Risk Based SSLs
Toxaphene	8001-35-2	440	UG/KG	12	UG/KG	NC		12	UG/KG	USEPA Risk Based SSLs	12	UG/KG	USEPA Risk Based SSLs

NA = not available; no criteria is available for that parameter for that chemical
1 - Section 742 Table A, Tier 1 Soil Remediation Objectives for Residential Properties (Ingestion, Inhalation, or Soil Component of Groundwater Ingestion Route)(Online July, 2008).
2 - Section 742 Table B, Tier 1 Soil Remediation Objectives for Industrial/Commercial Properties (Ingestion or Inhalation) (Online July, 2008).
3 - Soil Remediation Objectives for Residential Properties, Non-TACO Chemicals (May 1, 2007)
4 - Soil Remediation Objectives for Indusrial/Commercial Properties, Non-TACO Chemicals (May 1, 2007)
5 - Oak Ridge National Laboratory Regional Screening Level (ORNL, September 12, 2008)

Definitions:
C - Carcinogen
s - Concentration may exceeed soil saturation concentration.
DAF - Dilution Attneuation Factor
TACO - Tiered Approach to Corrective Action Objectives
N - Noncarcinogen
NC - Not Criteria: no criteria is available for that parameter for that chemical
sat - Soil Saturation Concentration
GW - Groundwater
SO - Soil
IL - Illinois
SSL - Soil Screening Limits

TABLE F-2
PROJECT ACTION LIMITS EVALUATION TABLE
SITE 12 SAP
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CORRECTED PARAMETER	CORRECTED CAS	Minimum IL Criteria		MINIMUM IL BASIS	Minimum Federal Criteria		MIN FEDERAL BASIS	OVERALL MINIMUM		OVERALL BASIS
SEMIVOLATILES										
BIS(2-CHLOROETHYL)ETHER	111-44-4	0.4	UG/KG	TACO - SO to GW Class I	0.031	UG/KG	USEPA Risk Based SSLs	0.031	UG/KG	USEPA Risk Based SSLs
2-CHLOROPHENOL	95-57-8	3600	UG/KG	TACO pH Specific Criteria	150	UG/KG	USEPA Risk Based SSLs	150	UG/KG	USEPA Risk Based SSLs
PHENOL	108-95-2	100000	UG/KG	TACO - SO to GW Class I	6300	UG/KG	USEPA Risk Based SSLs	6300	UG/KG	USEPA Risk Based SSLs
HEXACHLOROETHANE	67-72-1	500	UG/KG	TACO - SO to GW Class I	2.9	UG/KG	USEPA Risk Based SSLs	2.9	UG/KG	USEPA Risk Based SSLs
N-NITROSO-DI-N-PROPYLAMINE	621-64-7	0.05	UG/KG	TACO - SO to GW Class I	0.0072	UG/KG	USEPA Risk Based SSLs	0.0072	UG/KG	USEPA Risk Based SSLs
NITROBENZENE	98-95-3	100	UG/KG	TACO - SO to GW Class I	0.079	UG/KG	USEPA Risk Based SSLs	0.079	UG/KG	USEPA Risk Based SSLs
2-METHYLPHENOL	95-48-7	15000	UG/KG	TACO - SO to GW Class I	1500	UG/KG	USEPA Risk Based SSLs	1500	UG/KG	USEPA Risk Based SSLs
ISOPHORONE	78-59-1	8000	UG/KG	TACO - SO to GW Class I	23	UG/KG	USEPA Risk Based SSLs	23	UG/KG	USEPA Risk Based SSLs
4-METHYLPHENOL	106-44-5	200	UG/KG	NON-TACO - SO to GW Class I	150	UG/KG	USEPA Risk Based SSLs	150	UG/KG	USEPA Risk Based SSLs
1,1-BIPHENYL	92-52-4	150000	UG/KG	NON-TACO - SO to GW Class I	19000	UG/KG	USEPA Risk Based SSLs	19000	UG/KG	USEPA Risk Based SSLs
2,2'-OXYBIS(1-CHLOROPROPANE)	108-60-1	2400	UG/KG	NON-TACO - SO to GW Class I	0.12	UG/KG	USEPA Risk Based SSLs	0.12	UG/KG	USEPA Risk Based SSLs
2,4,5-TRICHLOROPHENOL	95-95-4	130000	UG/KG	TACO pH Specific Criteria	14000	UG/KG	USEPA Risk Based SSLs	14000	UG/KG	USEPA Risk Based SSLs
2,4,6-TRICHLOROPHENOL	88-06-2	90	UG/KG	TACO pH Specific Criteria	23	UG/KG	USEPA Risk Based SSLs	23	UG/KG	USEPA Risk Based SSLs
2,4-DICHLOROPHENOL	120-83-2	860	UG/KG	TACO pH Specific Criteria	130	UG/KG	USEPA Risk Based SSLs	130	UG/KG	USEPA Risk Based SSLs
2,4-DIMETHYLPHENOL	105-67-9	9000	UG/KG	TACO - SO to GW Class I	860	UG/KG	USEPA Risk Based SSLs	860	UG/KG	USEPA Risk Based SSLs
2,4-DINITROPHENOL	51-28-5	200	UG/KG	TACO - SO to GW Class I	82	UG/KG	USEPA Risk Based SSLs	82	UG/KG	USEPA Risk Based SSLs
2,4-DINITROTOLUENE	121-14-2	0.8	UG/KG	TACO - SO to GW Class I	0.29	UG/KG	USEPA Risk Based SSLs	0.29	UG/KG	USEPA Risk Based SSLs
2,6-DINITROTOLUENE	606-20-2	0.7	UG/KG	TACO - SO to GW Class I	50	UG/KG	USEPA Risk Based SSLs	0.7	UG/KG	TACO - SO to GW Class I
2-CHLORONAPHTHALENE	91-58-7	49000	UG/KG	NON-TACO - SO to GW Class I	15000	UG/KG	USEPA Risk Based SSLs	15000	UG/KG	USEPA Risk Based SSLs
2-NITROANILINE	88-74-4	140	UG/KG	NON-TACO - SO to GW Class I	150	UG/KG	USEPA Risk Based SSLs	140	UG/KG	NON-TACO - SO to GW Class I
2-NITROPHENOL	88-75-5	NC		NC	NC		NC	NC		NC
3,3'-DICHLOROBENZIDINE	91-94-1	7	UG/KG	TACO - SO to GW Class I	0.98	UG/KG	USEPA Risk Based SSLs	0.98	UG/KG	USEPA Risk Based SSLs
3-NITROANILINE	99-09-2	10	UG/KG	NON-TACO - SO to GW Class I	1420000000	UG/KG	EPA SSLs for Residential Inhalation	10	UG/KG	NON-TACO - SO to GW Class I
4,6-DINITRO-2-METHYLPHENOL	534-52-1	3.1	UG/KG	NON-TACO SO to GW Class I pH Spec	6.2	UG/KG	USEPA Risk Based SSLs	3.1	UG/KG	NON-TACO SO to GW Class I pH Spec
4-BROMOPHENYL PHENYL ETHER	101-55-3	NC		NC	NC		NC	NC		NC
4-CHLORO-3-METHYLPHENOL	59-50-7	NC		NC	4300	UG/KG	USEPA Risk Based SSLs	4300	UG/KG	USEPA Risk Based SSLs
4-CHLOROANILINE	106-47-8	700	UG/KG	TACO - SO to GW Class I	0.14	UG/KG	USEPA Risk Based SSLs	0.14	UG/KG	USEPA Risk Based SSLs
4-CHLOROPHENYL PHENYL ETHER	7005-72-3	NC		NC	NC		NC	NC		NC
4-NITROANILINE	100-01-6	100	UG/KG	NON-TACO - SO to GW Class I	1.4	UG/KG	USEPA Risk Based SSLs	1.4	UG/KG	USEPA Risk Based SSLs
4-NITROPHENOL	100-02-7	NC		NC	NC		NC	NC		NC
ACETOPHENONE	98-86-2	NC		NC	1100	UG/KG	USEPA Risk Based SSLs	1100	UG/KG	USEPA Risk Based SSLs
ATRAZINE	1912-24-9	66	UG/KG	TACO - SO to GW Class I	0.19	UG/KG	USEPA Risk Based SSLs	0.19	UG/KG	USEPA Risk Based SSLs
BENZALDEHYDE	100-52-7	3300	UG/KG	NON-TACO - SO to GW Class I	810	UG/KG	USEPA Risk Based SSLs	810	UG/KG	USEPA Risk Based SSLs
BIS(2-CHLOROETHOXY)METHANE	111-91-1	NC		NC	25	UG/KG	USEPA Risk Based SSLs	25	UG/KG	USEPA Risk Based SSLs
BIS(2-ETHYLHEXYL)PHTHALATE	117-81-7	46000	UG/KG	TACO Residential Ingestion	1100	UG/KG	USEPA Risk Based SSLs	1100	UG/KG	USEPA Risk Based SSLs
BUTYL BENZYL PHTHALATE	85-68-7	930000	UG/KG	TACO Residential Ingestion	510	UG/KG	USEPA Risk Based SSLs	510	UG/KG	USEPA Risk Based SSLs
CAPROLACTAM	105-60-2	14000	UG/KG	NON-TACO - SO to GW Class I	4500	UG/KG	USEPA Risk Based SSLs	4500	UG/KG	USEPA Risk Based SSLs
CARBAZOLE	86-74-8	600	UG/KG	TACO - SO to GW Class I	NC		NC	600	UG/KG	TACO - SO to GW Class I
DIBENZOFURAN	132-64-9	820000	UG/KG	NON-TACO Const Worker	NC			82000	UG/KG	NON-TACO Const Worker
DIETHYL PHTHALATE	84-66-2	470000	UG/KG	TACO - SO to GW Class I	12000	UG/KG	USEPA Risk Based SSLs	12000	UG/KG	USEPA Risk Based SSLs
DIMETHYL PHTHALATE	131-11-3	NC		NC	NC		NC	NC		NC
DI-N-BUTYL PHTHALATE	84-74-2	2300000	UG/KG	TACO Residential Ingestion	9200	UG/KG	USEPA Risk Based SSLs	9200	UG/KG	USEPA Risk Based SSLs
DI-N-OCTYL PHTHALATE	117-84-0	1600000	UG/KG	TACO Residential Ingestion	NC		NC	1600000	UG/KG	TACO Residential Ingestion
HEXACHLOROBENZENE	118-74-1	400	UG/KG	TACO Residential Ingestion	0.53	UG/KG	USEPA Risk Based SSLs	0.53	UG/KG	USEPA Risk Based SSLs
HEXACHLOROBUTADIENE	87-68-3	2200	UG/KG	NON-TACO - SO to GW Class I	1.7	UG/KG	USEPA Risk Based SSLs	1.7	UG/KG	USEPA Risk Based SSLs
HEXACHLOROCYCLOPENTADIENE	77-47-4	10000	UG/KG	TACO Residential Ingestion	160	UG/KG	USEPA MCL Based SSLs	160	UG/KG	USEPA MCL Based SSLs
N-NITROSODIPHENYLAMINE	86-30-6	1000	UG/KG	TACO - SO to GW Class I	75	UG/KG	USEPA Risk Based SSLs	75	UG/KG	USEPA Risk Based SSLs
PENTACHLOROPHENOL	87-86-5	20	UG/KG	TACO pH Specific Criteria	5.7	UG/KG	USEPA Risk Based SSLs	5.7	UG/KG	USEPA Risk Based SSLs
POLYNUCLEAR AROMATIC HYDROCARBONS										
ACENAPHTHENE	83-32-9	570000	UG/KG	TACO - SO to GW Class I	22000	UG/KG	USEPA Risk Based SSLs	22000	UG/KG	USEPA Risk Based SSLs
ACENAPHTHYLENE	208-96-8	85000	UG/KG	NON-TACO - SO to GW Class I	NC			85000	UG/KG	NON-TACO - SO to GW Class I
ANTHRACENE	120-12-7	12000000	UG/KG	TACO - SO to GW Class I	360000	UG/KG	USEPA Risk Based SSLs	360000	UG/KG	USEPA Risk Based SSLs
BENZO(A)ANTHRACENE	56-55-3	900	UG/KG	TACO Residential Ingestion	10	UG/KG	USEPA Risk Based SSLs	10	UG/KG	USEPA Risk Based SSLs
BENZO(A)PYRENE	50-32-8	90	UG/KG	TACO Residential Ingestion	3.5	UG/KG	USEPA Risk Based SSLs	3.5	UG/KG	USEPA Risk Based SSLs
BENZO(B)FLUORANTHENE	205-99-2	900	UG/KG	TACO Residential Ingestion	35	UG/KG	USEPA Risk Based SSLs	35	UG/KG	USEPA Risk Based SSLs
BENZO(G,H,I)PERYLENE	191-24-2	2300000	UG/KG	NON-TACO Residential Ingestion	NC			2300000	UG/KG	NON-TACO Residential Ingestion
BENZO(K)FLUORANTHENE	207-08-9	9000	UG/KG	TACO Residential Ingestion	350	UG/KG	USEPA Risk Based SSLs	350	UG/KG	USEPA Risk Based SSLs
CHRYSENE	218-01-9	88000	UG/KG	TACO Residential Ingestion	1100	UG/KG	USEPA Risk Based SSLs	1100	UG/KG	USEPA Risk Based SSLs
DIBENZO(A,H)ANTHRACENE	53-70-3	90	UG/KG	TACO Residential Ingestion	11	UG/KG	USEPA Risk Based SSLs	11	UG/KG	USEPA Risk Based SSLs
FLUORANTHENE	206-44-0	3100000	UG/KG	TACO Residential Ingestion	160000	UG/KG	USEPA Risk Based SSLs	160000	UG/KG	USEPA Risk Based SSLs
FLUORENE	86-73-7	560000	UG/KG	TACO - SO to GW Class I	27000	UG/KG	USEPA Risk Based SSLs	27000	UG/KG	USEPA Risk Based SSLs

TABLE F-2
PROJECT ACTION LIMITS EVALUATION TABLE
SITE 12 SAP
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CORRECTED PARAMETER	CORRECTED CAS	Minimum IL Criteria		MINIMUM IL BASIS	Minimum Federal Criteria		MIN FEDERAL BASIS	OVERALL MINIMUM		OVERALL BASIS
2-METHYLNAPHTHALENE	91-57-6	NC		NC	750	UG/KG	USEPA Risk Based SSLs	750	UG/KG	USEPA Risk Based SSLs
INDENO(1,2,3-CD)PYRENE	193-39-5	900	UG/KG	TACO Residential Ingestion	120	UG/KG	USEPA Risk Based SSLs	120	UG/KG	USEPA Risk Based SSLs
NAPHTHALENE	91-20-3	12000	UG/KG	TACO - SO to GW Class I	0.47	UG/KG	USEPA Risk Based SSLs	0.47	UG/KG	USEPA Risk Based SSLs
PHENANTHRENE	85-01-8	200000	UG/KG	NON-TACO - SO to GW Class I	NC			200000	UG/KG	NON-TACO - SO to GW Class I
PYRENE	129-00-0	2300000	UG/KG	TACO Residential Ingestion	120000	UG/KG	USEPA Risk Based SSLs	120000	UG/KG	USEPA Risk Based SSLs
PCBs										
AROCLOR-1016	12674-11-2	NC		NC	92	UG/KG	USEPA Risk Based SSLs	92	UG/KG	USEPA Risk Based SSLs
AROCLOR-1221	11104-28-2	NC		NC	0.12	UG/KG	USEPA Risk Based SSLs	0.12	UG/KG	USEPA Risk Based SSLs
AROCLOR-1232	11141-16-5	NC		NC	0.12	UG/KG	USEPA Risk Based SSLs	0.12	UG/KG	USEPA Risk Based SSLs
AROCLOR-1242	53469-21-9	NC		NC	5.3	UG/KG	USEPA Risk Based SSLs	5.3	UG/KG	USEPA Risk Based SSLs
AROCLOR-1248	12672-29-6	NC		NC	5.2	UG/KG	USEPA Risk Based SSLs	5.2	UG/KG	USEPA Risk Based SSLs
AROCLOR-1254	11097-69-1	NC		NC	8.8	UG/KG	USEPA Risk Based SSLs	8.8	UG/KG	USEPA Risk Based SSLs
AROCLOR-1260	11096-82-5	NC		NC	24	UG/KG	USEPA Risk Based SSLs	24	UG/KG	USEPA Risk Based SSLs
TOTAL AROCLOR	1336-36-3	1000	UG/KG	TACO Residential Ingestion	220	UG/KG	USEPA Residential Soil	220	UG/KG	USEPA Residential Soil
INORGANICS										
ALUMINUM	7429-90-5	78000	MG/KG	NON-TACO Residential Ingestion	55000	MG/KG	USEPA Risk Based SSLs	55000	MG/KG	USEPA Risk Based SSLs
ANTIMONY	7440-36-0	5	MG/KG	TACO pH Specific Criteria	0.66	MG/KG	USEPA Risk Based SSLs	0.66	MG/KG	USEPA Risk Based SSLs
ARSENIC	7440-38-2	30	MG/KG	TACO pH Specific Criteria	0.0013	MG/KG	USEPA Risk Based SSLs	0.0013	MG/KG	USEPA Risk Based SSLs
BARIUM	7440-39-3	1800	MG/KG	TACO pH Specific Criteria	300	MG/KG	USEPA Risk Based SSLs	300	MG/KG	USEPA Risk Based SSLs
BERYLLIUM	7440-41-7	160	MG/KG	TACO Residential Ingestion	58	MG/KG	USEPA Risk Based SSLs	58	MG/KG	USEPA Risk Based SSLs
CADMIUM	7440-43-9	59	MG/KG	TACO pH Specific Criteria	1.4	MG/KG	USEPA Risk Based SSLs	1.4	MG/KG	USEPA Risk Based SSLs
CALCIUM	7440-70-2	NC		NC	0	MG/KG	NC	0	MG/KG	NC
CHROMIUM	7440-47-3	230	MG/KG	TACO Residential Ingestion	276	MG/KG	EPA SSLs for Residential Inhalation	230	MG/KG	TACO Residential Ingestion
COBALT	7440-48-4	4700	MG/KG	TACO Residential Ingestion	0.49	MG/KG	USEPA Risk Based SSLs	0.49	MG/KG	USEPA Risk Based SSLs
COPPER	7440-50-8	2900	MG/KG	TACO Residential Ingestion	51	MG/KG	USEPA Risk Based SSLs	51	MG/KG	USEPA Risk Based SSLs
IRON	7439-89-6	55000	MG/KG	NON-TACO Residential Ingestion	640	MG/KG	USEPA Risk Based SSLs	640	MG/KG	USEPA Risk Based SSLs
LEAD	7439-92-1	107	MG/KG	TACO pH Specific Criteria	400	MG/KG	USEPA Residential Soil	107	MG/KG	TACO pH Specific Criteria
MAGNESIUM	7439-95-4	325000	MG/KG	TACO Residential Ingestion	0	MG/KG	NC	0	MG/KG	NC
MANGANESE	7439-96-5	1600	MG/KG	TACO Residential Ingestion	57	MG/KG	USEPA Risk Based SSLs	57	MG/KG	USEPA Risk Based SSLs
MERCURY	7439-97-6	6.4	MG/KG	TACO pH Specific Criteria	0.03	MG/KG	USEPA Risk Based SSLs	0.03	MG/KG	USEPA Risk Based SSLs
NICKEL	7440-02-0	700	MG/KG	TACO pH Specific Criteria	48	MG/KG	USEPA Risk Based SSLs	48	MG/KG	USEPA Risk Based SSLs
POTASSIUM	7440-09-7	NC		NC	0	MG/KG	NC	0	MG/KG	NC
SELENIUM	7782-49-2	3.3	MG/KG	TACO pH Specific Criteria	0.95	MG/KG	USEPA Risk Based SSLs	0.95	MG/KG	USEPA Risk Based SSLs
SILVER	7440-22-4	39	MG/KG	TACO pH Specific Criteria	1.6	MG/KG	USEPA Risk Based SSLs	1.6	MG/KG	USEPA Risk Based SSLs
SODIUM	7440-23-5	NC		NC	0	MG/KG	NC	0	MG/KG	NC
THALLIUM	7440-28-0	3.4	MG/KG	TACO pH Specific Criteria	0	MG/KG	NC	0	MG/KG	NC
VANADIUM	7440-62-2	550	MG/KG	TACO Residential Ingestion	180	MG/KG	USEPA Risk Based SSLs	180	MG/KG	USEPA Risk Based SSLs
ZINC	7440-66-6	16000	MG/KG	TACO pH Specific Criteria	680	MG/KG	USEPA Risk Based SSLs	680	MG/KG	USEPA Risk Based SSLs
TCLP-INORGANICS										
ALUMINUM	7429-90-5	3.5	MG/L	NON-TACO - SO to GW Class I	NC		NC	3.5	MG/L	NON-TACO - SO to GW Class I
ANTIMONY	7440-36-0	0.006	MG/L	TACO - SO to GW Class I	NC		NC	0.006	MG/L	TACO - SO to GW Class I
ARSENIC	7440-38-2	0.05	MG/L	TACO - SO to GW Class I	NC		NC	0.05	MG/L	TACO - SO to GW Class I
BARIUM	7440-39-3	2	MG/L	TACO - SO to GW Class I	NC		NC	2	MG/L	TACO - SO to GW Class I
BERYLLIUM	7440-41-7	0.004	MG/L	TACO - SO to GW Class I	NC		NC	0.004	MG/L	TACO - SO to GW Class I
CADMIUM	7440-43-9	0.005	MG/L	TACO - SO to GW Class I	NC		NC	0.005	MG/L	TACO - SO to GW Class I
CALCIUM	7440-70-2	NC		NC	NC		NC	NC		NC
CHROMIUM	7440-47-3	0.1	MG/L	TACO - SO to GW Class I	NC		NC	0.1	MG/L	TACO - SO to GW Class I
COBALT	7440-48-4	1	MG/L	TACO - SO to GW Class I	NC		NC	1	MG/L	TACO - SO to GW Class I
COPPER	7440-50-8	0.65	MG/L	TACO - SO to GW Class I	NC		NC	0.65	MG/L	TACO - SO to GW Class I
IRON	7439-89-6	5	MG/L	TACO - SO to GW Class I	NC		NC	5	MG/L	TACO - SO to GW Class I
LEAD	7439-92-1	0.0075	MG/L	TACO - SO to GW Class I	NC		NC	0.0075	MG/L	TACO - SO to GW Class I
MAGNESIUM	7439-95-4	NC		NC	NC		NC	NC		NC
MANGANESE	7439-96-5	0.15	MG/L	TACO - SO to GW Class I	NC		NC	0.15	MG/L	TACO - SO to GW Class I
MERCURY	7439-97-6	0.002	MG/L	TACO - SO to GW Class I	NC		NC	0.002	MG/L	TACO - SO to GW Class I
NICKEL	7440-02-0	0.1	MG/L	TACO - SO to GW Class I	NC		NC	0.1	MG/L	TACO - SO to GW Class I
POTASSIUM	7440-09-7	NC		NC	NC		NC	NC		NC
SELENIUM	7782-49-2	0.05	MG/L	TACO - SO to GW Class I	NC		NC	0.05	MG/L	TACO - SO to GW Class I
SILVER	7440-22-4	0.05	MG/L	TACO - SO to GW Class I	NC		NC	0.05	MG/L	TACO - SO to GW Class I
SODIUM	7440-23-5	NC		NC	NC		NC	NC		NC
THALLIUM	7440-28-0	0.002	MG/L	TACO - SO to GW Class I	NC		NC	0.002	MG/L	TACO - SO to GW Class I
VANADIUM	7440-62-2	0.049	MG/L	TACO - SO to GW Class I	NC		NC	0.049	MG/L	TACO - SO to GW Class I
ZINC	7440-66-6	5	MG/L	TACO - SO to GW Class I	NC		NC	5	MG/L	TACO - SO to GW Class I

TABLE F-2
PROJECT ACTION LIMITS EVALUATION TABLE
SITE 12 SAP
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CORRECTED PARAMETER	CORRECTED CAS	Minimum IL Criteria		MINIMUM IL BASIS	Minimum Federal Criteria		MIN FEDERAL BASIS	OVERALL MINIMUM		OVERALL BASIS
VOLATILE ORGANICS										
1,1,1-TRICHLOROETHANE	71-55-6	2000	UG/KG	TACO - SO to GW Class I	3200	UG/KG	USEPA Risk Based SSLs	2000	UG/KG	TACO - SO to GW Class I
1,1,2,2-TETRACHLOROETHANE	79-34-5	220	UG/KG	NON-TACO - SO to GW Class I	0.026	UG/KG	USEPA Risk Based SSLs	0.026	UG/KG	USEPA Risk Based SSLs
1,1,2-TRICHLOROETHANE	79-00-5	20	UG/KG	TACO - SO to GW Class I	0.078	UG/KG	USEPA Risk Based SSLs	0.078	UG/KG	USEPA Risk Based SSLs
1,1-DICHLOROETHANE	75-34-3	23000	UG/KG	TACO - SO to GW Class I	0.69	UG/KG	USEPA Risk Based SSLs	0.69	UG/KG	USEPA Risk Based SSLs
1,1-DICHLOROETHENE	75-35-4	60	UG/KG	TACO - SO to GW Class I	120	UG/KG	USEPA Risk Based SSLs	60	UG/KG	TACO - SO to GW Class I
1,2,4-TRICHLOROBENZENE	120-82-1	5000	UG/KG	TACO - SO to GW Class I	6.8	UG/KG	USEPA Risk Based SSLs	6.8	UG/KG	USEPA Risk Based SSLs
1,2-DIBROMOETHANE	106-93-4	0.4	UG/KG	TACO - SO to GW Class I	0.0018	UG/KG	USEPA Risk Based SSLs	0.0018	UG/KG	USEPA Risk Based SSLs
1,2-DICHLOROBENZENE	95-50-1	17000	UG/KG	TACO - SO to GW Class I	360	UG/KG	USEPA Risk Based SSLs	360	UG/KG	USEPA Risk Based SSLs
1,2-DICHLOROETHANE	107-06-2	20	UG/KG	TACO - SO to GW Class I	0.042	UG/KG	USEPA Risk Based SSLs	0.042	UG/KG	USEPA Risk Based SSLs
1,2-DICHLOROPROPANE	78-87-5	30	UG/KG	TACO - SO to GW Class I	0.13	UG/KG	USEPA Risk Based SSLs	0.13	UG/KG	USEPA Risk Based SSLs
1,3-DICHLOROBENZENE	541-73-1	NC		NC	NC		NC	NC		NC
1,4-DICHLOROBENZENE	106-46-7	2000	UG/KG	TACO - SO to GW Class I	0.41	UG/KG	USEPA Risk Based SSLs	0.41	UG/KG	USEPA Risk Based SSLs
2-BUTANONE	78-93-3	NC		NC	1500	UG/KG	USEPA Risk Based SSLs	1500	UG/KG	USEPA Risk Based SSLs
2-HEXANONE	591-78-6	NC		NC	11	UG/KG	USEPA Risk Based SSLs	11	UG/KG	USEPA Risk Based SSLs
4-METHYL-2-PENTANONE	108-10-1	340000	UG/KG	NON-TACO Const Worker	450	UG/KG	USEPA Risk Based SSLs	450	UG/KG	USEPA Risk Based SSLs
ACETONE	67-64-1	25000	UG/KG	TACO - SO to GW Class I	4500	UG/KG	USEPA Risk Based SSLs	4500	UG/KG	USEPA Risk Based SSLs
BENZENE	71-43-2	30	UG/KG	TACO - SO to GW Class I	0.21	UG/KG	USEPA Risk Based SSLs	0.21	UG/KG	USEPA Risk Based SSLs
BROMODICHLOROMETHANE	75-27-4	600	UG/KG	TACO - SO to GW Class I	0.032	UG/KG	USEPA Risk Based SSLs	0.032	UG/KG	USEPA Risk Based SSLs
BROMOFORM	75-25-2	800	UG/KG	TACO - SO to GW Class I	2.3	UG/KG	USEPA Risk Based SSLs	2.3	UG/KG	USEPA Risk Based SSLs
BROMOMETHANE	74-83-9	200	UG/KG	TACO - SO to GW Class I	2.2	UG/KG	USEPA Risk Based SSLs	2.2	UG/KG	USEPA Risk Based SSLs
CARBON DISULFIDE	75-15-0	9000	UG/KG	TACO Const Worker	310	UG/KG	USEPA Risk Based SSLs	310	UG/KG	USEPA Risk Based SSLs
CARBON TETRACHLORIDE	56-23-5	70	UG/KG	TACO - SO to GW Class I	0.077	UG/KG	USEPA Risk Based SSLs	0.077	UG/KG	USEPA Risk Based SSLs
CHLOROBENZENE	108-90-7	1000	UG/KG	TACO - SO to GW Class I	62	UG/KG	USEPA Risk Based SSLs	62	UG/KG	USEPA Risk Based SSLs
CHLOROETHANE	75-00-3	97000	UG/KG	NON-TACO Const Worker	5900	UG/KG	USEPA Risk Based SSLs	5900	UG/KG	USEPA Risk Based SSLs
CHLOROFORM	67-66-3	300	UG/KG	TACO Residential Ingestion	0.053	UG/KG	USEPA Risk Based SSLs	0.053	UG/KG	USEPA Risk Based SSLs
CHLOROMETHANE	74-87-3	11000	UG/KG	NON-TACO Const Worker	49	UG/KG	USEPA Risk Based SSLs	49	UG/KG	USEPA Risk Based SSLs
1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	2	UG/KG	TACO - SO to GW Class I	0.00014	UG/KG	USEPA Risk Based SSLs	0.00014	UG/KG	USEPA Risk Based SSLs
CIS-1,2-DICHLOROETHENE	156-59-2	400	UG/KG	TACO - SO to GW Class I	110	UG/KG	USEPA Risk Based SSLs	110	UG/KG	USEPA Risk Based SSLs
CIS-1,3-DICHLOROPROPENE	10061-01-5	NC		NC	0.15	UG/KG	USEPA Risk Based SSLs	0.15	UG/KG	USEPA Risk Based SSLs
CYCLOHEXANE	110-82-7	110000	UG/KG	NON-TACO Const Worker	13000	UG/KG	USEPA Risk Based SSLs	13000	UG/KG	USEPA Risk Based SSLs
CHLORODIBROMOMETHANE	124-48-1	400	UG/KG	TACO - SO to GW Class I	0.039	UG/KG	USEPA Risk Based SSLs	0.039	UG/KG	USEPA Risk Based SSLs
DICHLORODIFLUOROMETHANE	75-71-8	NC		NC	610	UG/KG	USEPA Risk Based SSLs	610	UG/KG	USEPA Risk Based SSLs
ETHYLBENZENE	100-41-4	13000	UG/KG	TACO - SO to GW Class I	1.7	UG/KG	USEPA Risk Based SSLs	1.7	UG/KG	USEPA Risk Based SSLs
ISOPROPYLBENZENE	98-82-8	51000	UG/KG	NON-TACO Const Worker	1100	UG/KG	USEPA Risk Based SSLs	1100	UG/KG	USEPA Risk Based SSLs
METHYL ACETATE	79-20-9	29000	UG/KG	NON-TACO - SO to GW Class I	7500	UG/KG	USEPA Risk Based SSLs	7500	UG/KG	USEPA Risk Based SSLs
METHYL CYCLOHEXANE	108-87-2	46000	UG/KG	NON-TACO Const Worker	490000	UG/KG	EPA SSLs for Residential Inhalation	46000	UG/KG	NON-TACO Const Worker
METHYLENE CHLORIDE	75-09-2	20	UG/KG	TACO - SO to GW Class I	1.2	UG/KG	USEPA Risk Based SSLs	1.2	UG/KG	USEPA Risk Based SSLs
METHYL TERT-BUTYL ETHER	1634-04-4	320	UG/KG	TACO - SO to GW Class I	2.8	UG/KG	USEPA Risk Based SSLs	2.8	UG/KG	USEPA Risk Based SSLs
STYRENE	100-42-5	4000	UG/KG	TACO - SO to GW Class I	1800	UG/KG	USEPA Risk Based SSLs	1800	UG/KG	USEPA Risk Based SSLs
TETRACHLOROETHENE	127-18-4	60	UG/KG	TACO - SO to GW Class I	0.049	UG/KG	USEPA Risk Based SSLs	0.049	UG/KG	USEPA Risk Based SSLs
TOLUENE	108-88-3	12000	UG/KG	TACO - SO to GW Class I	1600	UG/KG	USEPA Risk Based SSLs	1600	UG/KG	USEPA Risk Based SSLs
TRANS-1,2-DICHLOROETHENE	156-60-5	700	UG/KG	TACO - SO to GW Class I	31	UG/KG	USEPA Risk Based SSLs	31	UG/KG	USEPA Risk Based SSLs
TRANS-1,3-DICHLOROPROPENE	10061-02-6	NC		NC	1100	UG/KG	EPA SSLs for Residential Inhalation	1100	UG/KG	USEPA SSLs for Residential Inhalation
TRICHLOROETHENE	79-01-6	60	UG/KG	TACO - SO to GW Class I	0.72	UG/KG	USEPA Risk Based SSLs	0.72	UG/KG	USEPA Risk Based SSLs
TRICHLOROFLUOROMETHANE	75-69-4	NC		NC	830	UG/KG	USEPA Risk Based SSLs	830	UG/KG	USEPA Risk Based SSLs
1,1,2-TRICHLOROTRIFLUOROETHANE	76-13-1	1000000	UG/KG	NON-TACO Residential Ingestion	150000	UG/KG	USEPA Risk Based SSLs	150000	UG/KG	USEPA Risk Based SSLs
VINYL CHLORIDE	75-01-4	10	UG/KG	TACO - SO to GW Class I	0.0056	UG/KG	USEPA Risk Based SSLs	0.0056	UG/KG	USEPA Risk Based SSLs
TOTAL XYLENES	1330-20-7	5600	UG/KG	TACO Const Worker	200	UG/KG	USEPA Risk Based SSLs	200	UG/KG	USEPA Risk Based SSLs
PESTICIDES (SW-846 METHODS 3510C/3520C/3550B/8081A)										
4,4'-DDD	72-54-8	3000	UG/KG	TACO Residential Ingestion	86	UG/KG	USEPA Risk Based SSLs	86	UG/KG	USEPA Risk Based SSLs
4,4'-DDE	72-55-9	2000	UG/KG	TACO Residential Ingestion	60	UG/KG	USEPA Risk Based SSLs	60	UG/KG	USEPA Risk Based SSLs
4,4'-DDT	50-29-3	2000	UG/KG	TACO Residential Ingestion	87	UG/KG	USEPA Risk Based SSLs	87	UG/KG	USEPA Risk Based SSLs
Aldrin	309-00-2	40	UG/KG	TACO Residential Ingestion	0.84	UG/KG	USEPA Risk Based SSLs	0.84	UG/KG	USEPA Risk Based SSLs
alpha-BHC (alpha-HCH)	319-84-6	0.5	UG/KG	TACO - SO to GW Class I	0.074	UG/KG	USEPA Risk Based SSLs	0.074	UG/KG	USEPA Risk Based SSLs
alpha-Chlordane	5103-71-9	NC		NC	NC		NC	NC		NC
beta-BHC	319-85-7	NC		NC	0.26	UG/KG	USEPA Risk Based SSLs	0.26	UG/KG	USEPA Risk Based SSLs
delta-BHC	319-86-8	NC		NC	NC		NC	NC		NC
Dieldrin	60-57-1	4	UG/KG	TACO - SO to GW Class I	0.09	UG/KG	USEPA Risk Based SSLs	0.09	UG/KG	USEPA Risk Based SSLs
Endosulfan	115-29-7	18000	UG/KG	TACO - SO to GW Class I	9700	UG/KG	USEPA Risk Based SSLs	9700	UG/KG	USEPA Risk Based SSLs
Endosulfan I	959-98-8	NC		NC	NC		NC	NC		NC

TABLE F-2
PROJECT ACTION LIMITS EVALUATION TABLE
SITE 12 SAP
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CORRECTED PARAMETER	CORRECTED CAS	Minimum IL Criteria		MINIMUM IL BASIS	Minimum Federal Criteria		MIN FEDERAL BASIS	OVERALL MINIMUM		OVERALL BASIS
Endosulfan II	33213-65-9	NC		NC	NC		NC	NC		NC
Endosulfan sulfate	1031-07-8	NC		NC	NC		NC	NC		NC
Endrin	72-20-8	1000	UG/KG	TACO - SO to GW Class I	230	UG/KG	USEPA Risk Based SSLs	230	UG/KG	USEPA Risk Based SSLs
Endrin aldehyde	7421-93-4	NC		NC	NC		NC	NC		NC
Endrin ketone	53494-70-5	NC		NC	NC		NC	NC		NC
gamma-BHC (Lindane)	58-89-9	9	UG/KG	TACO - SO to GW Class I	0.43	UG/KG	USEPA Risk Based SSLs	0.43	UG/KG	USEPA Risk Based SSLs
gamma-Chlordane	5103-74-2	NC		NC	NC		NC	NC		NC
Heptachlor	76-44-8	100	UG/KG	TACO Residential Ingestion	1.6	UG/KG	USEPA Risk Based SSLs	1.6	UG/KG	USEPA Risk Based SSLs
Heptachlor epoxide	1024-57-3	70	UG/KG	TACO Residential Ingestion	0.079	UG/KG	USEPA Risk Based SSLs	0.079	UG/KG	USEPA Risk Based SSLs
Methoxychlor	72-43-5	160000	UG/KG	NC	3400	UG/KG	USEPA Risk Based SSLs	3400	UG/KG	USEPA Risk Based SSLs
Toxaphene	8001-35-2	600	UG/KG	TACO Residential Ingestion	12	UG/KG	USEPA Risk Based SSLs	12	UG/KG	USEPA Risk Based SSLs

Definitions:
TACO - Tiered Approach to Corrective Action Objectives
NC - Not Criteria: no criteria is available for that parameter for that chemical
sat - Soil Saturation Concentration
GW - Groundwater
SO - Soil
IL - Illinois
SSL - Soil Screening Limits
UG/KG - micrograms per kilogram
MG/L - miligrams per liter

TABLE F-3
TCLP PROJECT ACTION LIMITS FOR INVESTIGATION DERIVED WASTES (IDW)
SITE 12
NAVAL STATION GREAT LAKES
GREAT LAKES, ILINOIS

Analytes	CAS Number	Project Action Limit (mg/L) [1]	Quantitation Limit (mg/L)
TCLP METALS SW-846 1311/6010B/7470A FOR IDW DETERMINATION			
ARSENIC	7440-38-2	5	0.1
BARIUM	7440-39-3	100	2
CADMIUM	7440-43-9	1	0.05
CHROMIUM	7440-47-3	5	0.1
LEAD	7439-92-1	5	0.03
MERCURY	7439-97-6	0.2	0.002
SELENIUM	7782-49-2	1	0.05
SILVER	7440-22-4	5	0.1
TCLP VOC SW-846 1311/8260B FOR IDW DETERMINATION			
BENZENE	71-43-2	0.5	0.01
CARBON TETRACHLORIDE	56-23-5	0.5	0.01
CHLOROBENZENE	108-90-7	100	0.01
CHLOROFORM	67-66-3	6	0.01
1,2-DICHLOROETHANE	107-06-2	0.5	0.01
1,1-DICHLOROETHENE	75-35-4	0.7	0.01
2-BUTANONE	78-93-3	200	0.1
TETRACHLOROETHENE	127-18-4	0.7	0.01
TRICHLOROETHENE	79-01-6	0.5	0.01
VINYL CHLORIDE	75-01-4	0.2	0.02
TCLP SVOC SW-846 1311/8260C FOR IDW DETERMINATION			
O-CRESOL	95-48-7	200	0.05
M-CRESOL	95-48-7	200	0.05
P-CRESOL	106-44-5	200	0.05
1,4-DICHLOROBENZENE	106-46-7	7.5	0.05
2,4-DINITROTOLUENE	121-14-2	0.13	0.05
HEXACHLOROBENZENE	118-74-1	0.13	0.05
HEXACHLORO-1,3-BUTADIENE	87-68-3	0.5	0.05
HEXACHLOROETHANE	67-72-1	3	0.05
NITROBENZENE	98-95-3	2	0.05
PENTACHLOROPHENOL	87-86-5	100	0.2
PYRIDINE	110-86-1	5	0.2
2,4,5-TRICHLOROPHENOL	95-95-4	400	0.05
2,4,6-TRICHLOROPHENOL	88-06-2	2	0.05
TCLP PESTICIDES SW-846 1311/8270C FOR IDW DETERMINATION			
CHLORDANE	57-74-9	0.03	0.0005
ENDRIN	72-20-8	0.02	0.0001
HEPTACHLOR	76-44-8	0.008	0.0001
HEPTACHLOR EPOXIDE	1024-57-3	0.008	0.0001
LINDANE	58-89-9	0.4	0.0001
METHOXYCHLOR	72-43-5	10	0.0001
TOXAPHENE	8001-35-2	0.5	0.01
TCLP HERBICIDES SW-846 1311/8270C FOR IDW DETERMINATION			
2,4-D	94-75-7	10	0.005
2,4,5-TP (SILVEX)	93-72-1	1	0.001

[1] Project Action Limits for IDW management are based on disposal requirements as per RCRA CFR 261.24

TCLP = Toxicity Characteristic Leaching Procedure

APPENDIX G

QUALITY CONTROL LIMITS